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The Economic Impact of Public Support to Agriculture

An International Perspective

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The Economic Impact of Public Support to Agriculture

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Foreword by David Blandford

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Foreword

Despite a gradual and sustained decline in the contribution of agriculture to the economies of the member countries of the Organization for Economic Cooperation and Development (OECD), the sector remains socially and politically important. Although agriculture accounts for less than 2% of the gross domestic product of the OECD countries, it occupies over 35% of their total land area. Predominantly rural regions, where agriculture remains particularly important, contain almost one quarter of the population of OECD countries.

The past quarter century has witnessed significant changes in agricultural policies in OECD countries. Although total support remains high, a shift has taken place from price-linked measures to direct income support, most notably in the European Union. Policies have been adapted to meet pressing social concerns, such as ensuring food security and improving environmental quality. OECD countries face major economic issues due to the ageing of their populations and the need to adapt to globalization and increasing competition from emerging economies. Continued pressure to reform agricultural policies will be exerted by the need to economize on the use of scarce public resources. At the same time, agriculture faces new challenges generated by climate change, the "greening" of the economy, increasing scarcity of energy and water, and the demands placed on the food system by an expanding world population.

In the face of these challenges, how should agricultural policies evolve in the future? Finding an answer to this question requires both sound economic analysis and an appreciation for the art of the politically possible. This volume brings together a set of distinguished economists who address both of these dimensions by drawing on experience from both sides of the Atlantic. Key issues such as the transfer efficiency of agricultural support policies and their ability to address emerging issues such as climate change are addressed. The impacts of policies on economic efficiency and competitiveness and issues raised by the management of risk and uncertainty are explored. Finally, two particularly important dimensions of change – the search for alternative sources of energy and pressures for international reform through the World Trade Organization – are examined.

The chapters in this volume have much to offer analysts as they work to improve their ability to determine the economic impact of agricultural policies. They should also appeal to policy practitioners who are wrestling with how to continue the process of reform so that policies can help agriculture to address the increasingly complex challenges that it faces. As the forces of economic change intensify, the need to cast a critical eye over the direction of agricultural policy and the importance of adopting an international perspective on policy reform will both increase.

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Chapter 1
Introduction and Overview

V. Eldon Ball, Roberto Fanfani, and Luciano Gutierrez

The 2003 reforms of the Common Agricultural Policy (CAP) of the European Union (EU) extend in a significant way the “decoupling” process started some 10 years earlier. By adopting the Single Farm Payment (SFP) scheme only limited support for agriculture is tied to current production decisions. Payments are based on historic levels of support and are conditional on compliance with legislated environmental, food safety and quality, and animal welfare provisions. In addition, there has been an attempt to redirect support from agriculture to the wider rural economy and to environmental protection.

The United States farm policy has taken a somewhat different direction. The Reform Act of 1996 introduced greater planting flexibility, shifted some support to decoupled payments unrelated to market prices, reduced effective price support levels for peanuts, dairy, and sugar, and eliminated the authority for acreage programs. The 2002 and 2008 acts retained those features; however, they also added countercyclical components to direct payments, based on market prices and historic production, and allowed for updating of the base acreage underlying direct payments. These steps arguably reintroduced closer ties between support and farm production decisions.

Such policy goals as reducing greenhouse gas emissions and energy independence have resulted in increased production of biofuels in both the EU and the United States, with expected large impacts on the agricultural sector.

During 19–21 June 2008, the U.S. Department of Agriculture’s Economic Research Service (ERS) and the International Association of Agro-Food Systems (AIEA2) assembled policy analysts and other social scientists from academia, government, and multilateral institutions on the campus of the University of Bologna to discuss the economic implications of the recent changes in the design of agricultural policy in the EU and the United States. The proceedings are contained in this volume.[1]

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Collaboration between ERS and the AIEA2 began during 15–16 June 2006 with a conference on international competitiveness, which eventuated in the volume *Competitiveness in Agriculture and the Food Sector: US and EU Perspectives* (Fanfani et al., 2008).

The present volume is organized around five major topics. Part I contains four chapters that chronicle recent developments in U.S. and EU agricultural policy. The first of these chapters provides estimates of the level and composition of support to agriculture in the OECD countries. Chapter 3 focuses on the divergence of agricultural policies in the United States and the EU, especially given the reforms of 2003 and afterward. Chapter 4 provides an impact assessment of the CAP reform "Health Check", while Chapter 5 looks at the incidence of U.S. program payments.

Part II includes two chapters that assess the impacts of agricultural policy on economic performance of the sector. Chapter 6 examines how farm program payments impact technical efficiency. The authors' approach is unique in that it treats subsidies as an endogenous variable in models of production. Chapter 7 investigates the effect of public R&D expenditures on productivity growth. However, the authors take a broader view of the production process to account for the relationship between productivity change and changes in prices and profits, thus allowing the authors to decompose changes in profitability in agriculture into price and productivity components.

There are four chapters in Part III. Chapter 8 looks at the impact of expanding biofuel production on agricultural commodity markets worldwide. Chapter 9 looks at the effects of U.S. ethanol policies on commodity prices, as well as their impact on U.S. terms of trade. Chapter 10 formulates a simulation model of corn and soybean production and biofuel production to simultaneously evaluate the impacts of U.S. biofuel policies on domestic commodity and energy markets. Part III concludes with a look at EU biofuel production targets and the implied trade-off between food crop and feedstock production.

Part IV includes three chapters. Chapter 12 looks at how WTO commitments have shaped domestic farm policies in the United States and the EU. In Chapter 13, the authors provide a formal definition of the concept of competitiveness and relate it to more conventional concepts such as growth of productivity. Chapter 14 investigates convergence of exchange rates toward absolute purchasing power parity in food prices among the euro-zone countries and between the euro-zone countries and their European trading partners.

Part V examines farmers' attitudes toward risk. Chapter 15 addresses the political economy of the U.S. crop insurance industry. Chapter 16 presents a new, highly flexible structural model of micro-level production behavior that is exactly aggregable across cost differences between producers. The model is applied to a panel of state-level data on variable input choices in U.S. agriculture. The authors also develop a framework to incorporate the results of the model for variable input demands within a general life cycle model of investment and agricultural asset management under uncertainty. In Chapter 17, the authors examine attitudes toward risk of U.S. corn and soybean farmers.

Chapter 2 in Part I by Cahill and Martini provides estimates of the level and composition of support to agriculture in the OECD countries, with emphasis on the effects of agricultural policy reform on welfare and on the efficiency of income transfers. The best known and most widely used measure of support in agriculture is the Producer Support Estimate (PSE). The PSE is essentially a measure of transfer. Agricultural policies may provide for direct payments to farmers. They may maintain domestic prices above those at the country's border or grant tax and credit concessions to farmers. All these possible sources of transfer or support are included in the PSE measure.

In 2007, significant methodological changes were introduced to better capture recent policy developments (e.g., the move to more decoupled support). Using the new methods, Cahill and Martini estimate that in the OECD countries PSE transfers accounted for 23% of gross farm receipts in 2007. This measure of support fell for the third consecutive year, from 28% in 2005 to 26% in 2006.

While the average level of support is declining, large variations among countries remain. At one end of the spectrum are New Zealand and Australia, where PSE transfers account for 1 and 5%, respectively, of gross receipts. At the other end are Iceland, Norway, Korea, Switzerland, and Japan, where this indicator is above 50%. Between these two extremes are the United States and Mexico, where PSE transfers as a share of gross receipts are one-half of the OECD average; support levels in Canada and Turkey are also below the OECD average. In the EU, this share in gross receipts approaches the OECD average, but is still above it.

The composition of support is also changing, with output-based support giving way to more decoupled payments. The EU has achieved the most dramatic reduction in output-based support among OECD countries. Almost 50% of total transfers are provided on a basis other than current production.

In Chapter 3, Schmitz and Schmitz focus on the divergence of agricultural polices in the EU and the United States. They note that the 2008 U.S. Farm Bill has many similar features to the 2002 legislation, including such key provisions as the target price and loan rate. On the other hand, the EU is following a path of more decoupled support, especially given the reforms of 2003 and afterward. But many of the elements of both U.S. and EU farm policy may no longer be of significance, given the recent increases in commodity prices. In an environment of high prices, the welfare costs of both U.S. and EU policies are greatly reduced. However, especially in the EU, there remains a large income transfer to farmers since, under decoupling, farmers will receive annual payments at least through 2013. Given the SFP scheme, EU farmers are allowed to respond to high prices and, in addition, collect an annual fixed payment under the rubric of decoupling.

In Chapter 4, Haniotis discusses the recent "Health Check" of the CAP reforms. While the health check itself did not constitute a fundamental reform of the CAP, it nevertheless raised a series of questions that will shape the debate on the future of the CAP. These questions focused on three legislative areas – direct payments, markets, and rural development. Each of these issues is discussed in turn. First, the distribution of payments among member states has become central to the debate. It is becoming increasingly clear that a move toward a regional model of support that provides for the same payment per hectare is inevitable. What is less clear is the extent to which such a move will actually affect the distribution of payments.

Second, the succession of reforms of the CAP has shifted support away from commodity-based measures and toward direct payments. Although minor adjustments in intervention prices for cereals have been proposed, the main thrust of the "Health Check" has been to remove supply controls (such as the set-aside and the dairy quota) that limit producers' ability to respond to market signals. In the case of the dairy quota, the focus has been on determining the annual adjustment path that would minimize price declines in the transition period.

The third policy area addressed in the health check was rural development. The Commission of the European Union proposed an increase in funding for rural development through "modulation" and targeted that increased funding to so-called new challenges such as those posed by climate change, biofuels, water management, and biodiversity.

Part I concludes with a discussion of theory and evidence on the incidence of U.S. farm commodity programs. Simple theoretical models can be used to illustrate how different types of subsidies have different incidence. Analysis with such models indicates that we should expect a fully decoupled payment attached to land to be reflected entirely in land rents and capitalized fully into land. Yet econometric studies find a surprisingly small share of subsidy benefits going to landowners. Alston argues that the truth probably lies in between the results from the theoretical models and the econometric evidence. A significant share of even the so-called decoupled transfers goes to farmers rather than to landowners. Using data for 2005, he estimates that for every dollar of government spending on farm subsidies, farmers receive about 50 cents, landowners about 25 cents, and domestic and foreign consumers about 20 cents, and 5 cents is wasted. If the purpose of the subsidy is to transfer income to farmers, then the mechanism is very inefficient with only about one-half of the amount taken from taxpayers ending up with the intended recipients.

Government policies can have a large impact on farm performance. This is the focus of Part II. Chapter 6 of Part II, by Kumbhakar and Lien, examines how farm program payments impact technical efficiency. Two modeling approaches have been used to analyze the effects of subsidies on farm performance. The first approach treats subsidies as a traditional input in the production function to allow for direct influence on productivity. However, this approach suffers from two drawbacks. The first is that while traditional inputs are necessary for production, subsidies are not. The second is that subsidies alone cannot produce any output, while traditional inputs can.

The second approach employs a stochastic production function and only allows subsidies to affect productivity through the technical efficiency function. This latter approach escapes the "traditional input" criticism, but it does not allow for simultaneous examination of the impact of subsidies on productivity and efficiency change. In their chapter, Kumbhakar and Lien merge and extend the two approaches. They assume that farmers can manipulate, to some extent, the subsidies received. Since farmers can manipulate the subsidies received, they model subsidies as an endogenous variable in the production function, as well as in the efficiency function. They analyze the effects of subsidies on productivity and technical efficiency in Norwegian grain farming using an unbalanced panel of 1,000 farms over the period

1991–2006. Their results show that subsidies negatively affected farm productivity but had a positive influence on technical efficiency.

Chapter 7 in this section, by Ball et al., investigates the effect of public R&D on U.S. agricultural productivity using state-by-year panel data. They employ the Bennet–Bowley "indicator" to measure multifactor productivity. Their analysis confirms the anticipated positive relationship between investment in R&D and changes in total factor productivity. They also show that their measure of productivity change is a component, along with changes in real prices, of the change in profits. They find that the contributions of these two components are largely offsetting, with the long-term trend in profitability of the sector very nearly flat. Public R&D has a negative effect on real prices; the net effect on profit change is small and positive, albeit statistically insignificant. This suggests that the benefits of public R&D expenditures accrue largely to consumers through lower real prices.

Part III looks at the impact of biofuels policy on agricultural markets. In Chapter 8, Peters et al. use a dynamic partial equilibrium agricultural trade model to simulate the impacts of shifts in the demand for ethanol and biodiesel on markets for agricultural commodities.

The recent global increases in agricultural commodity prices can be attributed to a number of factors, but De Gorter and Just, in Chapter 9, argue that one of the most important factors was the large increase in U.S. ethanol production. Moreover, they argue that without a complex web of ethanol policies, little ethanol would be produced in the United States. This is likely the case for biofuel production in the EU, Canada, and other developed countries as well. It is increasingly evident that developing countries have a comparative advantage in the production of biofuels and their feedstock. Yet policies have been enacted that discriminate against trade. The result is little international trade in biofuels. This chapter puts into perspective the effects of U.S. ethanol policies on commodity prices, as well as their impact on U.S. terms of trade.

The Renewable Fuel Standard under the Energy Policy Act of 2005 redefines ethanol as a renewable fuel, rather than just a fuel oxygenate. In addition, the American Job Creation Act of 2004 creates biofuel tax credits, and the Energy Independence and Security Act of 2007 mandates biofuel blending. In Chapter 10, Kim et al. formulate an integrated economic simulation model of corn and soybean production and biofuel production to simultaneously evaluate the impacts of U.S. biofuel policies on domestic commodity and energy markets. The model is used to demonstrate that ethanol production increases as a result of both the ethanol tax credit and a blending mandate. But conventional gasoline and ethanol are substitutes due to the blending mandate. Therefore, a mandate to blend ethanol with conventional gasoline would have a negative impact on conventional gasoline production.

In Chapter 11, Canali and Aragrande focus on the land area required to meet EU biofuel production targets, the problems related to technical adaptation of farms to feedstock production, and the approach to biofuels in the CAP of the EU.

Chapter 12 of Part IV by Josling looks at the period since 1995 and the establishment of the WTO to see to what extent the WTO commitments have shaped domestic farm policies, particularly in the United States and the EU. This influence can come about either through negotiated constraints on policy outcomes or through litigation of complaints by other countries. Notification of domestic support levels shows little direct impact on U.S. farm policy, but the outcome of litigation has had some influence on policy choices. In the EU, the reform of the CAP has been much more influenced by WTO subsidy constraints, but somewhat less by litigation.

The other two chapters in this section look at international competitiveness of agriculture and the food sector. The most intuitive concept of competitiveness is that of price competitiveness. In Chapter 13, Ball et al. construct relative prices for eleven member states of the EU and the United States for the period 1973–2002. They assume that markets are perfectly competitive and in long-run equilibrium, so that the observed price equals average cost, as measured by the dual cost function. This result is used in their decomposition of relative price movements into changes in relative input prices and changes in relative productivity levels.

Their price comparisons indicate that the United States was more competitive than its European counterparts throughout the period 1973–2002, except for the years 1973–1974 and 1983–1985. Their results also suggest that the relative productivity level was the most important factor in determining international competitiveness. Over time, however, changes in competitiveness were strongly influenced by variations in exchange rates through their impact on relative input prices. During the periods 1979–1984 and 1996–2001, the strengthening dollar helped the European countries improve their competitive position, even as their relative productivity performance lagged.

In Chapter 14, Gutierrez et al. investigate convergence of exchange rates toward absolute purchasing power parity in food prices among the euro-zone countries and between the euro-zone countries and their European trading partners. If absolute purchasing power holds, the relative prices of similar goods expressed in a common currency should be exactly equal. They find that markets in the euro-zone are highly integrated; that is, real exchange rates tend to converge. The evidence is less persuasive for countries outside the euro-zone.

Part V examines farmers' attitudes toward risk. In Chapter 15, Babcock addresses the political economy of the U.S. crop insurance industry. Taxpayer support for the crop insurance industry has grown rapidly since 2000 even though total crop acres insured is stagnant and the number of policies sold has declined. Staunch support for the program by key members of Congress meant defeat for proposals in the 2008 Farm Bill that would have significantly reduced cost. These proposals included large changes in the formulas used to calculate industry reimbursement and new programs that would be integrated with or reduce the amount of risk insured by the crop insurance program. The reasons for this resilience are program complexity and biased analysis, which have allowed the industry to claim that they are undercompensated despite a doubling of taxpayer support. One unforeseen outcome of the strength of the crop insurance industry in protecting its interests is that a new insurance program, Average Crop Revenue Selection (ACRE), was passed in the 2008 Farm Bill. Large unintended consequences that could be brought about by ACRE include the likely demise of the marketing loan and countercyclical programs, an increased risk that the United States will violate its amber box limits, and, in the not-too-distant future, a complete change in the way that U.S. crop insurance is delivered to farmers.

Two common problems in econometric models of production are aggregation and unobservable variables. Many production processes are subject to production shocks, hence both expected and realized outputs are unknown when inputs are committed. Expectation processes are notoriously difficult to model, especially when working with aggregated data or risk averse decision makers. In Chapter 16, Ball et al. adapt duality methods for incomplete systems of consumer demand equations to the dual structure of the variable cost function in joint production. This allows the identification of necessary and sufficient restrictions on technology and cost so that the conditional factor demands can be written as functions of input prices, fixed inputs, and cost. These are observable when the variable inputs are chosen and committed to production, hence the identified restrictions allow ex ante conditional demands to be studied using only observable data. This class of production technologies is consistent with all von Neumann–Morgenstern utility functions when ex post production is uncertain. The authors then derive the complete class of input demand systems that are exactly aggregable, can be specified and estimated with observable data, and are consistent with economic theory for all von Neumann–Morgenstern risk preferences. They extend this to a general and flexible class of input demand systems that can be used to nest and test for aggregation, global economic regularity, functional form, and flexibility. The theory is applied to U.S. agricultural production and crop acreage allocation decisions by state for the years 1960–1999.

In Chapter 17, Livingston et al. estimate standard and Bayesian random coefficient models to examine the coefficients of absolute risk (AR) aversion and absolute downside risk (DR) aversion using panel data on corn and soybean farms stratified by sales (i.e., revenue) class. First, they find that the Bayesian model provides little in the way of extra information about risk attitudes relative to the standard model and little, if any, gain in precision. According to the standard model results, risk neutrality cannot be rejected for small or medium farms but is rejected (in favor of a very slight level of risk tolerance) for large and very large farms and for the entire sample. A very low level of DR aversion is detected for medium, large, and very large farms and for the full sample. Although risk tolerance and DR aversion cannot be rejected for the entire sample of farms and for medium, large, and very large farms, the magnitude of the AR and DR estimates is extremely small. This suggests that the frequent assumption of risk-neutral preferences adopted in the agricultural economics literature is justifiable, at least in the case of U.S. corn and soybean farms.

Note

1. While ERS cosponsored the conference, the views expressed in this volume are solely those of the authors. They do not necessarily reflect the views of the USDA. This volume, including chapters authored by USDA researchers, was not reviewed or approved by any agency of the USDA.

Reference

Fanfani, R., Ball, V.E., Gutierrez, L., Ricci-Maccarini, E., eds. (2008), *Competitiveness in Agriculture and the Food Sector: US and EU Perspectives*, Bologna University Press, Bologna.

Part I
New Directions in Agricultural Policy: US and European Perspectives

Chapter 2
Recent Developments and Applications from the OECD Toolbox

Carmel Cahill and Roger Martini

Abstract The most recent estimates (up to and including 2007) of the level and composition of support to agriculture in OECD countries and an update on recent changes in method and classification are presented. Results from a recent study on land issues and two recent country studies (Mexico and Korea) are used to illustrate how this support data, when combined with the PEM (Policy Evaluation Model), can shed light on the distributional and economic effects of the policies being measured. The emphasis is on the effects of agricultural policy reform, particularly of more decoupled policies, on welfare and on income transfer efficiency.

2.1 Estimating the Level of Public Support in Agriculture

For 20 years the Organization for Economic Cooperation and Development (OECD) has been estimating indicators of support and protection in agriculture with a view to monitoring and evaluating developments in agricultural policy, to establish a common base for policy dialogue among countries and to provide economic data to assess policy performance. With respect to the latter, the data serve as an *input into modelling* to assess the effectiveness and efficiency of policies in delivering the outcomes for which they were designed and to understand their effects on production, trade, income, the environment, etc. The most well-known and widely used indicators are the PSE – producer support estimate – and the CSE – consumer support estimate. Formal definitions of these and the entire suite of related and derived indicators are given in Box 2.1. While the indicators are not themselves a measure of impact, the economic information upon which they are based is an important building block for further analysis.

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Box 2.1 Names and Definitions of the OECD Indicators of Agricultural Support

Indicators of Support to Producers

Producer Support Estimate (PSE): the annual monetary value of gross transfers from consumers and taxpayers to agricultural producers, measured at the farm-gate level, arising from policy measures that support agriculture, regardless of their nature, objectives or impacts on farm production or income.

Percentage PSE (%PSE): PSE transfers as a share of gross farm receipts (including support).

Producer Nominal Assistance Coefficient (producer NAC): the ratio between the value of gross farm receipts (including support) and gross farm receipts valued at border prices (measured at farm gate).

Producer Nominal Protection Coefficient (producer NPC): the ratio between the average price received by producers at farm gate (including payments per tonne of current output), and the border price (measured at farm gate).

Producer Single Commodity Transfers (producer SCT): the annual monetary value of gross transfers from consumers and taxpayers to agricultural producers, measured at the farm-gate level, arising from policy measures directly linked to the production of a single commodity such that the producer must produce the designated commodity in order to receive the transfer.

Producer Percentage Single Commodity Transfers (producer %SCT): the commodity SCT as a share of gross farm receipts for the specific commodity.

Group Commodity Transfers (GCT): the annual monetary value of gross transfers from consumers and taxpayers to agricultural producers, measured at the farm-gate level, arising from policy measures whose payments are made on the basis that one or more of a designated list of commodities is produced, that is, a producer may produce from a set of allowable commodities and receive a transfer that does not vary with respect to this decision.

All Commodity Transfers (ACT): the annual monetary value of gross transfers from consumers and taxpayers to agricultural producers, measured at the farm-gate level, arising from policy measures that place no restrictions on the commodity produced but require the recipients to produce some commodity of their choice.

Other Transfers to Producers (OTP): the annual monetary value of gross transfers from consumers and taxpayers to agricultural producers, measured at the farm-gate level, arising from policy measures that do not require any commodity production at all.

Indicators of Support to General Services for Agriculture

General Services Support Estimate (GSSE): the annual monetary value of gross transfers to general services provided to agricultural producers collectively (e.g., research, development, training, inspection, marketing and promotion), arising from policy measures that support agriculture regardless of their nature, objectives and impacts on farm production, income, or consumption. The GSSE does not include any transfers to individual producers.

Percentage GSSE (%GSSE): transfers to general services (GSSE) as a share of total support estimate (TSE).

Indicators of Support to Consumers

Consumer Support Estimate (CSE): the annual monetary value of gross transfers from (to) consumers of agricultural commodities, measured at the farm-gate level, arising from policy measures that support agriculture, regardless of their nature, objectives or impacts on consumption of farm products.

Percentage CSE (%CSE): CSE transfers as a share of consumption expenditure (measured at farm gate) net of taxpayer transfers to consumers.

Consumer Nominal Assistance Coefficient (consumer NAC): the ratio between the value of consumption expenditure on agricultural commodities (at farm gate) and that valued at border prices (measured at farm gate).

Consumer Nominal Protection Coefficient (consumer NPC): the ratio between the average price paid by consumers (at farm gate) and the border price (measured at farm gate).

Consumer Single Commodity Transfers (consumer SCT): the annual monetary value of gross transfers from (to) consumers of agricultural commodities, measured at the farm-gate level, arising from policy measures directly linked to the production of a single commodity.

Indicators of Total Support to Agriculture

Total Support Estimate (TSE): the annual monetary value of all gross transfers from taxpayers and consumers arising from policy measures that support agriculture, net of associated budgetary receipts, regardless of their objectives and impacts on farm production and income, or consumption of farm products.

Percentage TSE (%TSE): TSE as a share of GDP.

While the indicators were calculated initially for OECD countries, the analysis has gradually included non-OECD countries also, such as Brazil, China, Russia, South Africa and Ukraine. It currently includes 43 countries (27 EU members treated as a single entity), with estimates covering the period from 1986 to the 2007. The international comparability of the indicators and wide country coverage make the indicators a useful tool for policy dialogue not only among OECD countries, but also with non-OECD countries, inter-governmental organizations (e.g., WTO, World Bank, IMF and FAO), farming and non-governmental organizations, as well as research institutions.

The main avenues for dissemination of the support indicators are the annual report, the title of which alternates between *Agricultural Policies in OECD Countries: Monitoring and Evaluation* and *Agricultural Policies in OECD Countries: At a Glance,* and the indicator database incorporating country-specific documentation (Definitions and Sources), available on the website www.oecd.org/agr/support. A comprehensive manual (*OECD's Producer Support Estimate and Related Indicators of Agricultural Support: Concepts, Interpretation and Use*) is also available from the same website.

The PSE is essentially a measure of transfer. Agricultural policies may provide direct payments to farmers. They may maintain domestic agricultural prices above those at the country's border, or grant tax and credit concessions to farmers. All of these possible sources of transfer or support are included in the PSE measure. In other words, support is not only comprised of budgetary payments that appear in government accounts, but also includes support of market prices, as well as other concessions that do not necessarily imply actual budgetary expenditure, such as tax concessions. The common element to all these policies is that they generate transfers to agriculture.

The formal definitions are quite explicit about the fact that the measure relates to transfers arising from measures that support agriculture irrespective of their nature, objectives or impacts on farm production or income. Coverage in the PSE is defined as measures whose incidence is at the farm level and that are directed specifically to agricultural producers or that treat agricultural producers differently from other agents in the economy. The support provided by the policy measure may be delivered in several different ways: an increased output price (market price support); a reduced input price (e.g., a fertiliser subsidy) or cost share for fixed capital; a direct payment (e.g., a cheque from the government); a revenue foregone by government (e.g., a tax concession); a reimbursement of a tax or charge (e.g., as for fuel taxes in some countries); or a gratuitous service in kind to individual farmers (e.g., delivery of extension services).

It is not just the aggregate level of transfer that is of interest, although as a general measure of policy effort it is important. It is also important to understand the different ways in which support is provided to farmers and how it is changing over time. This information has intrinsic value but is also very important when the data are used as inputs into more analytical work aimed at estimating impacts or assessing policy performance. Over the years it has been found that classifying measures by "implementation criteria" is both the least ambiguous and the most useful way of proceeding, given all the different uses to which the indicators are put. Implementation criteria generally relate to the first incidence of a transfer – does it affect the price of an output, an input or a factor of production? – and are particularly useful when using the PSE data as an input into a modelling framework designed to elicit information about impacts. This aspect of the PSE classification will be discussed in more detail later when the policy evaluation model is introduced.

Significant changes were introduced in 2007 in the approach and methods used to measure support, to enable the indicators to better capture recent policy developments; for example, the move to "decouple" the provision of support from specific commodity production and "re-couple" the provision of support to other criteria. Three major changes were made:

1. Although still based on implementation criteria, the PSE categories were substantially redefined. The new classification is shown in summary form in Annex 1.
2. Labels were introduced, with the result that each policy, in addition to being classified into a PSE category, could also have up to six different labels attached to it so as to provide further detail on implementation criteria; labels serve as a shorthand for categories not included in the main presentation. For example, labels give additional information on whether a payment is with or without limit, or whether a payment implies any constraints on input use by the recipient. The range of possible labels is also indicated in Annex 1.
3. PSEs for individual commodities are no longer calculated. Instead, a country total PSE is divided into single commodity transfers, group commodity transfers, all commodity transfers and other transfers to producers. This change reflects the fact that as a result of policy reform, support in many OECD countries is less tied to an individual commodity. Support is being increasingly provided to groups of commodities or all commodities in general, or without obliging a recipient to engage in commodity production at all. In this situation the link between some support transfers and individual commodities becomes less apparent. This necessitated an alternative presentation of support transfers with respect to their commodity specificity.

Annex 1 New PSE classification

A. Support based on commodity output

A.1 Market price support (MPS)
A.2 Payments based on output

B. Payments based on input use

B.1 Variable input use
B.2 Fixed capital formation
B.3 On-farm services

C. Payments based on current A/An/R/I, production required

C.1 Based on current revenue/income
C.2 Based on current area/animal numbers

D. Payments based on non-current A/An/R/I, production required
E. Payments based on non-current A/An/R/I, production not required

E.1 Variable rates
E.2 Fixed rates

F. Payments based on non-commodity criteria

F.1 Long-term resource retirement
F.2 Specific non-commodity output
F.3 Other non-commodity criteria

G. Miscellaneous payments

Labels to be attached to programmes in the above categories of policy measures:

- *With/without L (with or without current commodity production limits and/or payment limits).*
- *With V/F rates (with variable or fixed payment rates).*
- *With/without input constraints (C) (with mandatory/with voluntary/without input constraints).*
- *With/without E (with or without any commodity exceptions).*
- *Based on A/An/R/I (based on area, animal numbers, receipts or income).*
- *Based on SC/GC/AC (based on a single commodity, group of commodities or all commodities).*

* A (area), An (animal numbers), R (receipts) or I (income).

2.2 Most Recent Results Using the New Approach

The level of producer support in the OECD area, as measured by the %PSE, was 23% in 2007, meaning that agricultural support increased farmers' gross receipts in OECD countries by somewhat less than one-quarter (Fig. 2.1 and Table 2.1). The %PSE fell for the third consecutive year, from 28% in 2005 and 26% in 2006.

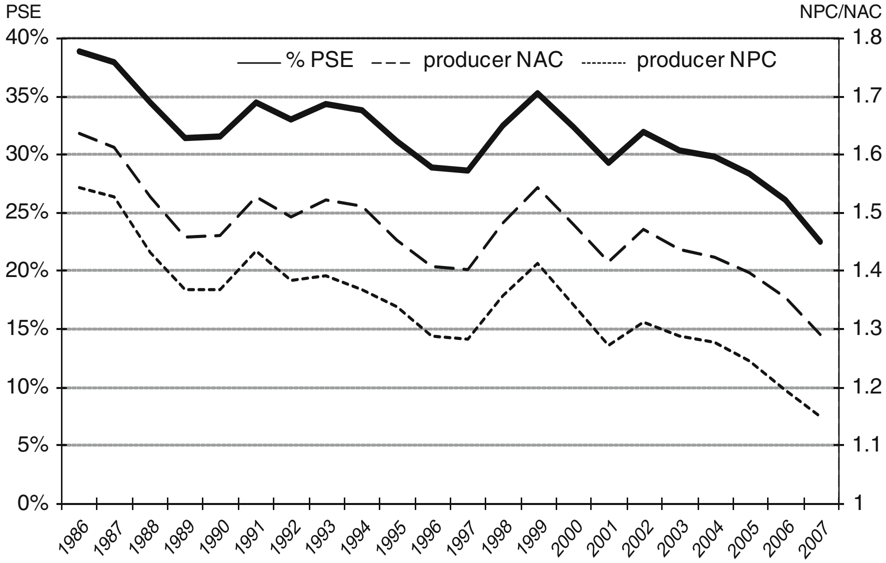

Fig. 2.1 Evolution of OECD support indicators. *Source*: OECD, PSE/CSE Database 2008a

%PSE producer support estimate (*left scale*), *NPC* producer nominal protection coefficient (*right scale*) *NAC* producer nominal assistance coefficient (*right scale*)

Table 2.1 OECD: Estimates of support to agriculture (USD million)

	1986–88	2005–07	2005	2006	2007*p*
Total value of production (at farm gate)	**591,839**	**902,972**	**834,679**	**858,328**	**1,015,910**
of which share of MPS commodities (%)	72	67	68	67	67
Total value of consumption (at farm gate)	**557,838**	**885,580**	**806,401**	**847,589**	**1,002,750**
Producer support estimate (PSE)	**239,269**	**269,533**	**272,076**	**257,287**	**258,236**
Support based on commodity output	196,715	144,902	163,172	139,520	132,014
Market Price Support	184,494	135,149	146,787	131,691	126,970
Payments based on output	12,221	9,753	16,385	7,829	5,044
Payments based on input use	20,129	29,813	27,593	29,360	32,485
Based on Variable input use	9,745	11,749	11,094	11,932	12,222
with input constraints	739	505	514	614	387

Table 2.1 (continued)

	1986–88	2005–07	2005	2006	2007*p*
Total value of production (at farm gate)	**591,839**	**902,972**	**834,679**	**858,328**	**1,015,910**
of which share of MPS commodities (%)	72	67	68	67	67
Total value of consumption (at farm gate)	**557,838**	**885,580**	**806,401**	**847,589**	**1,002,750**
Based on fixed capital formation	6,643	9,943	8,451	9,593	11,786
with input constraints	1,235	2,033	2,043	1,736	2,319
Based on on-farm services	3,740	8,120	8,048	7,835	8,478
with input constraints	451	1,230	1,365	1,194	1,130
Payments based on current A/An/R/I[b], production required	18,666	31,670	38,100	29,182	27,728
Based on Receipts / Income	2,051	4,037	4,052	4,266	3,794
Based on Area planted / Animal numbers	16,615	27,633	34,048	24,916	23,934
with input constraints	3,685	21,790	27,405	19,686	18,279
Payments based on non-current A/An/R/I, production required	533	1,021	717	820	1,527
Payments based on non-current A/An/R/I, production not required	2,080	51,031	38,819	53,642	60,634
With variable payment rates	181	3,025	5,142	2,166	1,767
With fixed payment rates	1,899	48,006	33,676	51,476	58,867
Payments based on non-commodity criteria	935	4,194	4,027	4,811	3,744
Based on long-term resource retirement	934	3,487	3,277	4,041	3,142
Based on a specified non-commodity output	1	551	576	615	462
Based on other non-commodity oritena	0	156	174	154	140
Miscellaneous payments	210	−99	−352	−48	104
Percentage PSE	**37**	**26**	**28**	**26**	**23**
Producer NPC	**1.50**	**1.20**	**1.24**	**1.20**	**1.15**
Producer PAC	**1.59**	**1.35**	**1.40**	**1.35**	**1.29**
General services support estimate (GSSE)	**40,809**	**75,791**	**73,969**	**75,767**	**77,638**
Research and development	3,562	7,081	6,730	6,748	7,766
Agricultural schools	837	1,993	2,056	1,684	2,238
Inspection servies	1,092	3,281	3,195	3,228	3,421
Infrastructure	13,866	22,184	22,169	22,143	22,239
Marketing and promotion	13,274	37,180	35,564	38,133	37,843
Public stockholding	6,561	1,562	1,801	1,385	1,499
Miscellaneous	1,617	2,510	2,455	2,446	2,630
GSSE as a share of TSE (%)	**13.6**	**20.6**	**19.7**	**20.9**	**21.3**

Table 2.1 (continued)

	1986–88	2005–07	2005	2006	2007*p*
Total value of production (at farm gate)	**591,839**	**902,972**	**834,679**	**858,328**	**1,015,910**
of which share of MPS commodities (%)	72	67	68	67	67
Total value of consumption (at farm gate)	**557,838**	**885,580**	**806,401**	**847,589**	**1,002,750**
Consumer support estimate (CSE)	**−161,389**	**−125,210**	**−135,700**	**−124,026**	**15,904**
Transfers to producers from consumers	−171,385	−134,374	−145,835	−132,021	−125,265
Other transters from consumers	−22,633	−22,095	−21,429	−22,703	−22,152
Transfers to consumers from taxpayers	19,735	29,412	29,516	29,512	29,209
Excess feed cost	12,894	1,846	2,048	1,186	2,305
Percentage CSE	**−30**	**−15**	**−17**	**−15**	**−12**
Consumer NPC	**1.54**	**1.22**	**1.26**	**1.22**	**1.17**
Consumer NAC	**1.43**	**1.18**	**1.21**	**1.18**	**1.14**
Total support estimate (TSE)	**299,813**	**367,736**	**375,560**	**362,565**	**365,082**
Transfers from consumers	194,018	156,468	167,264	154,724	147,418
Transfers from taxpayers	128,428	233,362	229,726	230,545	239,817
Budget revenues	−22,633	−22,095	−21,429	−22,703	−22,152
Percentage TSE (expressed as share of GDP)[d]	**2.49**	**0.97**	**1.05**	**0.97**	**0.89**

[a] *p* provisional, *NPC* nominal protection coefficient, *NAC* nominal assistance coefficient
[b] A (area planted) / An (animal numbers) / R (receipts) / I (income)
[c] MPS is net of producer levies and Excess Feed Cost.
[d] TSE as a share of GDP for 1986–88 for the OECD total excludes the Czech Republic, Hungary, Poland and the Slovak Republic as GDP data are not available for this period
Source: OECD, PSE/CSE database 2008

The producer nominal assistance coefficient (producer NAC) complements the %PSE. It is the ratio between the value of gross farm receipts including support and the value of farm receipts estimated at border prices. The average producer NAC for the OECD area was 1.29 in 2007, indicating that farmer receipts were 29% higher than if entirely generated at border prices and with no other support. This differential was narrower than in 2006 when it was 35%, and represents an even stronger reduction over 2005 when it was 40%.

The producer nominal protection coefficient (producer NPC) is a ratio between the producer price (including payments per unit of output) and the border price, and shows the degree to which policies increase prices received by domestic producers. The average producer NPC for the OECD area was 1.15 in 2007, meaning that, in the OECD, farmers received, on average, prices that were 15% above international levels (20% in 2006 and 24% in 2005).

Averaging over 3 years, the %PSE in 2005–2007 was, at 26%, down from 37% in 1986–1988. This is the lowest level observed since OECD began estimating producer support in 1986. A decline in support is also reflected in the producer NAC, showing that in 2005–2007 agricultural policies added over one-third (35%) to what producer receipts would have been without any support, while in 1986–1988 they added 59%. The most rapid reduction is observed in the producer NPC, which indicates the rate of price protection. It has more than halved for the OECD area as a whole since the 1980s; that is, producer prices exceeded international levels by 20% in 2005–2007, whereas in 1986–1988 this differential was 50%. The fact that of the two producer support indicators – the NAC and NPC – the NPC shows the strongest decline indicates that the observed fall in producer support in OECD countries was largely due to alignment of domestic and border prices.

2.3 What Caused the Changes in PSE in 2007?

The change in the PSE from year to year can be decomposed into its component parts; firstly, the contribution of market price support (MPS) (which measures the transfers associated with those mechanisms, both domestic and trade, that result in a price gap between domestic and border prices) and budgetary payments, secondly, the relative contribution of volume changes or unit transfers in explaining changes in unit MPS (i.e., per tonne) and finally, the relative importance of exchange rate changes and border prices in explaining the latter. Between 2006 and 2007, not surprisingly, the general run-up in world food commodity prices, as reflected in the border prices, is the dominant factor in the development of MPS in an otherwise comparatively stable policy environment. The depreciation of the US dollar against most OECD currencies only partly offset the increase in US dollar-nominated border prices and all countries faced higher average border prices expressed in national currencies. Higher border prices generally reduced the gap between domestic and international prices; this is reflected in the drop in unit MPS in most countries (Tables 2.2, 2.3, and 2.4).

2.4 Wide Variations in Support Across Countries

Although in the long term all OECD members (with the exception of Turkey) are on the same path of reducing support, large variations in support levels remain. These differences, among other things, stem from the varying economic, social and political priorities of countries that translate into more or less interventionist policy frameworks; they also reflect different degrees and speeds of agricultural policy reform.

At one end of the spectrum there is *New Zealand* and *Australia* where the %PSEs are at 1 and 5%, respectively; at the other end are Iceland, Norway, Korea, Switzerland and Japan where this indicator is above 50% (Fig. 2.2). Between these

Table 2.2 Factors contributing to the change in the Producer Support Estimate by country, 2006–2007

	Producer support estimate (PSE)		Contribution of		Contribution of budgetary payments (BP) based on:						
	USD mn, 2007	% change[a]	MPS	BP	Output	Input use	Current A/An/R/I production required	Non-current A/An/R/I production required	Non-current A/An/R/I production not required	Non-commodity criteria	Miscellaneous
			% change in PSE if all other variables are held constant								
Australia	1,872	11.9	−0.1	12.0	0.0	−9.7	1.0	0.0	20.7	0.0	0.0
Canada	7,001	−8.4	−16.0	7.6	0.0	−0.4	−0.2	6.0	2.1	−0.1	0.1
European Union[b]	129,896	−8.8	−7.7	−1.1	−0.8	0.6	−1.4	0.0	1.0	−0.7	0.1
Iceland	212	−9.6	−11.2	1.6	−1.3	0.0	2.8	0.4	0.0	−0.3	0.0
Japan	35,230	−9.1	−10.4	1.3	−1.7	1.1	−0.2	0.0	2.1	0.0	0.0
Korea	25,461	−1.7	−0.9	−0.7	0.0	0.5	−1.1	0.0	0.0	0.0	0.0
Mexico	6,053	−1.1	−9.3	8.2	−3.9	7.4	1.8	3.1	0.0	−0.2	0.0
New Zealand	82	−24.5	−22.5	−2.1	0.0	3.1	−5.1	0.0	0.0	0.0	0.0
Norway	2,803	−14.9	−16.4	1.5	0.3	0.2	0.8	0.2	0.0	0.0	0.0
Switzerland	4,180	−18.0	−18.6	0.6	−0.9	0.4	1.8	0.0	−0.9	0.1	0.0
Turkey	13,438	13.0	10.2	2.8	3.3	0.4	0.1	0.0	−0.9	0.0	0.0
United States	32,663	5.8	18.3	−12.5	−4.7	−0.6	−4.7	0.0	−2.0	−0.5	0.0
OECD[c]	258,236	−3.9	−3.4	−0.5	−1.2	0.9	−1.1	0.2	1.0	−0.4	0.1

[a] Percent changes in national currency

[b] EU25 for 2006 and EU27 for 2007

[c] An average of percentage changes in individual country PSEs in national currencies, weighted by the shares of the country PSEs in the OECD PSE in the previous year; not equivalent to the variation in OECD PSE in any common currency

Source: OECD, PSE/CSE database, 2008

Table 2.3 Contribution to the change in the market price support by country, 2006–2007

	Market price support (MPS)	Contribution to % change in MPS of:	
		Quantity	Unit MPS
	% change[a]	if all other variables are held constant	
Australia	−89.7	−98.6	8.9
Canada	−29.8	−0.4	−29.4
European Union[b]	−19.1	−0.3	−18.8
Iceland	−22.8	0.0	−22.8
Japan	−11.8	1.1	−12.9
Korea	−1.1	1.7	−2.7
Mexico	−25.6	0.2	−25.8
New Zealand	−39.5	−1.4	−38.2
Norway	−37.2	1.7	−38.8
Switzerland	−40.1	−0.5	39.6
Turkey	16.2	9.5	6.8
United States	91.5	−7.6	99.2
OECD[c]	−6.6	1.7	−8.3

[a]Percent change in a countries total MPS is the average of per cent changes in MPS for individual commodities in national currencies, weighted by the shares of individual commodity MPS in country total MPS in the previous year
[b]EU25 for 2006 and EU27 for 2007
[c]An average of percent changes in individual countries' MPS, weighted by the shares of the countries' MPS in the OECD total MPS in the previous year; not equivalent to the variation in OECD MPS in any common currency
Source: OECD, PSE/CSE database 2008

two extremes, the support levels are also widely spread. The United States and Mexico have %PSEs which are around one-half the OECD average; support levels in Canada and Turkey are also lower than, but much closer to, the OECD average level. The %PSE in the European Union approaches the OECD average, but is still above it.

2.5 The Composition of Support Has Been Changing Too

The level of support is important because it provides insights into the burden that agricultural support places on consumers and taxpayers. But it is also necessary to analyse the composition of support, which shows the different ways in which support is provided. For example, support may be linked to commodity output directly, as is the case of market price support, payments based on output or on variable inputs used. But it may also be less directly related to commodity production and be based on parameters such as area, animal numbers, or farm receipts, or income. Payments of this kind may be based on current or non-current parameters and may or may not impose an obligation on the recipient to produce in order to be eligible for

Table 2.4 Contribution to change in border price by country, 2006–2007

	Border price	Contribution to % change in border price[a] of:	
		Exchange rate	Border price (USD)
	% change[b]	if all other variables are held constant	
Australia	8.9	−11.0	19.9
Canada	51.0	−6.9	57.9
European Union[c]	6.7	−8.9	15.6
Iceland	33.5	−10.2	43.7
Japan	14.7	1.3	13.5
Korea	14.5	−2.6	17.1
Mexico	12.0	0.2	11.7
New Zealand	7.1	−13.0	20.1
Norway	37.1	−10.8	48.0
Switzerland	42.8	−5.3	48.1
Turkey	38.8	−11.5	50.3
United States	24.3	0.0	24.3
OECD[d]	15.0	−4.6	19.6

[a]Border price at farm gate, i.e. price net of marketing margins between border and farm gate
[b]An average of percent changes in Border Prices for individual commodities in national currencies, weighted by the shares of individual commodity MPS in total MPS in the previous year
[c]EU25 for 2006 and EU27 for 2007
[d]An average of percent changes in Border Prices for individual countries, weighted by the value of countries' MPS in OECD total MPS in the previous year
Source: OECD, PSE/CSE database 2008

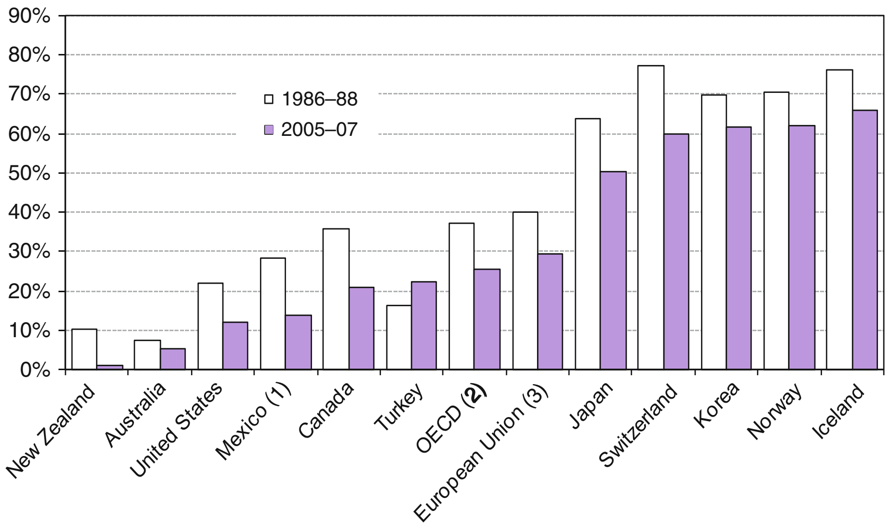

Fig. 2.2 Producer support estimate by country in percent of value of farm gross receipts

the payment. Furthermore, support may be implemented with no link to commodity production, but on the basis of certain non-commodity criteria. These different ways to implement policy transfers are represented by the PSE categories (various types of payments as shown in Table 2.1 and Annex 1). These distinctions are important because different ways to implement policy transfers have different consequences for farmers' production decisions and hence for the impact on production, trade, income and the environment. Support which is more decoupled from production means reduced interference with agricultural markets and trade and is also shown to be more efficient in rising producer incomes.

2.6 Most Distorting Support Is Being Reduced, But Is Still Important

The composition of support as shown by the shares of the different policy categories mentioned above in the PSE is described in Fig. 2.3. There has been a gradual movement in the OECD towards support that is more decoupled from production. One principal dimension of this movement is the declining share of support directly

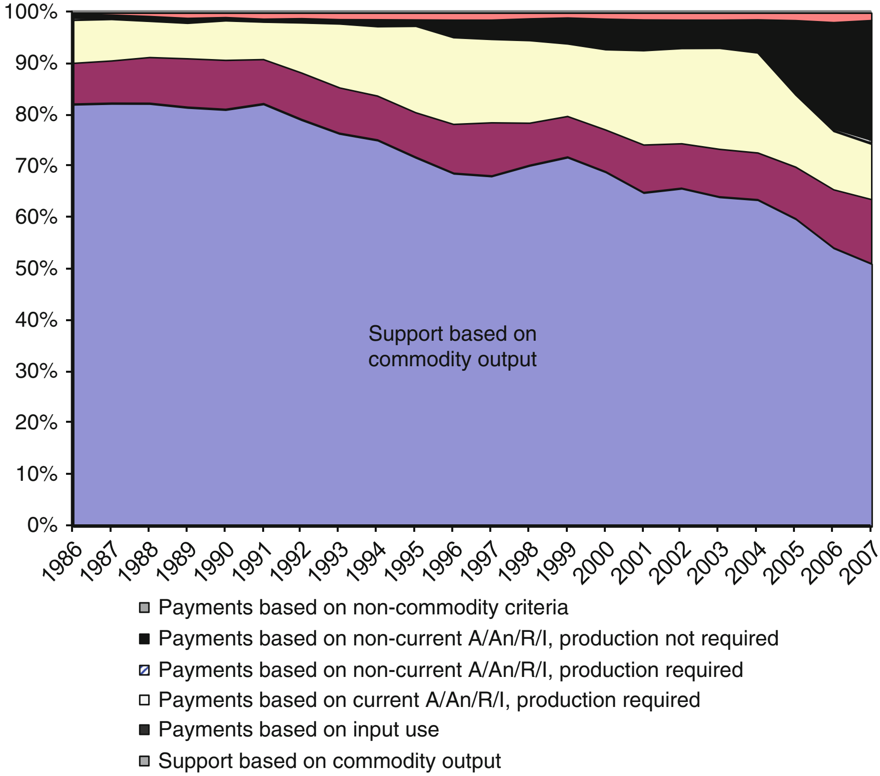

Fig. 2.3 OECD: composition of producer support estimate 1986–2007. *Source*: OECD, PSE/CSE database 2008a

linked to commodity output, such as payments based on output. The share of this category of support in the OECD total PSE fell from 82% in 1986–1988 to 55% in 2005–2007.

Output-based support is gradually giving way to more decoupled payments. The aggregate share of payments based on area, animal numbers, receipts or income in the OECD total PSE rose from 9% in 1986–1988 to 32% in 2005–2007. There has also been a notable re-distribution within this broad group – from payments based on current parameters (current area, animal numbers, receipts or income) to payments based on non-current parameters (area, and animal numbers corresponding to some base period). Furthermore, among the latter payments those which also do not impose a requirement to produce now predominate, accounting for nearly two-thirds of all payments based on area, animals, receipts or income in the OECD area (2005–2007 average).

A significant development in the composition of support is the growing share of payments provided conditionally. Various constraints on use of inputs, specific production practices or various environmental or societal criteria (e.g., related to animal welfare) are required. Thus, over one quarter of total PSE transfers in the OECD were provided with some kind of constraints in 2005–2007, whereas in 1986–1988 this share was only 5%. Provision of support is also to a growing degree associated with production quotas or incorporates limits on the amount of payment – transfers with these characteristics accounted for 40% of the OECD PSE in 2005–2007, compared to 28% in 1986–1988. Another marked feature is the increased provision of support with no requirement for farmers to produce. Examples are the single payment schemes applied in the European Union or the counter-cyclical payments in the United States. These payments accounted for only 1% of total PSE transfers in 1986–1988; by 2005–2007, their share had reached 21%.

Although reform has led to the provision of more decoupled support in all its various dimensions, and the process has advanced, particularly in the current decade, through reform efforts in many countries, a large part of support in OECD continues to be provided in the most production- and trade-distorting ways. The aggregate share of support based on output and variable inputs with no constraints attached to their use still accounted for slightly less than 60% in 2005–2007.

2.7 Progress in Re-instrumentation of Support is Uneven Across Countries

The changes in support composition for the OECD as a whole hide significant differences across countries. The *European Union, Mexico, Norway, and Switzerland* have seen the most important reductions in output and variable input–based support (without constraints), although this result also reflects the current reduction in price support due to strong world prices. These countries, as well as *Australia*, *Canada* and the *United States* which initiated re-instrumentation reforms earlier, provided almost 50% or more of total policy transfers to producers on a basis other than output and non-constrained use of variable inputs (in 2005–2007). In contrast, *Japan* and *Korea* are at the very beginning of reform, with only 7 and 9% of payments provided with no link to output or variable inputs used and where the bulk of support is in the form of price support (mainly in rice markets).

While more decoupled payments, based on parameters such as area, animal numbers, receipts or income, have gained in importance throughout the OECD area, the degree to which implementation of these payments is decoupled from production varies across countries. In *Australia*, *Mexico*, *Turkey, the European Union* and the *United States,* all or the overwhelming majority of such payments are provided on the basis of past (non-current) parameters with no requirement for the farmer to produce in order to be eligible for support (Fig. 2.4). In *Norway* and *Iceland,* all such payments require production, and some are provided on the basis of current

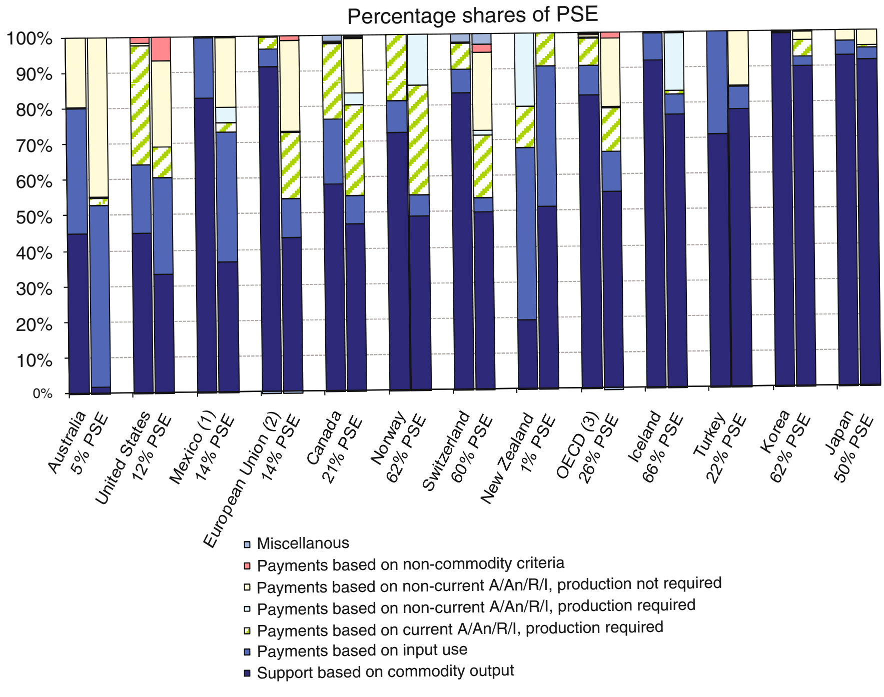

Fig. 2.4 Composition of producer support estimate by country, 1986–1988 and 2005–2007. *Source*: OECD, PSE/CSE database 2008a

Countries are ranked according to 2005–2007 shares of market price support and payments based on output in the PSE

1. For Mexico, 1986–1988 is replaced by 1991–1993
2. EU12 for 1986–1994 including ex-GDR from 1990; EU15 for 1995–2003; EU25 for 2004–2006 and EU-27 from 2007
3. Austria, Finland and Sweden are included in the OECD total for all years and in the European Union from 1995. The Czech Republic, Hungary, Poland and the Slovak Republic are included in the OECD total for all years and in the European Union from 2004. The OECD total does not include the non-OECD EU member states

area, animal, receipts or income. *Canada,* and *Switzerland* apply various mixes of implementation criteria – production required versus not required and current versus non-current parameters.

To illustrate one important aspect of recent policy developments on which the new classification is able to throw some light, Fig. 2.5 compares the importance of support not requiring production in different OECD countries. This support combines payments based on non-current area, animal numbers, receipts or income that are provided with no obligation to produce together with payments based on non-commodity criteria. A considerable re-orientation towards support that does not require production happened in the *United States* and the *European Union*, where payments not requiring production make up around 30% of the PSE (2005–2007).

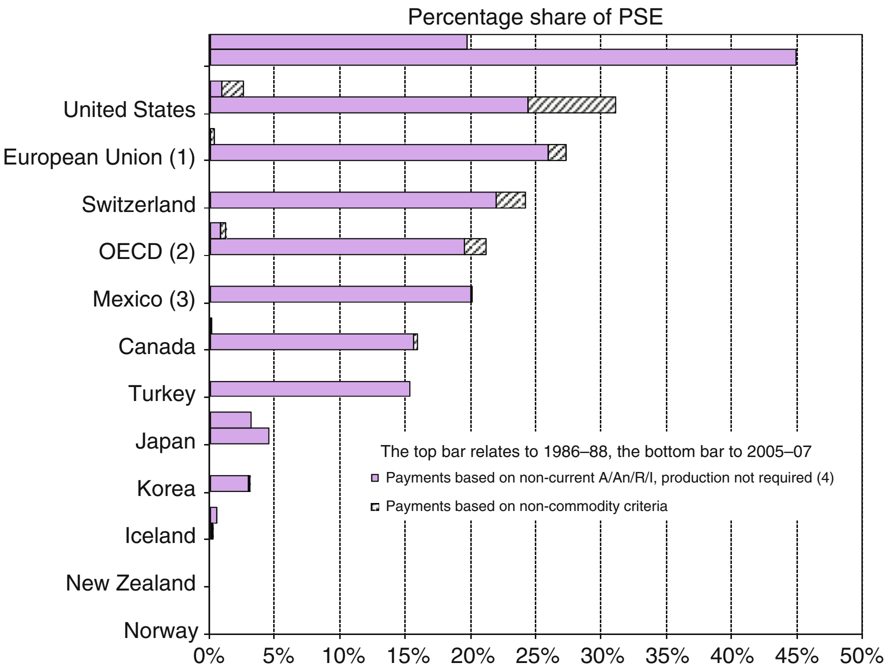

Fig. 2.5 Use of payments not requiring production, by country. *Source*: OECD, PSE/CSE database 2008a

Countries are ranked according to 2005–2007 levels

1. EU12 for 1986–1994 including ex-GDR from 1990; EU15 for 1995–2003; EU25 for 2004–2006 and EU-27 from 2007
2. For Mexico, 1986–1988 is replaced by 1991–1993
3. Austria, Finland and Sweden are included in the OECD total for all years and in the EU from 1995. The Czech Republic, Hungary, Poland and the Slovak Republic are included in the OECD total for all years and in the EU from 2004. The OECD total does not include the non-OECD EU member states
4. *A* area planted, *An* animal numbers, *R* receipts, or *I* income

Support not requiring production is also now important in *Switzerland*, *Mexico*, *Canada* and *Turkey*, having been virtually non-existent in the mid-1980s.

2.8 From Measures of Transfers to Estimates of Impacts – the PEM (Policy Evaluation Model)

It has been stressed that the PSE (and related and derived indicators) are transfer indicators that do not themselves measure impacts. The final impacts of policies depend on a whole range of factors of which the level of transfers is only one. Net results depend on how markets react to those transfers, up and down the supply chain from inputs to consumer, as well as across commodities. The OECD policy evaluation model was developed as a counterpart of the PSE database in order to estimate the impacts of policy transfers on production and trade, and their performance in terms of income transfer efficiency, welfare or degree of decoupling. The PEM model is directly and explicitly linked to the classification of measures within the PSE.

PEM contains a partial-equilibrium representation of the agricultural sectors in eight OECD countries/regions (including 25 EU countries represented as two regions), representing in an aggregate manner the production of wheat, coarse grains, oilseeds, rice, beef and milk. The model has its conceptual basis as an "equilibrium displacement model" in Gardner (1987) and in application is most similar to Gunter et al. (1996) and Hertel (1989). The model is calibrated to match observed production and trade in a specific base period (which may be any year included in the PSE database – 1986–2007) and makes use of estimates of supply and demand responsiveness in each market (elasticities of demand and supply), information on the production technology (elasticity of substitution of factors of production) and information on relative factor intensity. For more information on this model please see Market Effects of Crop Support Measures (OECD, 2001).

The earliest application of the PEM was to investigate the relative impacts of different PSE policy categories in terms of their effects on production and trade, and their effectiveness in increasing the income of recipients of transfers. A robust hierarchy of policy measures was established from the most production distorting (variable input subsidies) to the least (area payments based on historical entitlements) (OECD, 2001). The importance of the distribution of payments in determining their production-distorting effect was also demonstrated, indicating that support distributed more evenly across commodities tended to have a lower net impact than the same amount of support focussed on a single commodity. This report also demonstrated that transfer efficiency, the proportion of a policy transfer that becomes higher income for the recipient, is strongly related to the degree of decoupling of the policy. It was also observed that the marginal impact of a policy transfer declines as the level of the transfer increases.

Subsequent applications of the PEM investigated the impacts of dairy reform, the 2002 Farm Bill in the United States and the 2003 EU CAP reform. More recent studies have assessed the impact of reform in Mexico, Korea and Japan (underway currently). In addition to these country-specific investigations, the model has been used to look at more general problems, such as the design of compensation policy and how policy reforms can affect land prices and how policy transfers are shared between landowners and farmers. Some of these applications are presented in the following sections in order to illustrate the scope and relevance of the analysis that can be undertaken using the integrated PSE/PEM analytical framework.

2.9 An Application Investigating the Effect of Policy Changes on Land Prices and Rental Rates

In this application, carried out for all the countries represented in the model, the PEM is used to illustrate the relationship between the design of agricultural policies and their impact on the rental rate of land. The analytical strength of PEM for this purpose is its relatively detailed representation of the different types of land used in agricultural production.[1] These results were initially presented in *Agricultural Support, Farm Land Values and Sectoral Adjustment* (OECD, 2008a).

Land in the model is seen as a resource that is heterogeneous in nature; while a particular plot of land may be best suited in use for wheat production because of soil type and the combination of other physical characteristics such as location and length of growing season, for example, it could also be used to produce other commodities, if somewhat less efficiently. This heterogeneity is represented in practice through a series of cross-price elasticities for land that indicate how land will shift between alternative uses as the rental rate of land in those uses change. This assumption of heterogeneity implies that different land uses have different rental rates. This broadly reflects the observed fact, but whether the origin of the heterogeneity is physical or policy based is not specified. Land heterogeneity is an important determinant of land supply elasticity, and cross-effects in the land market often shape model results.

Supply elasticity is a reflection of the available alternatives. How a farmer responds to a higher rental rate for land used to produce wheat depends on the rent for other uses of the land, and a policy may affect several of these rental rates simultaneously depending on the breadth of the policy's application. The relative changes in these rental rates determine the optimal response. The results of the analysis depend on two axes of effect: how the policy affects the relative rental rates of land, and thereby the supply of land for any particular use, and how the policy affects the relative costs of using different factors of production, in particular the relative cost of land versus other factors. Most agricultural policies may be expected to have some impact on the use and price of land, not only those explicitly directed at land – regardless of the initial incidence of a policy, interrelationships between markets imply effects are felt through the entire value chain. In fact, the value of policy transfers is often captured to a significant degree in the price of land.

This "capitalisation" of policy transfers occurs by virtue of the fact that land is the most-fixed factor of production.

In the following scenario, the level of support in each selected PSE category is reduced by 1% of the value of production in the year 2004 in six countries – Canada, the EU-15, Japan, Mexico, Switzerland and the United States. The purpose of this experiment is to estimate the relative impacts on the land market of an equal change in support provided through four different PSE categories: market price support for crops, input payments (without restrictions), area payments for crops (production required) and payments based on non-current parameters (production not required).

An important consideration in designing experiments of this type is deciding how the policy is changed with respect to each commodity affected. Few modern agricultural policies are applied to a single commodity, especially in the case of the crops policies which are under investigation here, and so single-commodity-only results can be misleading. For example, reducing area payments for all crops compared to reducing area payments for wheat only yields substantially different results. A complete policy simulation experiment is defined by the amount of change in support, and the distribution of that change across commodities.

Policy experiments are designed to be as neutral as possible between commodities. For MPS and area payments, where support rates may vary by commodity, the subsidy *rates* as applied to each commodity are reduced by the same proportion, preserving relative rates of support and so representing a uniform reduction of the policy. Support is reduced for crops, but not for beef or milk. Therefore, because of the change in relative returns, this leads to a shift in land use from crops to pasture.

Payments based on non-current production are assumed to have no impact on the relative *rental rates* of land for different land uses in agriculture. This ensures that such payments do not directly influence commodity choice among crops covered by the policy. This assumption determines the distribution of the payments. For payments based on input use, the assumption that these generically apply to most purchased inputs with a single rate of support determines their distribution. These inputs have a common supply that is not differentiated by the commodity in whose production they are used.

Area payments and payments based on non-current production have their first incidence in the land market (the latter because of capitalisation). Market price support has its first incidence in the market for the commodity output, and payments based on input use on the market for purchased inputs. As expected, the policies where the first incidence of payment is in the land market have a greater impact on the rental rate of land (Table 2.5). These policies change the rental rate directly and all other adjustments in the model are secondary to that initial shock. However, this does not imply that these forms of support have the greatest impact on land allocation (Table 2.6).

The uniform proportional decrease in land rental rates brought about by reducing payments based on non-current production provides no incentive to re-allocate land across uses. Along the axis of relative rental rates for land, nothing has changed and

Table 2.5 Estimated impact of a reduction in support on land rental rates

Change, percent

	Market price support		Input support		Area payments		Historical entitlements	
	Cropland	Pasture	Cropland	Pasture	Cropland	Pasture	Cropland	Pasture
Canada	−3.10	0.04	−1.48	−1.24	−6.96	−1.00	−3.46	−3.46
EU15	−1.16	−0.32	−0.43	−0.71	−4.04	−0.74	−3.36	−3.35
Japan	−2.14	−0.11	−2.01	−0.93	−8.04	−0.81	−4.72	−4.69
Mexico	−3.55	−0.02	−2.20	−0.54	−6.15	−0.24	−1.82	−1.82
Switzerland	−3.29	−0.40	−0.90	−0.21	−14.70	−0.79	−3.70	−3.68
United States	−1.75	−0.10	−0.76	−1.40	−5.17	−0.86	−2.59	−2.59

Source: OECD PEM

Table 2.6 Estimated impact of a reduction in support on land use

Change, percent

	Market price support		Input support		Area payments		Historical entitlements	
	Cropland	Pasture	Cropland	Pasture	Cropland	Pasture	Cropland	Pasture
Canada	−0.30	0.28	−0.10	−0.05	−0.65	0.49	0.00	0.00
EU15	−0.17	0.07	0.06	−0.02	−0.60	0.34	−0.02	−0.02
Japan	−0.10	0.08	−0.08	0.00	−0.32	0.33	−0.04	−0.04
Mexico	−0.35	0.13	−0.19	0.03	−0.61	0.22	−0.01	−0.01
Switzerland	−0.27	0.09	−0.07	0.02	−1.36	0.47	−0.01	−0.01
United States	−0.16	0.16	−0.01	−0.47	−0.47	0.41	−0.01	−0.01

Source: OECD PEM

so no adjustment occurs. Along the axis of relative costs of land versus other factors of production, land has become more expensive as the demand price, defined as the rental rate plus subsidy, has increased. The incentive would be for producers to substitute other factors of production for land, but there is no additional land available; total agricultural land area is fixed in the model. Moreover, all commodities face the same incentive, which minimizes land movement between commodities as relative factor prices change.

In the case of area payments, reducing these payments moves land out of the commodities that currently receive these payments (major crops) into those that do not (pasture). This reflects the change in relative prices between land uses that result from the policy change. Reducing MPS reduces the rental rate of land because, like all factors of production, the demand for its use is derived from the value of production in the commodity market. Reducing the price of a commodity reduces the implied value of the factors that are used to produce it. Reducing input support makes land relatively more attractive as purchased factors become more expensive, but rental rates are still reduced as the implied reduction in production more than compensates for this relative price effect.

The results above consistently suggest a hierarchical ranking for the impact of the support categories on land rents. Payments based on non-current production have the highest impact on land rents. Recall that in terms of production distortion, these payments have by design no direct influence on production allocation decisions. At the other extreme, market price support has the lowest impact on land rents, yet is one of the most production-distorting types of support (Fig. 2.6).[2]

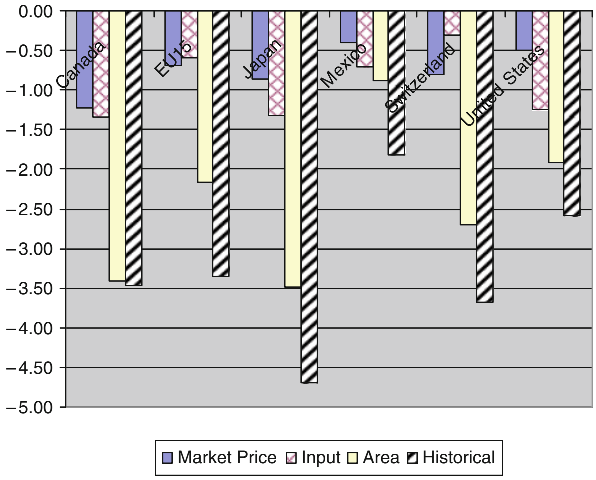

Fig. 2.6 Estimated impact of a reduction in support on land rents

2.10 An Application to Income Transfer Efficiency in Mexico

A key benchmark of the effectiveness and efficiency of agricultural policy is its transfer efficiency. The ratio of the change in producer welfare to the change in policy expenditure measures the proportion of agricultural policy transfers that actually accrues to agricultural producers. Transfer efficiency is always less than perfect (value of one) because the suppliers of purchased inputs are able to capture some proportion of the benefit of any policy.[3] Consumers and taxpayers also gain or lose from policy changes. Deadweight losses also reduce the potential benefit to producers. These losses are a result of allocative inefficiency – the reduction in consumer and producer surplus resulting from policies that distort output away from its efficient level. To the extent that raising farm income is an objective of agricultural policies, higher transfer efficiency is critical to achieve that end with least costs and fewest unintended consequences.

The PSE indicates that there has been quite significant change in the way in which support is delivered to farmers in Mexico and in the level of that support during the past 15 years. Most significant has been the virtual dismantling of border protection, domestic deregulation and the introduction of a large direct payment programme in the form of PROCAMPO. In order to evaluate the impact of these changes in Mexican agricultural policy on farm welfare, PEM was used to estimate the total transfer efficiency of the mix of agricultural policies in place in each year between 1990 and 2004 (OECD, 2006). To generate welfare estimates, it is assumed that producers earn the producer surplus from the factors of production that they own – their land, their own labour and their livestock. This means that changes in producer welfare are driven by changes in the rental rate of land, the (implicit) wage rate of the farmer's labour, the value of the livestock herd and the changes in the respective quantities used of each of these factors. The changes in welfare of other agents, namely the suppliers of purchased inputs, consumers and taxpayers, are calculated in a similar manner. Simulation results from models such as that used here represent just one of many possible outcomes, and are intended to illustrate the implications of the economic assumptions and reasoning that they contain.

Simulation results show that the estimated transfer efficiency of Mexican agricultural policy improved steadily, from an initial level of around 30% in 1990 to an excess of 70% in 2004 (Fig. 2.7).[4] That is to say, an additional MXN 100 transferred through the array of agricultural support existing in 1990 would raise farm income by only MXN 30, whereas MXN 70 of an additional MXN 100 spent on the policies existing in 2004 would find its way to farmers. Thus, the effectiveness of Mexican agricultural policy at transferring income to farmers has more than doubled over the study period, from an initial condition where less than one peso in three was actually captured by producers in the form of a net income increase. This reflects mainly the reduced importance of MPS in the total PSE – and the increasingly narrow base of MPS which mostly relates to milk in recent years – and the increasing importance of the PROCAMPO program.

Within the same framework, it is possible to track the incidence of overall costs and benefits resulting from the policy changes in Mexico in the period under

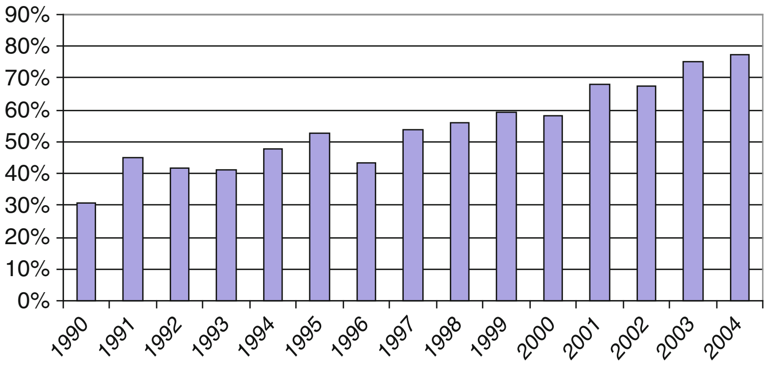

Fig. 2.7 Estimated transfer efficiency of Mexican agricultural policy 1990–2004, percent. *Source*: OECD PEM model

review. In addition to producers, consumers, taxpayers and input suppliers may be affected by the policy changes. With respect to Mexico, the main beneficiaries of the increase in transfer efficiency since 1994 (and the reduction in deadweight loss – not presented here) are consumers and taxpayers. While the benefits to producers in real (2004) terms have been relatively flat over the period, ranging from MXN 27 billion in 1990 to MXN 21 billion in 2004, with a high of 40 billion in 1994, costs to consumers have fallen from an average of almost MXN 50 billion in the early 1990s to 12 billion in 2004. Tax expenditures too have fallen by nearly half from MXN 50 billion in 1990 to MXN 24 billion in 2004, following the elimination of the substantial consumer subsidies associated with the MPS in the early to mid-1990s (but ignoring the introduction of PROGRESA/Oportunidades).[5] Benefits to input suppliers fell from an average of around MXN 10 billion in the early 1990s to around MXN 4 billion in the last part of the study period (Fig. 2.8).

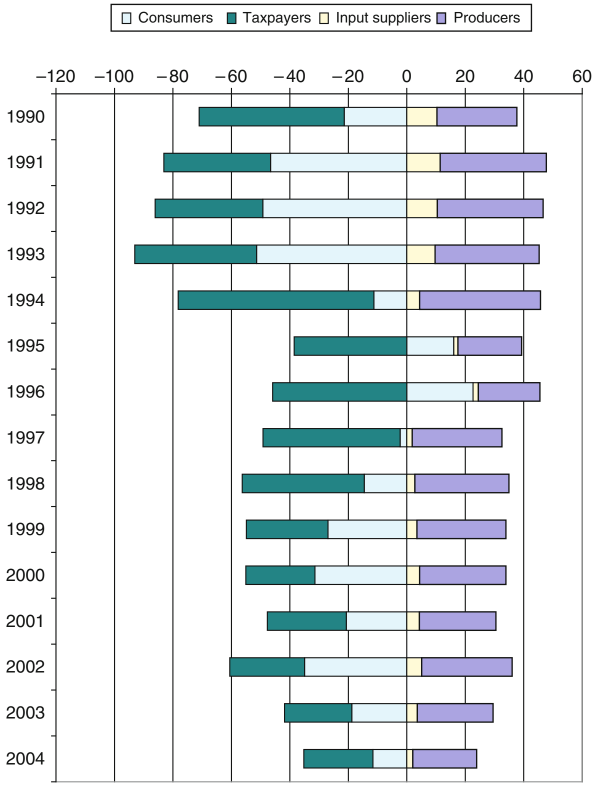

Fig. 2.8 Estimated distribution of benefits and cost of support, real MXN billion, base 2004. Calculated as the negative of the welfare changes from removal of support. Figures for 1995 and 1996 are exceptional due to negative MPS. *Source*: OECD PEM

2.11 An Application to Policy Reform in Korea

The PEM model was used to study the impact of changes in the policy mix in a recent report reviewing developments in the last decade in Korea (OECD, 2008b). An historical perspective on Korean agricultural policy is taken, inquiring as to the effects of the full set of agricultural policies represented in the PSE database on the welfare of different participants in the agro-economy. Other scenarios not reported here take a forward-looking approach to the situation facing the rice market after 2014 according to certain assumptions, a counterfactual look at rice policies, investigating three alternatives that adjust the amount of transfers arising from the different policies currently in use and policy alternatives in the milk market.

As in the Mexican example we are interested not only in the ways in which changes in agricultural policies have affected the income transfer efficiency of the policies with respect to farm household income, but also how they have affected the incomes of consumers and taxpayers and the ability of suppliers of purchased inputs to capture some of the rents from agricultural programs through higher prices for their products. In this scenario, the impacts of the policy set for commodities included in the PEM (e.g., grains and oilseeds, rice, milk, and beef) on the welfare of producers, consumers, taxpayers and input suppliers is considered for the years 1986–2006. This includes most of the policies reported in the PSE for these commodities: MPS, fixed and variable payments to paddy rice, the subsidy to milk used for manufacturing and payments affecting farm income or revenue (e.g., disaster payments and social programmes).

The effects of the policy set can be assessed by conducting a thought experiment: "What if these policies did not exist?" The welfare impact of the policies is assessed by investigating the impact of their elimination. The model results indicate that consumers are the most impacted by agricultural policies paying between KRW 12,087 billion (USD 8,640 million in 1998) and KRW 19,409 billion (USD 17,331 million in 2000) in higher prices for agricultural products. (Results are converted to real 2000 KRW using a GDP deflator) (Fig. 2.9).[6] Farmers gain on average KRW 5,998 billion (USD 6,675 million) through higher prices and budgetary transfers, suppliers of purchased inputs gain on average KRW 1,399 billion (USD 1,568 million) through increased demand for farm inputs while taxpayers receive KRW 2,364 billion (USD 2,475 million) on average from import tariff receipts. Overall, the costs to consumers outweigh the benefits to other economic agents, and the result is a net welfare cost ranging between KRW 3,713 billion (USD 2,654 million) in 1998 and KRW 8,572 billion (USD 11,117 million) in 1995 – the result of deadweight losses due to resource misallocation. The results indicate a stable policy environment in real terms, with no major trends in the level of policy transfers over the period. Exchange rate movements have a strong influence on the results, in particular for consumers, as does the somewhat greater variability of MPS for beef compared with other policies in place over the study period. The period between 1996 and 2000 is noteworthy because of the substantial exchange rate movements that took place at that time. In particular, this short period contains both the highest and lowest consumer welfare numbers.

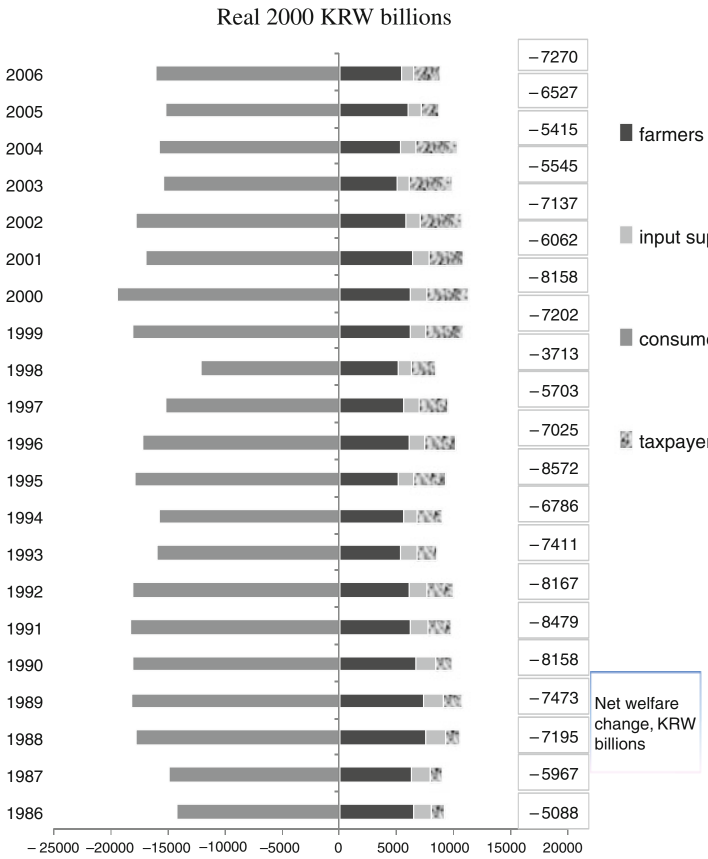

Fig. 2.9 Welfare impacts of Korean agricultural policy, 1986–2006. *Source*: OECD PEM

The high cost to consumers of agricultural policies relative to the benefits gained by producers indicates a level of transfer efficiency of approximately 50%. In fact, the degree of transfer efficiency of agricultural policy has been fairly constant over the study period (Fig. 2.10). The variation in the measured transfer efficiency is driven by changes in the level of MPS for beef, which has been the most volatile element of the policy mix in the PSE. Recent improvements in transfer efficiency resulting from the introduction of the fixed payment for paddy land in 2005 and 2006 have been counterbalanced by higher MPS levels for beef in the same period.[7] The degree of measured transfer efficiency is in line with that for other countries represented in PEM. The dominance of MPS in the Korean PSE would normally indicate lower transfer efficiency, but this is mitigated by the assumption maintained here that agricultural land is exclusively owned by farmers as a matter of law. The absence of non-farming landowners improves the measured transfer efficiency markedly.[8]

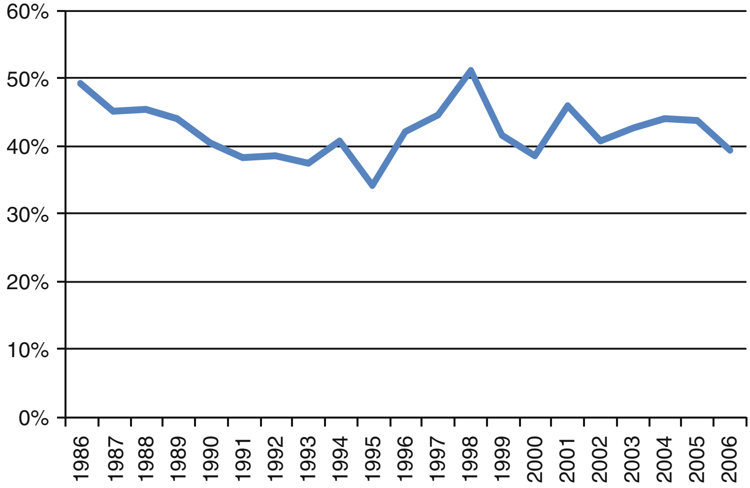

Fig. 2.10 Transfer efficiency of agricultural policies, 1986–2006. *Source*: OECD PEM

In the absence of non-farming landowners, the level of transfer efficiency is determined by the scale of deadweight losses and the gains to input suppliers from higher input prices. Deadweight losses from economic inefficiencies arising from market distortions appear to be the dominant factor, accounting for almost 80% of the difference between PSE transfers and increased farm welfare (Fig. 2.11). This is explained by the dominance of MPS in the policy mix; this form of support tends to introduce significant market distortions.

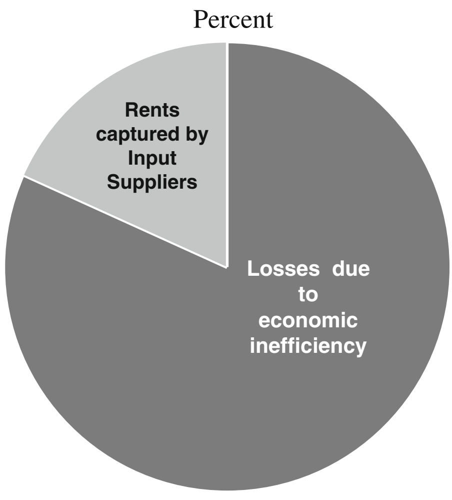

Fig. 2.11 Sources of inefficiency in transfers from consumers and taxpayers to producers. *Source*: OECD PEM

2.12 Conclusions

This chapter provides an overview of work carried out on a regular basis at OECD to estimate the level of public support to agriculture and the impacts of that support. Recent changes to the methodology and approaches used are described and results covering the period up to and including 2007 are presented. The policy evaluation model (PEM), a simulation model designed specifically as the counterpart of the PSE/CSE measurement exercise, is also presented along with some selected applications from recent OECD work. These relate mainly to the assessment of the welfare effects and the income transfer efficiency of the changing policy mix in Korea and Mexico. A more generic application relates to the effect of policy change on land rental values in the countries or regions represented in the model. This application exploits the rather detailed representation of land markets and interactions within them, which is a particular feature of the PEM model. The PSE (and related indicators) database is the most comprehensive source of information on the level of public support to agriculture in OECD countries (and for a significant group of other countries also), available annually and in a timely fashion, following a process of scrutiny and approval by the countries covered. In itself, it is a valuable source of comparable information. Combined with the PEM model, it is a unique resource of information and analysis of the level of policy effort made by governments in respect of agriculture and of some key impacts in terms of effects on production or trade. It can also provide valuable insights into aspects of policy performance such as welfare, degree of decoupling and income transfer efficiency.

Notes

1. PEM is a partial equilibrium model, and therefore does not capture effects on land that come from outside the agricultural sector. Total land in agriculture is assumed to be fixed.
2. The results for crop and pasture land have been combined using their respective initial areas as weights.
3. The model holds as a basic tenant that there are no, or only minimal, imperfections in the market, but some researchers posit that there is evidence of incomplete markets for rural finance to small-scale producers.
4. These results, as with those for all simulation models, hinge on the assumptions that underlie its workings. In particular, the OECD policy evaluation model used here assumes that prices operate to clear well-operating markets, both for commodities and factors of production. Some modifications of the model have been made to accommodate, for example, non-commercial producers. However, the complexities of the land tenure system, such as the system of *eijidos*, are such that the results should be interpreted with due care.
5. PROGRESA/*Oportunidades* are not components of agricultural policy, so expenditures under these programs are not included in PSE data and the effects are not estimated in the analysis of this chapter.
6. US dollar equivalents are calculated using the same GDP deflator and the exchange rate for the year in question.
7. In fact, excluding beef MPS from the simulation results in an improvement of transfer efficiency of 9% (from 46 to 54%) between 2004 and 2005, the year the fixed payment to paddy

rice was introduced. MPS for beef increased from KRW 1,004 billion to KRW 1,784 billion in 2005, while the payments to paddy fields introduced in 2005 amounted to KRW 1,514 billion.

8. The standard approach used in PEM to allocate welfare between farmers and non-farming landowners is to allocate the welfare gains derived from changes in producer surplus to land ownership according to the percentage of land that is rented. Thus, if half of the land in a particular country was rented, then 50% of the welfare change accruing from changes in the land market would be considered to be "leaving" the agricultural sector, thereby reducing measured transfer efficiency.

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Chapter 3
US and EU Agricultural Policy: Divergence or Convergence?

Andrew Schmitz and Troy G. Schmitz

Abstract The 2008 US Farm Bill has many similar features to the 2002 US Farm Bill where key provisions such as the target price and loan rate remain. On the other hand, the European Union is following a path of more decoupled payments, especially given the reforms in 2003 and afterward. However, many of the elements of either farm program may no longer be of significance if high commodity prices remain, many of which are above US target prices. High prices have caused many countries to lower tariff and nontariff barriers. In the context of high prices, the welfare costs of both the US and EU policies have been greatly reduced. However, especially for the European Union, there remains a large income transfer from the treasury to farmers since, under decoupling, farmers are given annual payments at least through 2013. Given the single farm payment scheme of the European Union, farmers are allowed to respond to high prices and, in addition, collect a subsidy from the treasury under the rubric of decoupling. Producers have collected double rents: from the market and the government.

3.1 Introduction

In 2008, after months of debate, the United States passed a new farm bill. It contains many of the key features present in the 2002 US Farm Bill, with little progress toward decoupling production from income support. On the other hand, the European Union's Common Agricultural Policy (CAP) is moving toward a more decoupled outcome. Historically, it is generally thought that CAP provides greater farm income support than does the US farm program. The aggregate percentage of producer subsidy equivalent (PSE) for Europe reached a low of 30.9 in 1989 and a high of 41.7 in 1986 for the period 1986 through 2003. For the United States, the

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aggregate PSE fell to a low of 11.3% in 1995 and reached a peak of 29.4% in 1986 for the same period (OECD Database 1986–2003). The average for Europe was 36.9%, while the average for the United States was 19.7%. In assessing the impacts of the two quite different farm programs, future commodity prices play an important role. At the high prices in 2007 and 2008, the payouts from US policy were greatly reduced. However, under CAP, farmers can take advantage of high prices and collect market rents while, at the same time, collecting annual compensatory payments from the EU Treasury extending beyond 2013.

3.2 US Farm Policy

> If money could have solved the farm problem, we would have solved it a long time ago (Ronald Regan).

> In the 1980s, the United States had a large dairy surplus "We have enough surplus to fill an average-size train stretching from Washington, D.C. to New York City .... This is embarrassing ... it's unacceptable..., it's intolerable! It cannot continue!" (John Block, former U.S. Secretary of Agriculture).

Agricultural commodity and conservation legislation in the United States has roots in the Agricultural Adjustment Act of 1933. Between 1929 and 1932, net cash farm income fell from US$5.2 billion to US$1.4 billion. With the introduction of new stabilization policies, the magnitude of government transfers to US agricultural producers increased from zero in 1933 to US$28 billion in 2000. Correspondingly, US farm income increased from approximately US$1.4 billion in 1932 to approximately US$56 billion in 2000.

The first US Farm Bill was passed by Congress in 1933. Until 1970, US Farm Bills dealt mainly with issues such as rural poverty, soil conservation, crop insurance, and farm credit. The 1970 US Farm Bill introduced direct commodity price supports for the first time. Farm bills from 1970 to 1996 introduced a number of measures to reduce agricultural production, such as the Conservation Reserve Program (CRP), payment in kind (PIK), and the Export Enhancement Program (EEP). The Reform Act of 1996 introduced dramatic changes such as removing restrictions on acreage set-asides, and the target price and deficiency mechanisms were replaced with seven annual market transition payments (details are furnished in Schmitz et al., 2002). The 2002 US Farm Bill reintroduced target prices in view of the sharp drop in commodity prices in the late 1990s. Its key provisions included the following:

- Income support for wheat, feed grains, upland cotton, rice, and oilseeds provided through direct payments, countercyclical payments, and marketing loans with loan deficiency payments (LDP).
- Target prices were reinstated along with associated countercyclical payments (a major change from the 1996 US Farm Bill).

- Support for peanuts was changed from a price-support program with marketing quotas to marketing loans, countercyclical payments, direct payments, and quota buyouts.
- Sugar was to operate as a no-net program. The nonrecourse loan program was reauthorized at 18 cents per pound for raw cane sugar and 22.9 cents per pound for refined beet sugar.
- Federal milk marketing orders.
- The minimum support for milk was fixed at US$9.90 per hundredweight (cwt) for milk containing 3.6% butterfat. In addition, a national Dairy Market Loss Payment (DMLP) program was established.
- The Dairy Export Incentive Program (DEIP) was extended to 2007.
- No changes were made in the basic crop insurance program.
- The Agricultural Risk Protection Act (ARPA) of 2000 provided an additional US$8.2 billion for insurance premium subsidies for fiscal years 2001 through 2005.
- Country-of-origin labeling (COOL) requirements were introduced.
- Funding for the Environmental Quality Incentives Program (EQIP) was increased. A conservation security program was introduced. Land-retirement programs were expanded, particularly for wetlands. Funding was expanded for farmland protection. A new grassland reserve was created.
- The maximum acreage enrolled in the Conservation Reserve Program (CRP) was increased from 36.4 million acres to 39.2 million acres.
- Under the Wetlands Reserve Program (WRP), the maximum acreage was increased from 1.08 million acres to 2.8 million acres.

The 2008 US Farm Bill was enacted into law in May 2008. Many of its provisions are similar to those contained in the 2002 US Farm Bill. However, there are some major additions, especially in the area of specialty crops. It provided for US$2.5 billion for specialty crop research and promotion and school nutrition programs. This legislation came after more than 100 grower groups formed an alliance and poured millions of dollars into lobbying Congress. While fruit and vegetable growers will not receive direct subsidies under the new legislation, they will be eligible for grants administrated by federal and state agriculture departments to combat pests and disease, facilitate global trade, and conserve land. Other monies will go toward bolstering school food programs with locally grown fruits and vegetables.

Key elements of the 2008 US farm program, like the 2002–03 program, are the loan rate and target price provisions for grains, upland cotton, and oilseeds. The loan rate for corn remained unchanged as did the target price. This was also true for rice. For soybeans, the loan rates remained unchanged, but the target price was increased by 20 cents per bushel. For cotton, both the loan rate and target price essentially remained unchanged. For wheat, both the loan rate and the target price were increased, with the latter increasing from US$3.92 per bushel to US$4.17 per bushel (Table 3.1). Overall, support prices in nominal terms changed very little. However, in view of the sharp rise in input cost beginning in 2006, real support prices (i.e., loan rate and target price) were significantly reduced.

Table 3.1 US loan rates and target prices, selected crops: 2002 and 2008

	2002		2008	
	Loan rate	Target price	Loan rate	Target price
Commodity	(US$)		(US$)	
Corn (US$/bushel)	1.95	2.63	1.95	2.63
Rice (US$/hundredweight)	6.50	10.50	6.50	10.50
Soybeans (US$/bushel)	5.00	5.80	5.00	6.00
Upland cotton (US$/pound)	0.52	0.72	0.52	0.71
Wheat (US$/bushel)	2.75	3.92	2.94	4.17

Source: Chad Hart, CARD

Two of the most controversial programs, those dealing with dairy and sugar, changed relatively little (for details on dairy, see Price, 2004; Schmitz et al., 2002; Sumner and Wolf, 1996). The import quota through which US producers have received sugar prices above world market levels is the mainstay of the 2002 US sugar policy (Orden, 2002). The US sugar program has been under attack for decades, yet the basic instrument remains in place. Unlike the heavily subsidized EU sugar industry, US sugar policy has not been challenged through the WTO by its trading partners. In contrast, in 2004, Brazil challenged the EU sugar subsidies through the WTO, alleging that the EU policy significantly distorts world sugar prices (Powell and Schmitz, 2005). For the US sugar program the key elements in the 2008 US Farm Bill are as follows: an inventory management approach, a new market balancing mechanism (limited sucrose–ethanol program), a minimum overall allotment quantity (OAQ), import management, and a loan rate increase (three-quarters of a cent per pound, raw value, phased in over 4 years, with no change for the 2008 crop and one-quarter of cent increase in crop years 2009 through 2011; raw cane loan rate will increase gradually from 18 cents per pound in 2008 to 18.75 cents in 2011; and a proportionate increase for the refined beet sugar loan rate).

3.3 Often-Neglected Elements

In assessing the impact of past US farm programs, key components are often overlooked: grain stocks, conservation reserve programs, and peanut and tobacco quota buyouts.

3.3.1 Wheat Stocks

Of extreme importance, especially in the context of the sharp rise of commodity prices, is the role of government storage. The US government essentially got out of the stockholding business with the passage of the 1985 US Farm Bill, where

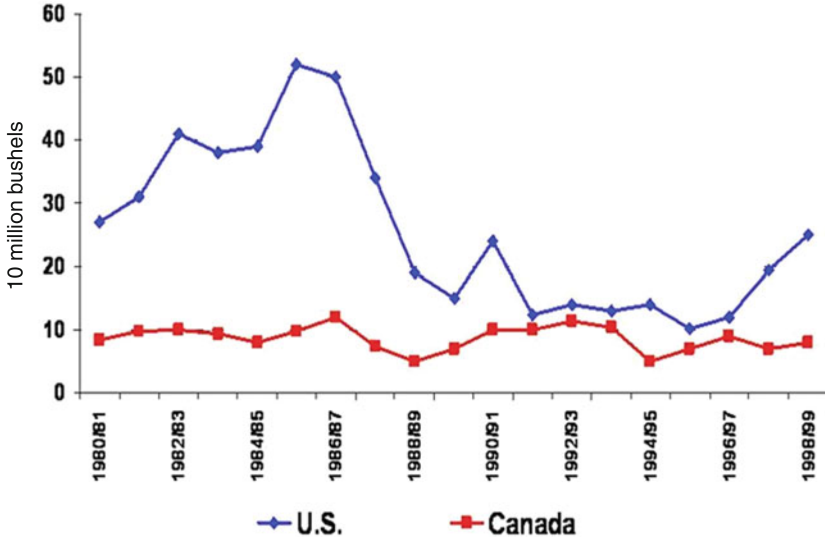


Fig. 3.1 US–Canada wheat stocks: 1980–1981 to 1998–1999. *Source*: Schmitz and Furtan (2000)

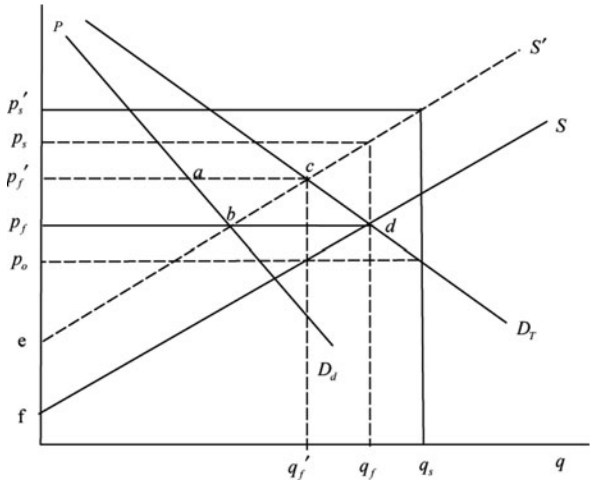
the United States was no longer obligated to buy and store commodities when prices drop below the loan rate. Between 1985 and 1995, US wheat stocks fell from roughly 500 million bushels to 100 million bushels (Fig. 3.1). The lack of government stocks added to the commodity price escalation in 2007.

3.3.2 CRP-Type Programs

Like previous farm bills, in the 2008 US Farm Bill, the United States has large acreage set-aside requirements under the CRP, and these are likely to continue. USDA (2004, p. 33) forecasts that CRP acreage for the years 2015 through 2017 will be roughly 36 million, which is approximately the same acreage as for 2006 and 2007. This program has the effect of raising cereal prices, unlike other elements of the US farm program that depress farm prices. Consider Fig. 3.2 in which supply without the CRP payment is given by S. The total demand D_T includes the domestic demand schedule D_d. The competitive price and quantity are given by p_f and q_f. The effect of the CRP payment in the absence of price supports is to shift supply to S', which raises the price to p_f' and reduces the quantity to q_f'. The loss to domestic consumers equals $p_f'abp_f$, and the loss to importers due to the CRP payment is *abdc*. The effect on producers is $\{(p_f df - p_f' ce) + (\text{CRP payments})\}$.

What happens when CRP payments are combined with price supports? If the price support is set at p_s, the free-market price p_f prevails. In this case, the importing country is unaffected by the combination of price supports and the

Fig. 3.2 The US farm program: CRP



CRP payment. However, if support is set at p_s', output q_s is greater than output under competition. The market price falls to p_o, which is below the competitive level. In this case, both domestic consumers and importers gain from the subsidies. For a price support below p_s, however, domestic consumers and importers are taxed because the world price is set above the competitive free-trade level. De Gorter and Cranfield (2005) find that the net price support payment effect may or may not be greater than the CRP payment effect. Thus, they conclude (as does Gardner, 2002) that US grain subsidies do not necessarily have a negative effect on world grain prices. Sullivan et al. (2004) argue that roughly 51% of the CRP acres (including wheat and corn) would go back into production if payments were terminated.

3.3.3 Peanuts and Tobacco

3.3.3.1 Peanuts

Historically, the US peanut policy consisted of a volume (poundage) quota system in which production was regulated for the domestic edible market. Quota peanut production exceeded domestic edible demand in the mid-1990s, about the same time that the North America Free Trade Agreement (NAFTA) and WTO agreements began to loosen the strict import restrictions that had been necessary to implement the price support (Dohlman and Livezey, 2005). To balance the market, the 1996 US Farm Bill lowered the peanut loan rate. Other changes followed with the passage of the 2002 Farm Act. For example, US peanut policy includes linking direct and countercyclical payments to historical production levels on specific "peanut base acres" (similar to those for grains and cotton), thus introducing greater flexibility and market incentives to peanut producers (Dohlman and Livezey, 2005). Initiation of a peanut-quota buyout program was another significant change, whereby US peanut farmers were compensated for the value of their peanut quota, based on the quota owner's 2001 quota. The unit value of this program is worth US$220 per short ton, offered in annual installments for 2002–2006, or as a lump-sum payment in the fiscal year of the owner's choice. According to Dohlman and Livezey (2005), compliance with international trade agreements (e.g., NAFTA and WTO) was a source of concern that influenced the demise of the peanut marketing-quota system in 2002.

3.3.3.2 Tobacco

The federal tobacco program dates back to 1938 and was designed to stabilize the US tobacco market and ensure fair prices for tobacco farmers. Marketing quotas and price supports were the two basic elements of the US tobacco program. Tobacco farmers were allocated an annual acreage-based quota, limiting the quantity of tobacco that quota owners could place on the market. Initially, tobacco quotas were allotted to each producer on the basis of historical tobacco production. Over time, most of the tobacco produced in the United States was converted from acreage-based production quotas to poundage-based marketing quotas. Annual quotas were set on the basis of a formula that included the purchase intentions of domestic tobacco manufacturers, a 3-year average of exports, and a stock adjustment giving the US Secretary of Agriculture limited flexibility for quota adjustments. Since the 1980s, the federal tobacco program has operated as a no-net-cost program. The total cost of operating the tobacco price support loan program is covered by annual assessments paid by each producer on every pound of marketed tobacco.

Increased import competition led to recent adjustments in the US tobacco program. As the quantity and quality of foreign-grown tobacco increased over time, lower-priced imported tobacco began to displace significant quantities of domestic tobacco used in manufacturing, and there was limited ability to adjust domestic prices within the constraints of the program. Other problems also emerged that put pressure on the tobacco price support program. For example, domestic tobacco manufacturers began to bypass traditional auction markets in favor of direct contracts with producers (Schmitz et al., 2006).

In response to the negative outlook for future production, tobacco producers supported a tobacco quota buyout. In October 2004, the US Congress included the Fair and Equitable Tobacco Reform Act (the tobacco buyout) as part of larger corporate tax-reform legislation (American Jobs Creation Act of 2004, PL 108–357). Beginning with the 2005 crop, the tobacco quota buyout (1) terminated the federal tobacco price support and supply-control programs; (2) made compensation payments to tobacco quota owners and to active tobacco growers for the elimination of the tobacco quota asset; and (3) provided for the orderly disposal of existing CCC tobacco pool stocks. Payments to tobacco quota owners and growers were expected to total US$9.6 billion by the end of the 2005 crop year and annual payments to be spread evenly over the next 10 years. Additional funding for handling CCC tobacco pool stocks and administration costs brings the total buyout package to US$10.14 billion, which is funded entirely by assessments on tobacco product manufacturers and tobacco product importers. Since 2005, farmers have no restrictions on the amount or location of production. Similarly, they can sell tobacco to anyone they want, at any price.

3.3.4 Ethanol and Market Distortions

One of the most controversial subjects involving US farm policy is the production of ethanol from corn. The benefits and costs of ethanol production partly depend on the extent to which ethanol production through higher corn prices reduces US farm payments (Schmitz, Moss et al., 2007). Appendix 1 provides the basis of the following discussion of the link between ethanol production and the US agricultural policy.

The findings on the impact of ethanol hinge on several key parameters, including impacts on gasoline prices and the quality of distillers grain. Schmitz, Moss et al. (2007) find that there can be net positive benefits from ethanol if there are price-dampening effects in the fuels market and if distillers grain is of high feed quality. Also, a key component is the interaction between the impact of ethanol and commodity payments. The rise in corn prices due to ethanol has wiped out the need for commodity payments. In terms of distributional impacts, corn importers lose, and therefore it is important to identify net benefits and costs from a world perspective versus a US perspective, where little weight may be given to foreign impacts. While ethanol certainly benefited corn farmers, it had a negative impact on livestock producers. On this there is general agreement. An interesting study by FarmEcon LLC for the Coalition for Balanced Food & Fuel, a group representing US livestock, poultry, milk, and egg producers and meat processors, finds that the costs for 2008–2009 for biofuel support exceeds US$1 billion for Iowa, North Carolina, and Texas (Elam, 2008). There are at least ten states with costs for each ranging between US$500 million and US$1 billion.

There is little agreement on the impact of corn prices from ethanol production. At the high end, Elam (FarmEcon LLC, 2008) estimated the price impact at roughly US$1.30/bushel. Gardner (2007) and Schmitz, Moss et al. (2007) put the price at below US$1.00/bushel. In this regard, caution should be exercised when interpreting the impact of the ethanol tax credit along with the ethanol tariff on the use of corn for ethanol. A model is badly needed that estimates the impact of these on corn demand. Given high oil prices, ethanol may well have emerged even without tax credits. Then there is the nagging issue of the impact of ethanol on food prices. Elam (FarmEcon LLC, 2008) estimates that the price impact is significant, while the Agricultural and Food Policy Center at Texas A&M University argues that ethanol has a minor effect on food costs. The Texas A&M study argues that corn and oil play a small role in higher food prices and that tight global supplies are more to blame (Anderson et al., 2008). In addition, they find that the livestock industry is struggling with passing on costs. Regardless of the goodness or badness of ethanol production, it is being fueled by many factors, including mandated ethanol blends in fuel. In a study cosponsored by the US Department of Energy and the American Coalition for Ethanol, from a fuel efficiency standpoint, the optimal blend of ethanol is greater than 10%, and that a mandate greater than this level would likely absorb an even larger share of the corn crop and increase competition for livestock producers.

3.4 Moving Forward

For years, the United States spent large sums of money on agriculture as market prices remained well below support prices. However, for most commodities, this was no longer true in 2008 (Figures 3.3–3.6). Market prices were well above the support levels set in the 2008 legislation (government payments in 2007 and 2008 were significantly lower than in previous years in view of high commodity prices). However, in the commodity set, cotton is a major crop, where market prices remain slightly below support prices (Fig. 3.7). It was this crop that triggered the controversy over the extent to which US farm programs distort world market prices. In the historic Brazilian challenge through the WTO against the US cotton policy, the WTO ruled that the US cotton policy was trade distorting (Powell and Schmitz, 2005). An analysis by Schmitz et al. and others showed that world cotton prices were depressed somewhere in the range of 10–20% for 2001–2003.

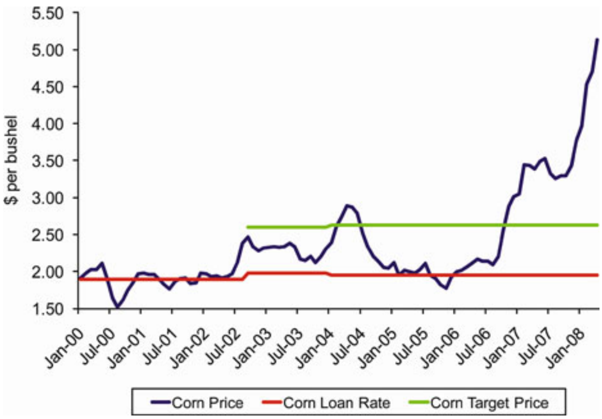


Fig. 3.3 Corn: loan rate and target prices

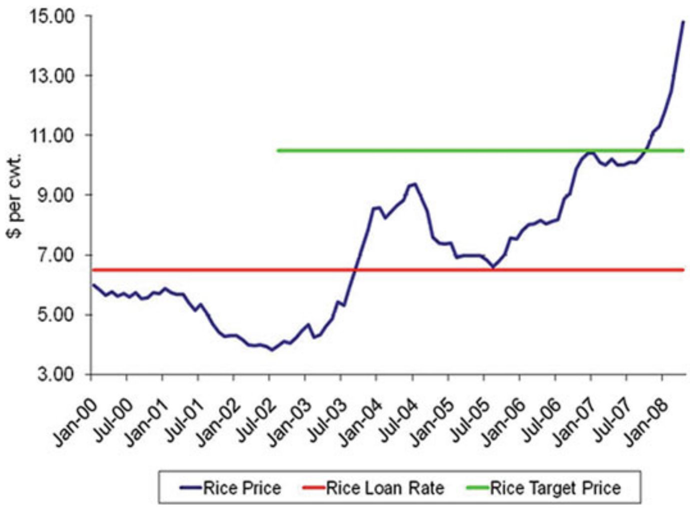


Fig. 3.4 Rice: loan rate and target prices

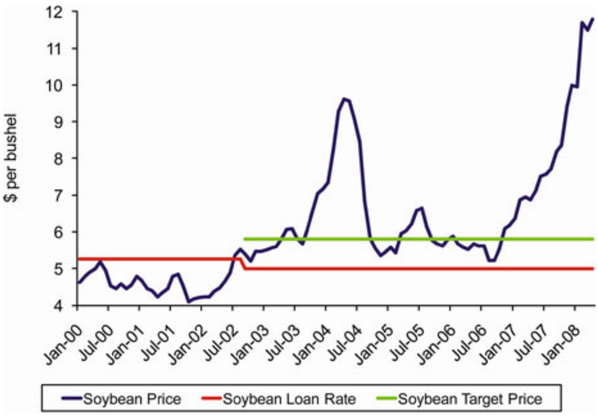


Fig. 3.5 Soybeans: loan rate and target prices

3.5 EU Agricultural Policy

The EU agricultural policy is very complex. It has undergone changes toward decoupling. The CAP has taken a somewhat different direction than the US agricultural policy.

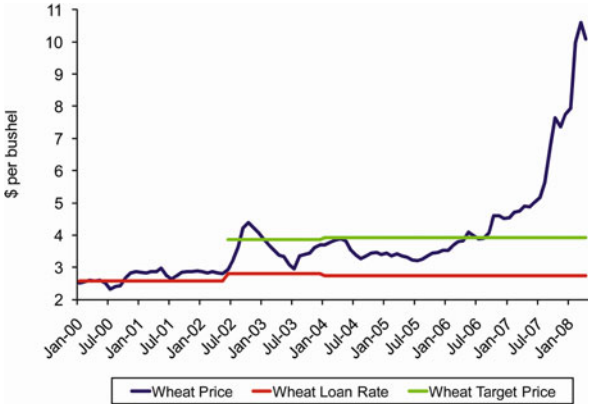


Fig. 3.6 Wheat: loan rate and target prices

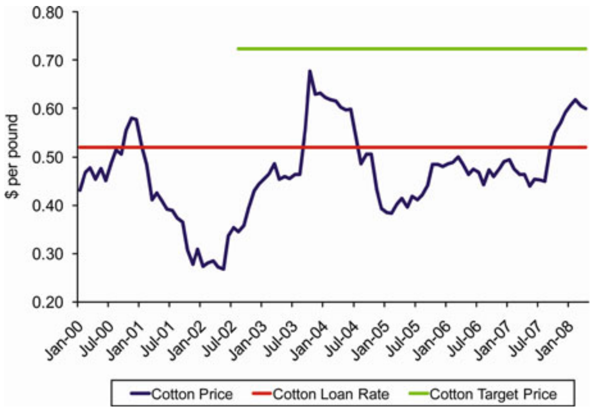


Fig. 3.7 Upland cotton: loan rate and target prices

3.5.1 EU Cereal Policy

3.5.1.1 The Early Years

At its formation in the 1960s, the European Union (EU) was a net cereal grains importer. Over time, because of technological change and other factors, it became a net gain exporter (Schmitz, Giese, and Shultz 2008). Carter and Schmitz (1979) argued that at least prior to 1980, the EU imposed the optimal welfare tariff on cereal imports. Later, the EU, as it switched from a net importer to exporter, provided for export subsidies.

3.5.1.2 CAP Reform

Two decades after the Common Agriculture Policy (CAP) was put into place, major changes occurred that led to significant decoupling of the support designed to sustain farming incomes. In addition, there has been an attempt to switch support from agriculture to the wider rural economy and to protection and enhancement of the environment by switching from Pillar 1 to Pillar 2 (Swinbank, 2008). Pillar 1 funds price and income supports, while Pillar 2 is concerned with rural development.

There have been two major changes in supporting the income of European farmers since the 1980s. First, the EU adopted the MacSharry Reforms in 1992 (Swinbank and Tanner, 1996). This involved reducing intervention prices for cereals and beef and entitling farmers to area and headage payment schemes, respectively, for crops and livestock. These changes made it easier to comply with the URAA's export subsidy constraints and to reduce tariffs. In 2000, the EU also added milk reforms to reduce intervention prices and compensation for milk quotas.

Second, the EU adopted the Fischler Reforms in 2003, which further decoupled area and headage payments by creating the single payment scheme (SPS). The SPS based entitlements on historic patterns of receipts of area and headage payments, but future payments would no longer be linked to crops grown or animals kept. In addition, annual subsidy payments would be based on cross-compliance conditions (Swinbank and Daugbjerg, 2006).

3.5.2 Restructured Overall CAP Spending

The reforms in the CAP have led to changes in the direction of CAP spending. However, total spending has increased. Between 1986 and 2006, CAP spending

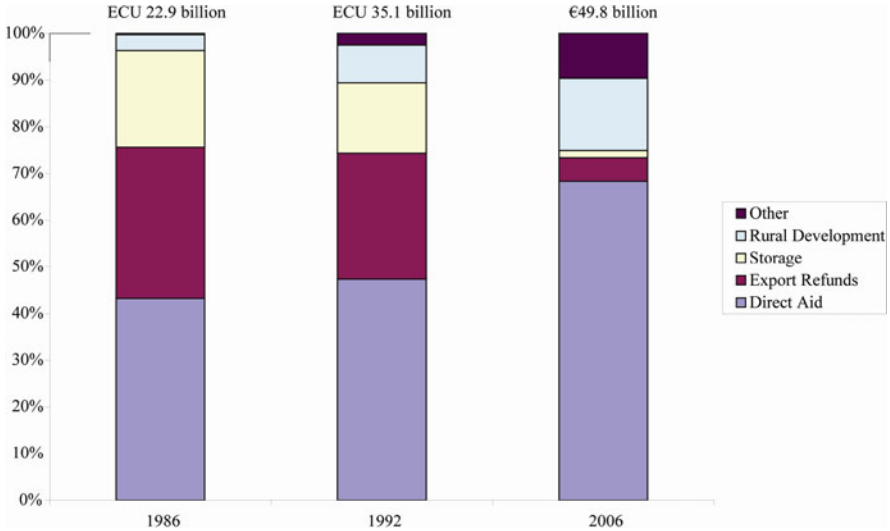


Fig. 3.8 The changing structure of total CAP spending. *Source*: Ackrill et al. (2008)

increased from ECU 22.9 billion to €49.8 billion (Fig. 3.8). In 1986, roughly 45% of the monies were paid out as direct aid, whereas in 2006, the figure was roughly 70%.

3.6 Welfare Impacts

3.6.1 The United States

How much inefficiency has resulted from the US farm programs? Gardner (2000) provides an estimate of welfare costs and benefits of US farm programs for the years 1987 and 1999–2000. He estimates the efficiency loss for wheat, corn, soybeans, and cotton under the 1996 FAIR Act for the year 1999–2000 to be US$210 million and then compares this estimate for the 1996 FAIR Act to that of the farm commodity program costs for the same program crops in 1987. Gardner argues that FAIR was an improvement over previous farm bills. Also, income transfers through farm programs are generally an efficient way of redistributing income (Schmitz and Gray, 2001).

For all farm commodities in both years, the programs resulted in benefits to producers. Also, consumers benefited from farm programs (Gardner does not separate out the costs to taxpayers from farm programs, nor does he separate out the benefits to consumers). In 1987, the deadweight loss (DWL) as a percentage of producers' gain is small for grains and oilseeds but not for cotton. The changes introduced in the 1996 FAIR Act significantly reduced the DWLs over those in the year 1987.

When examined in this light, the inefficiencies caused by the US farm commodity programs are very small indeed. However, for certain programs, there may be even net positive gains. As pointed out by Rausser (1982), not all the expenditures made on US farm programs are PESTs (programs that lead to net welfare losses); some programs fall under PERTs (programs that lead to net welfare gains). For example, Rausser argues that crop insurance falls under PERTS. However, Just et al. (1999) argue that perhaps this is not the case since they find that US crop insurance is open to moral hazard and that farmers have not used crop insurance as a risk-management tool.

At the heart of the debate over policy reform and its linkage to international trade is the extent to which domestic farm policies are decoupled from production. A considerable amount of theoretical development has been completed on the topic of decoupling (e.g., Schmitz et al., 2002). Unfortunately, there is little empirical work to parallel these theoretical efforts. We have argued elsewhere (Schmitz, Rossi et al., 2007a and b) that the construction of a *decoupling index* is badly needed to rank and quantify the extent to which each commodity program is decoupled from production. Unfortunately, the current system of classifying agricultural policies under the WTO (referred to as green box, blue box, amber box, and red box policies) is somewhat ambiguous with respect to the level of decoupling required in order for a policy to be assigned to a particular box. This was highlighted by the cotton challenge brought against the United States by Brazil, where the WTO ruled that

US cotton policy distorts trade and significantly suppresses world cotton prices to the detriment of competing cotton exporters.

In response to the Brazilian challenge, the United States removed Step 2 cotton payments (Powell and Schmitz, 2005). However, the Brazilians wanted further changes and challenged the United States through the WTO. Brazil once again won as the WTO Appellate Body ruled in 2008 that Congress failed to change cotton policies enough to comply with rulings that some policies violated international trade treaties. This put Brazil in a position to impose massive trade sanctions against US goods and services which it did in 2010.

When analyzing the impact of US cotton subsidies, Rossi et al. (2005) assume that producers formulate price expectations based on the target price set by the government. However, later, Schmitz, Rossi et al. (2007a, b) develop a "decoupled model" under the assumption that producers formulate price expectations based only on the loan rate, rather than the target price. Gardner (2002a, b) also believes the decoupled model seems plausible and argues that if producers respond to support prices, they likely do so at prices slightly above the loan rate.

Table 3.2 compares the impact of US cotton subsidies on world cotton prices between the 2002 decoupled loan-rate model and the 2002 coupled target-price model. The price impacts are much smaller under the decoupling assumption: the fall in world cotton prices relative to free trade is cut by nearly one-half under the loan-rate model. In percentage terms, the price impact of the US cotton policy for 2002 is reduced from 22.8 to 12.8%.

Table 3.2 The 2002 cotton price changes, given a simulated free-trade price

Parameter	Description	2002 Coupled	2002 Decoupled
P_f (US$ per bale)	Free-trade price	247.49	227.39
P_w (US$ per bale)	World price	201.60	201.60
$P_f - P_w$ (US$ per bale)	Price differential	45.89	25.79
$P_f - P_w$ (%)	Percent change	22.80	12.80

Source: Rossi et al. (2005); Schmitz, Rossi et al. (2007a and b)

Decoupling has important implications for the calculation of the welfare impacts of agricultural policy, because it leads to a lower free-trade price and a smaller level of production compared to the coupling model. When the decoupled model is compared to the coupled model, (1) the total welfare cost of a given policy is reduced; (2) the distortion of the world price is less; (3) the total cost of government price support payments is the same; (4) the distribution of rents is different – in particular, the gains to US consumers and the slippage effect are reduced; and (5) the economic rents to producers increase because they capture a portion of the reduced deadweight loss, the rents lost to domestic consumers, and the rents lost to foreign countries. According to Schmitz, Rossi et al. (2007), the welfare gains to US consumers are cut by 43% (US$101 million) under decoupling, while the slippage is reduced by 41% (US$196 million). The reductions to both the deadweight loss and the net US welfare loss are even more significant. The deadweight loss under decoupling is US$67 million, or 76% less than the coupled amount, while the net US welfare loss is reduced from US$756 million to US$353 million (53%). Producer rents increase from US$1.99 billion to US$2.45 billion because the countercyclical payment is no longer totally coupled to production.

In modeling, using the loan rate as a price support mechanism probably provides an underestimate of the effect of US cotton policy. Gardner (2002a, b) and Westcott and Price (2001) argue that producers respond to prices that are slightly above the loan rate. Gardner (2002a, b) correctly states that the loan rate is a price floor; but, if market prices rise above that level, the farmer will get the market price. Thus, the appropriate price expectation is the probability of the market price being at or below the loan level times the loan level plus the probability of the price being above the loan level times the expected price given that outcome (Schmitz, Rossi et al., 2007a, b). Also, the loan deficiency payments and marketing-loan gains provide revenue to farmers that exceed the loan rate for at least the crop years 1999, 2000, and 2001. As a result, farmers are expected to count on this added revenue when making spring planting decisions. Gardner (2002a, b) estimates that in 2000, cotton growers expected to receive 9% more than they would have received under the 2002 US loan rate.

Under target price specifications, the welfare costs of US cotton policy for 2002 and 2003 ranged between US$756 million and US$403 million (Table 3.3). However, under the loan rate specifications, the net welfare losses are cut in half. Also, given the rise in cotton prices, the welfare costs arising from the US cotton policy for 2007 through 2008 are much below those presented in Table 3.3.

The basic model used by Schmitz, Rossi et al. (2007a, b) and Schmitz et al. (1997) to calculate the welfare costs of the US cotton program is given in Fig. 3.9. The following example assumes that a water subsidy lowers the cost of production and induces a downward shift of the supply curve, causing the multiplicative effects of the two subsidy instruments (i.e., water subsidy and price support) to be greater than a mere summation of the individual effects. Figure 3.9 shows that the production quantity q^* is established where a given support price (P_s) intersects the water-subsidized supply curve (S') at point o instead of at point i, where

Table 3.3 Cotton policy: welfare impacts, 2002 and 2003

Welfare component	2002	2003
	(US$ million)	
Producer rents	1,988*	830*
US consumer rents	236	116
Slippage	482	350
Deadweight loss	274	53
Government cost	2,944*	1,341*
Cost of water subsidy	433*	432*
Net US welfare loss	756	403

Source: Rossi et al. (2005)

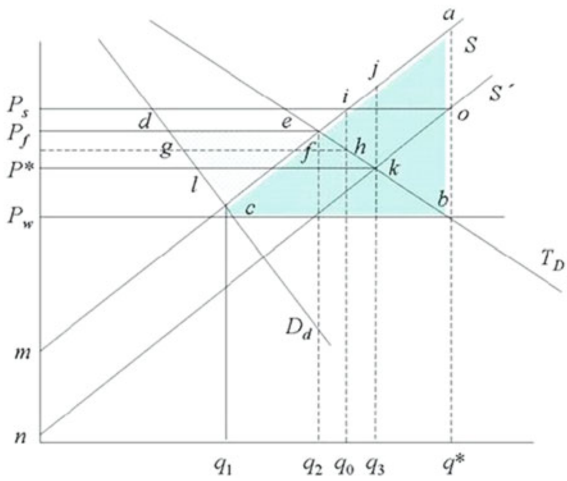


Fig. 3.9 Multiplicative effects of water subsidy and price supports. *Source*: Rossi et al. (2005)

it would otherwise be if only a price support subsidy was in effect. The addition of the water subsidy to the price support subsidy must necessarily increase q_0 to q^*, given that both types of subsidies are binding simultaneously. In addition to the increased output, there is a decrease to the resulting price necessary to clear the world cotton market, P_w. For example, under a price support subsidy alone, the market-clearing equilibrium shifts from point *e* (i.e., no subsidies) to point *h*; while for a water subsidy alone, the shift from point *e* is to point *k*. However, with both subsidies in place, the market-equilibrating shift is from point *e* to point *b*.

Under the multiplicative effects (ME) scenario illustrated in Fig. 3.9, the intersection of the support price (P_s) and the subsidized supply curve (S') establishes both the output quantity q^* (at point *o*) and the world price P_w (at point *b*). Domestic producers receive the area $P_s onme P_f$ as a net gain, while domestic consumers gain the area $P_f dc P_w$. The area *cdeb* (slippage) represents the rents received by importing countries. The cost to the government for the water subsidy is area *amno*, while the cost of the government price support payments equals area $P_s ob P_w$. Therefore, the combined net domestic cost to society of the two subsidies applied together is the shaded area *aedcb*. The net cost comparison is made with reference to point *e*, where P_f and q_2 are free from distortions caused by US cotton subsidies.

One of the key elements that determines the size of the welfare cost of cotton is the extent to which domestic production is exported. The greater the exports are, the greater the cost is. Large exports are one of the reasons for the cost associated with cotton. Table 3.4 shows roughly 70% of the cotton produced in the United States is exported. Of the major commodities, corn is at the bottom, at less than 20% of total production.

Table 3.4 Selected US commodities and the importance of trade, 2002–2005

Commodity	World production (%)	World trade (%)	Production exported (%)
Cotton	20	40	70
Corn	40	60	18
Rice	2	13	52
Soybeans	38	44	35
Wheat	9	25	50

Source: CRS

3.6.2 European Union

3.6.2.1 Effects of the Single Farm Payment

The different modeling approaches use different assumptions with respect to the major change in the CAP – the single farm payment (SFP). It is assumed to be fully decoupled in the Gohin and Latuffe (2006) and European Commission (2003) models. In AGLINK and FAPRI, the coupling factors are reduced from the shares used for the pre-reform regime. AGLINK reduces the coupling factor from 14 to 6%, and FAPRI reduces the coupling factor from 50 to 15% (Balkhausen et al., 2007). IDEMA and CAPSIM treat the SFP as fully coupled but applied uniformly to all activities.

Table 3.5 provides a summary of the impacts of the SFP on the production of different commodities in the European Union (Balkhausen et al., 2007) for a representative sample of prior studies. In some cases, ranges of results are shown between the double-arrowed lines. For cereals, the range covers the impact across various cereals (wheat, coarse grains, etc.), and for dairy products, the range covers the

Table 3.5 Production impact of the single farm payment scheme: EU – 15

	Cereals	Oilseeds	Beef	Dairy
	(Percentage change)			
OECD (PEM)	−0.7 ↔ 0.3	−0.7	N/A	N/A
OECD (AGLINK)	−0.5 ↔ 0.1	−0.4	−0.6	−6.2 ↔ 1.2
Gohin and Latuffe	−9.1 ↔ 8.7	−6.4	−4.2	−10.0 ↔ 4.4
EU commission	−2.6	−2.9	−2.7	−6.6 ↔ 1.7
FAPRI	−0.6 ↔ 0.4	−0.6 ↔ −0.2	−2.6 ↔ −0.2	N/A
DEFRA	−7.5	−2.9	−2.7	N/A
CAPSIM	−7.5	−4.8	6.4	N/A
IDEMA[a]	−7.6	−12.2	−1.4	N/A
GENDEG[b]	−1.6	N/A	6.3	0.1

N/A not available
[a]IDEMA results are at the member state level and have been aggregated by production shares.
[b]Arfini et al. (2007)
Source: Rude (2008)

impact across different types of dairy products. In the cases of FAPRI and AGLINK, the range of results represents scenarios with maximum and minimum degrees of coupling (see Binfield et al., 2004 and OECD, 2004 for details). All of the studies show changes to production that are smaller than 10%.

The impacts are smallest in the case of the FAPRI and AGLINK results. Both approaches introduce a smaller change in the degree of decoupling because compensatory payments were less coupled in the pre-reform scenario and the SFP payments remain relatively more coupled in the postreform scenario. Conversely, other studies assumed full coupling pre-2003 and, in some cases, full decoupling after the reform (EU Commission 2003; Gohin and Latuffe, 2006). Furthermore, the IDEMA and CAPSIM studies offer significantly more ability for markets to adjust after reform because of a more comprehensive modeling approach for the allocation of commercial crops and fodder/pasture area. As well, with the exception of FAPRI and AGLINK, the other modeling approaches use a more disaggregated approach so that they are better able to incorporate regional differences in implementation of the SFP reform. Finally, the Gohin and Latuffe (2006) results show relatively larger effects because factors of production are relatively more mobile between sectors in a CGE modeling framework than in a partial equilibrium model.

3.6.2.2 Double Payments to Farmers

Under the single farm payment (SFP) scheme, producers are paid restitution payments through at least 2013. There still remains, however, a price support system, but prices as of 2008 are well above support levels. Producers can and do respond to market signals and hence receive high rents from high market prices. However, in addition, they receive an annual compensatory payment (Appendix 4, Table 3.6), which does not depend on future prices since they are calculated using historical support prices only. The bottom line is that even though EU policy is more decoupled, EU producers "laugh all the way to the bank" because of the double payments: one from the government and the other from the marketplace (Schmitz, Schmitz and Schure, 2008).

There is some similarity between the EU and US agricultural policies in terms of direct payments to farmers. Under the new 2008 US Farm Bill, farmers will still receive direct payments, but historically they have been much smaller than the countercyclical and loan deficiency payments.

3.6.2.3 Sugar and Dairy

Two commodities that receive the highest government support in the EU are sugar and dairy. In terms of PSE measures for the EU, sugar reached a peak of 63.5% in 1992 and a low of 36.2% in 1989 for the period 1986 through 2001. For milk, the PSE was 62.7% in 1986 and reached a low of 39.8% in 2001. These numbers are similar to those for the United States. For sugar, the US PSE varied between 39.1 and 68.4%. For milk, the US PSE ranged from 35.2 to 70.2%. Like in the Brazilian case against the United States over cotton, Brazil challenged through the

WTO the EU sugar policy and won. Small changes were made in the EU sugar policy as a result (Powell and Schmitz, 2005). The EU sugar regime is extremely complicated, consisting of A, B, and C sugar (Schmitz, 2002). The EU has reduced subsidizing C sugar and is allowing for more imports from non-EU countries (Dillen et al., 2007).

3.7 Conclusion

In 2008, the United States implemented a new farm program. It contains many of the same elements as the previous farm bill. However, monies were added for the fruits and vegetables sectors. In terms of support levels for the basic commodities, including corn, wheat, rice, and cotton, support levels did not increase appreciably. In real terms, price supports have fallen dramatically. In view of world market prices in 2008 and 2009, the only major export commodity where price supports are binding is cotton. Through 2009, cotton traded below target levels. It appears that the new US farm program did not make progress toward decoupling since the old mechanism design for income support remains and the buyouts that did occur for peanuts and cotton were prior to the 2008 US Farm Bill. The net cost of US farm policy is small for grains and oilseeds but much larger for cotton and sugar (Gardner, 2002a, b; Schmitz et al., 2002; Sumner, 2007).

The European Union is moving more and more toward a decoupling program, where, in 2003, they introduced the single farm payment scheme. Correspondingly, farmers will be paid yearly compensatory payments until at least 2015. This approach has reduced the welfare costs of the CAP. However, EU farmers not only receive these payments, but also additional market rents from high commodity prices. In a sense, the EU farmers are being paid twice: once from the government and again from the market. If the single payment scheme had not been introduced, farmers would have benefited from rising prices through market payments, but government payments would have been drastically reduced (i.e., compensatory payments would not have been made – a situation similar to the United States).

Sugar is always at the center of debate in both the United States and the European Union. Little change has been made in the US sugar policy, and only minor changes have been made in the EU policy. Internal prices in both countries are over twice the world market prices, which is a very different situation for commodities such as wheat and corn. Interestingly, though the US sugar policy has been within the WTO guidelines, EU sugar policy was challenged by Brazil through the WTO.

With the sharp rise in commodity prices, several observations are of importance. First, it is unclear in the European Union what level of support remains, since the support levels upon which compensatory payments were made are no longer binding. If prices fall to old levels, what threshold prices are in place will once again become binding. Second, given the high prices of commodities, the welfare costs of both the US and EU policies have been greatly reduced. In addition, the treasury outlays have been greatly reduced. For example, in the United States, except for direct payments, cotton will be the only major commodity receiving government payments.

Appendix 1: Ethanol and Market Distortions

Appendix 1, Fig. 3.10 depicts the US corn market where S is the supply schedule and D_{T} is total demand. Given the loan rate under the 2002 Farm Security and Rural Investment (FSRI) Act of 2002, farmers receive a price of p_{LR} for each bushel of corn produced, yielding a total production of q_{s} bushels. Given a domestic demand curve D_{d} and an export demand curve of D_{e}, the total demand curve is D_{T}. These demand curves result in a market clearing price of p_0. With this market clearing price, q_{d} is consumed domestically and q_{e} is exported. At this equilibrium, the loan deficiency payments paid to farmers based on the level of production is represented by the area $p_{\mathrm{LR}}abp_0$. In addition, farmers receive a countercyclical payment based on their historical level of production (q_{k}, typically 85% of historical yields) and the target price (p_{TP}). Graphically, this payment is depicted by the area $p_{\mathrm{TP}}cdp_{\mathrm{LR}}$. The net cost of the subsidy program from the US perspective is *aefgb,* of which *efgb* is a gain to importers (the "slippage" effect).

In this original equilibrium, we assume that the market clearing price (p_0) is less than the choke price for the derived demand curve for corn used to produce ethanol (D_{ET}). Thus, given the total demand curve of $D_{\mathrm{T}} + D_{\mathrm{ET}}$, no ethanol is produced. Next, we assume that increases in the price of gasoline shift the derived demand for

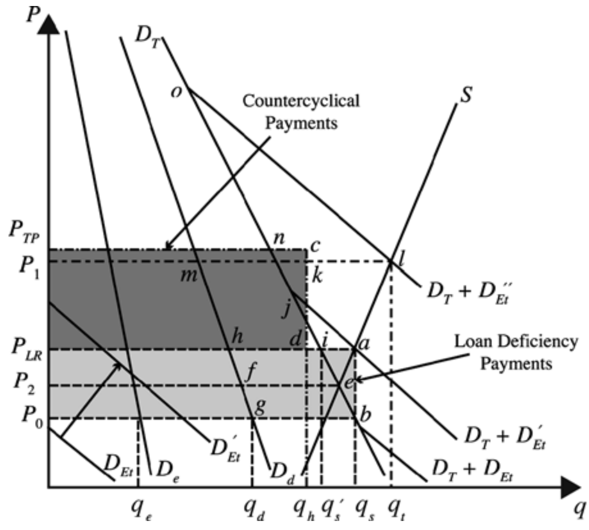


Fig. 3.10 Ethanol effects: direct and indirect subsidies

corn used to produce ethanol outward to D_{ET}'. This changes the shape of the total demand curve to $D_T + D_{ET}'$. This rightward shift in the derived demand for corn from ethanol producers is sufficient to raise the equilibrium price of corn to the loan rate, eliminating the loan deficiency payments to farmers. Thus, there are no direct subsidies based on production, but there are indirect subsidies to corn producers via ethanol tax credits.

Consider further the demand for corn derived from ethanol production. Starting from D_{ET}' (which assumes a fixed oil price), a sufficiently large increase in corn prices (above p_2) chokes off the demand for corn to produce ethanol. This point represents the corner solution in Appendix 1, Fig. 3.10. However, if one assumes an increase in oil prices for a given price of corn, the derived demand curve for corn shifts to the right. It is important to note that from a theoretical perspective, the demand for corn for ethanol production could be positive without a tax credit, which is discussed later. At least two factors affect ethanol production, namely, the favorable oil to corn price ratio and a tax credit for ethanol production.

In the first case, we assume that producers are not impacted by ethanol demand even though corn prices rise. This is because the loan deficiency payments no longer exist (and the countercyclical payments remain unchanged). Also, an important result is derived from the observation that market clearing prices rise from p_0 to p_{LR}, causing both domestic and export demand to fall for those components making up demand D_T. (The demand for corn for ethanol is $q_s - q_s'$.) Domestic consumers now pay a higher price for corn and related products, given demand D_d. Likewise, foreign importers pay a higher price for the corn they import.

The market for corn-given demand $D_T + D_{ET}'$ might look like a "free market" except for the subsidies provided to the ethanol sector. From a distributional standpoint, (1) producers are unaffected from ethanol demand, (2) domestic consumers lose $p_{LR}hgp_0$, (3) foreign importers lose *hibg*, (4) the government saves loan deficiency payments $p_{TP}cdp_{LR}$, (5) the consumers of ethanol gain *jia*, and (6) there are government cuts from the indirect subsidy on ethanol production.

To calculate the "net effect" of ethanol, one needs to consider (1) the net welfare gain of *aefgb*, (2) the consumer gain from the introduction of ethanol of *jia*, and (3) the cost of the indirect ethanol subsidy. The first two components are positive, while the last one is negative. Ethanol subsidies replace direct subsidies. The price impact due to ethanol affects consumers. The direct effect from ethanol is a rise in the price of corn. Production costs are now covered so direct subsidies are no longer binding.

To further show the interrelationship between ethanol production and government payments to corn farmers, we assume that the derived demand for corn used to produce ethanol shifts farther outward to D_T^{it}. This increased derived demand causes the total demand for corn to shift outward to $D_T + D_{ET}^{it}$, increasing the market equilibrium price to p_1 and the equilibrium quantity to q_t. Comparing this equilibrium with the equilibrium at the loan rate, producers gain p_1lap_{LR}. However, part of this gain (p_1kdp_{LR}) is offset by reductions in the countercyclical payments to farmers. Thus, the net producer gain is *kdal*. This shift results in an economic loss to domestic consumers of $p_1 mhp_{\mathrm{LR}}$ and a loss to foreign consumers of *mndh*. Completing the model, the economic gain for ethanol producers is the area *onl*.

If the demand for ethanol shifts even farther to the right than $D_{\mathrm{ET}}^{\mathrm{it}}$, all government payments (including countercyclical payments) are eliminated. Thus, there a direct linkage between tax credit to ethanol and farm program payments.

Appendix 2: Coupled Versus Decoupled Subsidies: The Case of Cotton

In the following theoretical discussion, we emphasize that the price impact of US cotton policy critically depends on the choice of which cotton price to use in the analysis, since the positioning of the supply and demand structure is dependent on the particular price. In Appendix 2, Fig. 3.11, S is the US supply curve under a coupled framework, while S' is the US supply curve under a coupled framework that includes water subsidies. Likewise, S_0 is the supply curve under decoupling and S'_0 is the supply curve under decoupling that includes water subsidies. Domestic demand is D_{d}, and total demand is D_{D}. Given a specific domestic supply–price elasticity and production point q^*, one can either use the target price P_{s} to derive the intercept and slope of the subsidized supply curve (that leads to the coupled subsidized supply curve S') or the loan rate P_{l} to derive the decoupled supply curve S_0 (and the decoupled subsidized supply curve S'_0). Under the decoupled model, the subsidized supply curve changes from S' to S'_0 by shifting downward and rotating clockwise. Essentially, the initial free-trade equilibrium price P_{f}, derived from the intersection of the coupled unsubsidized supply curve S and the total demand curve T_{D}, moves downward along the total demand curve to establish a smaller decoupled

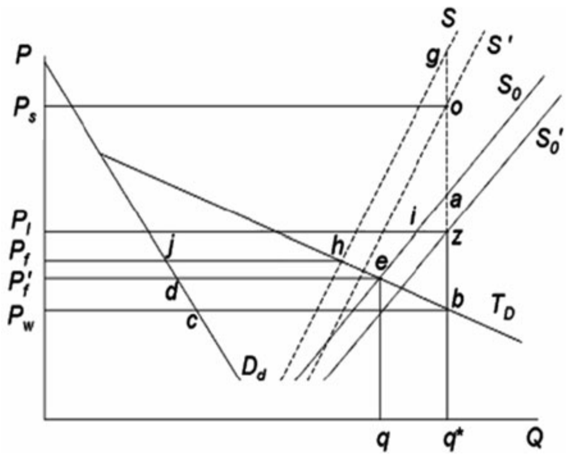


Fig. 3.11 A decoupled policy

free-trade price $P_f{}'$ and free-trade quantity q. Schmitz et al. (2006) perform sensitivity analyses for the coupled model by rotating the coupled subsidized supply curve S_0 around point o in Appendix 2, Fig. 3.11, using different elasticities. They also perform sensitivity analyses for the decoupled model by rotating the decoupled subsidized supply curve S'_0 around point z using different elasticities.

Appendix 3: US and EU Producer Supports

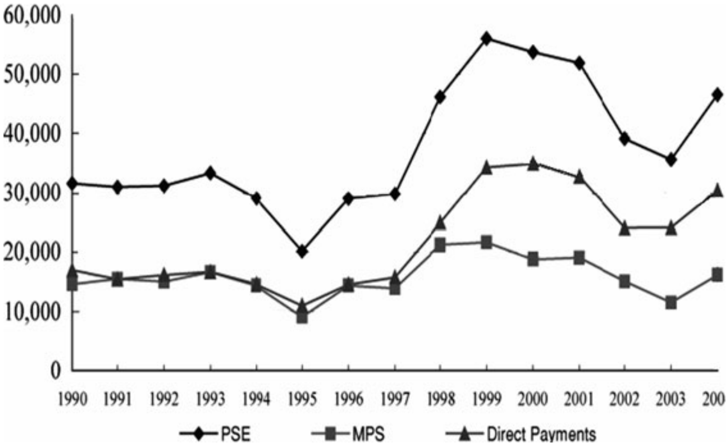


Fig. 3.12 US producer supports: 1990–2004 (US$ millions). *Source*: OECD (2005)

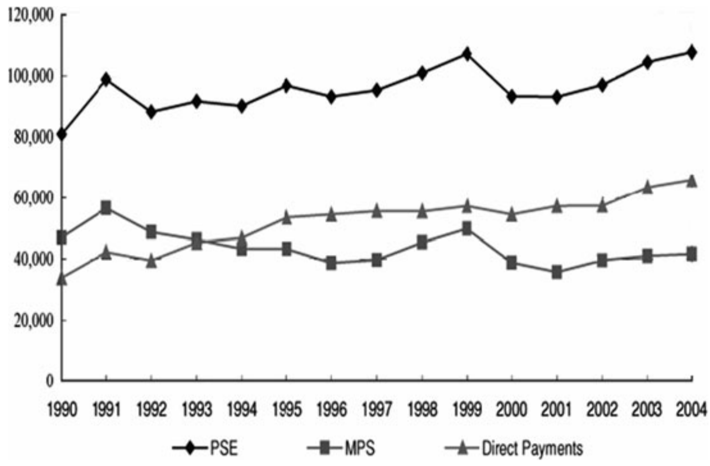


Fig. 3.13 EU producer supports: 1990–2004 (ECU million). *Source*: OECD (2005)

Appendix 4: National Ceilings

Table 3.6 Ceiling amounts for selected EU member states, 2009–2015

EU member state	2009	2011	2013	2015
	(1,000 EURs)			
Germany	5,770,024	5,770,024	5,770,024	5,770,024
Spain	4,838,512	4,838,512	4,838,512	4,838,512
France	8,404,502	8,404,502	8,404,502	8,404,502
Italy	4,143,175	4,143,175	4,143,175	4,143,175
Poland	1,877,107	1,877,107	1,877,107	1,877,107

Source: Swinbank (2008)

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Chapter 4
The "Health Check" of the CAP Reform: Lessons from Its Impact Assessment

Tassos Haniotis

Abstract The "Health Check" of the Common Agricultural Policy (CAP) reforms addressed three policy questions aimed at assessing the implementation of the reforms: how to simplify and render more efficient the system of direct payments; how to best grasp market opportunities; and how to meet new challenges, especially those linked to the effects of climate change. Although none of the proposed legislative changes constitute a fundamental reform of the CAP, they will, nonetheless, shape the debate on its future.

4.1 Introduction

With the 2003–2004 reforms of the Common Agricultural Policy (CAP) came the formal requirement to "check" the implementation of a series of provisions agreed to by the council of ministers. Thus provisions linked both to market and direct payment issues, which were part of the legal text of the agreed reforms, predetermined to a large extent the scope of what was termed the *Health Check of the CAP reform*. The Health Check brought together into one coherent package the various reports and reviews the European Commission was required to submit to the council of ministers.

From its timing to its name, the Health Check spurred questions about the scope of the review.[1] Although such questions habitually accompany any European Commission initiative, it was widely known that fundamental reform of the CAP would not be possible, or even desirable, with the 2003/2004 reforms still in progress. Yet this reality did not stop some from considering the Health Check too limited in scope and ambition, leaving the expected changes in the CAP (more

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often, *their* expected changes in the CAP) for the period after 2013 when current budgetary authority expires. Still others, especially those hostile to any changes in the CAP, like to consider the Health Check as premature.

While both sides have expressed legitimate concerns, they seem to underestimate the most important contribution of the Health Check in the process of CAP reform: the link it provides between changes that improve the CAP reform process now and changes that would need to be implemented at a later date. The objectives of this chapter are to identify the most important issues addressed in the impact analysis of the Health Check, to summarize the conclusions reached in that analysis, and to demonstrate how the issues discussed will be at the core of any future debate of the CAP. After providing an overview of the main Health Check proposals, we focus on three policy areas covered by the Health Check – markets, direct payments, and rural development – and the questions addressed in the Impact Assessment. Lastly, we offer some tentative conclusions as to the long-term future of the CAP.

4.2 The "Health Check" Proposals

The Health Check proposals were based on the assessment that the 2003/2004 reforms continued the gradual shift away from price-based support and toward less distorting direct payments. The changes in the manner and level of support for agriculture are depicted graphically in Fig. 4.1.

The 2003/2004 reforms were largely successful in achieving their primary objective of decoupling income support from producers' decisions through the adoption of the single payment scheme (SPS). Indeed, with a rate of decoupling close to 90%, the reforms exceeded expectations. Under the SPS, payments are based on historical levels of support and are conditional upon compliance with legislated environmental, food safety and quality, and animal welfare provisions.

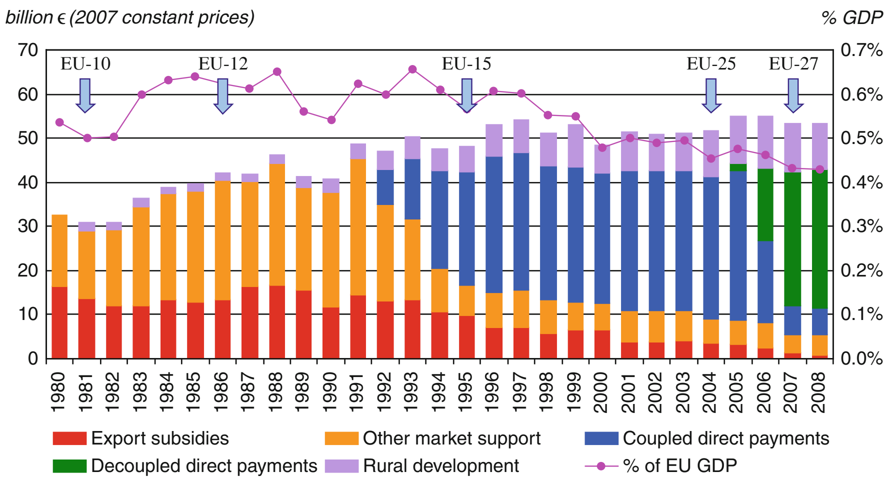

Fig. 4.1 CAP expenditure and CAP reform path

A second objective of the reforms was strengthening of rural development provisions of the CAP. Increased funding was provided through the transfer to rural development initiatives of 5% of all direct payments above €5,000, a process referred to as “modulation”.

While offering a generally positive assessment of the reform process, the Health Check identified three main areas where further changes were deemed necessary in

Table 4.1 Summary of main Health Check proposals

A. Direct support
Move toward a flatter rate of support in the single payment scheme (SPS)
Member states are allowed to move to flatter rates of support
For new member states, the application of the single area payment scheme (SAPS) could be extended until the end of 2013
Simplification of a series of provisions in the SPS
Set-aside entitlements are abolished
Several rules of direct payments simplified
Lower payment limitations (of either 1 ha or €250) are introduced
Cross compliance
Redundant provisions, not relevant to farming activities, are deleted
Some provisions related to set-aside benefits are added in the list of good agricultural environmental conditions (GAEC)
Partially coupled support and other aid schemes
Full decoupling is proposed for most sectors from 2010
Member states are allowed to maintain coupled payments only for suckler cows, sheep, and goats
The energy crop premium is abolished
Revised “Article 68” measures
Up to 10% of all direct support can shift to targeted measures aiming at:
supporting income in regions and sectors facing economic disadvantages
allowing the support of risk management measures (crop insurance or mutual funds)
B. Market measures
Milk quotas
Increase milk quotas by 1% annually from 2009 to 2013
Review clause in 2011 to assess market developments
Cereals
Wheat intervention only cereals support price with no quantitative limits
Quantitative ceilings are set to zero for all coarse grains
Durum wheat intervention is abolished
Other measures
Rice and pig meat intervention abolished
Processing aids to be decoupled with variable transition periods
C. Rural Development measures
Existing rural development measures are considered sufficient to address new challenges
Present funding deemed insufficient to meet additional needs
Modulation
Existing modulation scheme tailored to EU-15 needs
New member states affected beginning in 2012
Progressive modulation results in balanced contribution of large farms
Member states should use additional funds to address new and ongoing challenges such as climate change, bio-energy, water scarcity, and biodiversity

order to realize the reforms' objectives. These proposed changes are summarized in Table 4.1. The rationale that led the Commission to these proposals will be taken up in the next three sections. At this point, however, it is important to stress that the proposed changes are likely precursors of the issues that will define the policy debate about the future of the CAP.

4.3 Direct Support Issues

The introduction of the single payment scheme and the decoupling of support took most observers by surprise. One consequence was that, once member states chose the model (historic or regional) to implement the SPS, they had no option for future review.[2] This was a choice the council of agricultural ministers took in order to make sure that a reversal of decoupling would not be possible. But the 2003 reforms involved only the cereals/oilseeds, the beef and sheep, and the dairy sectors. Other sectors were reformed subsequently – olive oil, cotton, and tobacco in 2004; sugar in 2005; and fruits and vegetables and wine in 2007. The integration of these sectors into the SPS altered the allocation of payments to producers, depending on whether they chose to implement the SPS according to the historic or regional model.

4.3.1 The Model of Direct Support

It is natural that some member states would want to reconsider the way payments are allocated given the model of support they have chosen. The Health Check recognized this by allowing member states, on a voluntary basis, to adjust their SPS system in order to meet their specific objectives. In practice, such an adjustment would imply a movement away from the prevailing historic model (where the individual farm is the basis for allocating payments) and toward some form of regional model.

However, the proposed changes to the SPS were not limited to the way payments were allocated within member states, but extended to the distribution of payments among them. The present distribution of payments largely reflects that of production among member states. This is because the CAP, prior to the 2003/2004 reforms, was commodity oriented. Accordingly, the closer the SPS model is to the historic model, the closer the distribution of payments will be to that of production.

4.3.2 The Distribution of Support

This fact has brought attention to the often quoted 80–20 figure; that is, 20% of the recipients receive 80% of the payments. Yet, as the Impact Assessment has demonstrated, the uneven distribution of support is linked more closely to structural characteristics of agriculture than to the method of support. Even if one were to move toward a community-wide flat-rate system whereby all farmers received the same area payment, the distribution of support would still be very uneven, and close to the previously cited 80–20 figure. In this case, close to 80% of the payments would go to roughly 20% of a different set of recipients – land owners – reflecting the fact that the distribution of land is also very uneven.

The Impact Assessment of the Health Check has demonstrated the disparities in support among member states, as well as the difficulties in achieving a more even distribution of payments. The problem is not so much the 80–20 ratio, but the disparities in the two extremes of the distribution of support (see Fig. 4.2). In 2006, a significant portion of payments (roughly 13%) went to just 0.3% of the beneficiaries, while at the other extreme some 13% of beneficiaries received very small payments, representing no more than 0.3% of the total. Since these figures differ significantly among member states, it is easier to observe the problem than to actually convince member states to come up with a solution.[3]

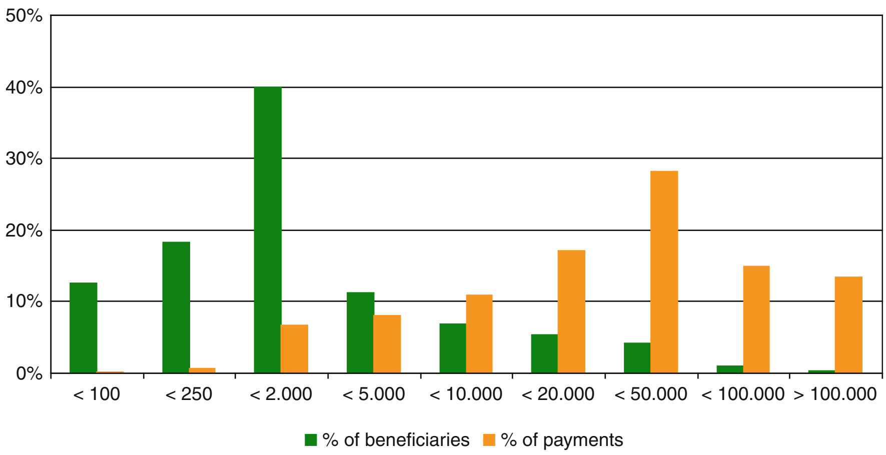

Fig. 4.2 Distribution of EU CAP payments (payment thresholds in euro)

The main issue that adjustment of the SPS model must address is not so much the distribution of support but the long-term justification for it. There are two schools of thought in this debate. One views direct payments as income support. This group views current payments as allowing the necessary structural adjustments before a move to a more targeted level of support on a regional basis. The other justifies continued support under the CAP on the basis of providing public goods (such as environmental amenities), and considers that adjustments in the CAP should prepare for a move in this direction.

With fundamental reform of the CAP not an option at this stage, the above arguments set the stage for the debate that is likely to follow. But the Commission's position, based on an external study that looked at alternative scenarios for the CAP by 2020, is that the present debate introduces a false dilemma.[4] The cited study concludes that the abolition of the CAP would adversely affect both farm income and the provision of public goods, with the loss in income felt disproportionately in the most disadvantaged regions while environmental impacts associated with intensive production would likely be felt in the most competitive regions.

4.3.3 A "Flat" or "Flatter" Rate

No matter what justification one uses for support under the CAP, the question of how this support is to be distributed comes to the fore, as it did during the Health Check debate. Indeed, this question became central to that debate, especially among new member states.

At first sight, the distinction between payments under the historic and regional models may seem unimportant. But the difference in the potential impact of moving toward one community-wide flat rate per hectare and one payment that is flat per region or per country (i.e., a "flat" or "flatter" rate) is quite significant. Not only is the distribution of payments within member states different from the distribution among member states, but the likely impacts on land values also differ under the two models.[5]

The distributional aspects of direct payments have received much attention in the past and will certainly do so in the future as we move closer to a decision on the next EU budget. But the impact of direct payments on land values has emerged as an issue only recently. As the implementation of the two competing models of support advanced, it became clear that capitalization of payments in the value of land was greater under the regional model than the historic model.

A simple glance at the distribution of support among member states suffices to show the large disparity, whether measured as payments per hectare of land or as payments per farmer. And herein lies the complication. What model of support is most likely to achieve a fair distribution of support? And if a more equal distribution is considered to be a more fair distribution then what should be the "yardstick" used to measure the equality of payments – the area (the core of the regional model) or the farm (the core of the historic model)?

4.4 The Impact of Alternative Models of Direct Support

Different answers have been given to the above questions, with the verdict anything but unanimous (especially on what is considered a "fair" distribution of support). This debate will have to find its conclusion in the post-2013 period, as any changes in the distribution of payments among member states would violate the financial perspectives agreed to in the 2007–2013 budget. But the issues were addressed, and their potential impact on member states underscores the challenges faced in trying to achieve this seemingly simple goal.

The biggest impact of a community-wide flat rate would be a significant shift of support from the EU-15 countries to the EU-12. Although this distinction is rather simplistic (even within the EU-15 and the EU-12, there are significant differences in the average level of support), the two groups of member states are characterized by very different situations. Among the EU-12 countries, the level of support did not change so much with CAP reform as did the type of payment (from product to producer; from coupled to decoupled).

Among the EU-15 countries, both the level and type of support changed significantly after the 2004 enlargement. This created the need for a gradual transition among the new member states to the level of support received by the EU-12 countries, with an almost even split between income support and structural adjustment measures.

Developments since enlargement have proven the merit of this approach. The rate of growth of farm income has exceeded that of GDP in the EU-12 countries as a group. The opposite is true for the EU-15 countries; not only has the pace of economic growth been slower than in the EU-12 countries, but growth in farm income also has been lagged still further behind. Yet, when measured as a share of GDP, direct payments are similar in both groups of countries.

4.5 Article 68 and Its Relevance to Direct Support

While there has been movement toward further decoupling, there remain areas where decisions have yet to be made regarding the manner in which support is provided. Indeed, there are situations where a complete decoupling of support could have negative impacts, either on the local economy or on the environment. Most of the issues that the Impact Assessment identified relate to such problems. In assessing the impact of decoupling, the Health Check considers that in the intensive livestock sector (suckler cows and sheep) and in rice production (which generates environmental benefits), the continuation of coupled support should be allowed in order to avoid negative consequences for both the environment and the local economy.

In a number of sectors, where support was coupled to varying degrees, a gradual transition toward fully decoupled support was deemed necessary. A case in point is the dairy sector, where it became clear that in certain regions the potentially negative impact on prices of eliminating the dairy quota would require a targeted solution. Thus Article 68 was modified to allow the retention of up to 10% of *all* direct support to target specific needs.

These needs were meant to be addressed either by measures that allowed a reallocation of decoupled support toward disadvantaged regions, the introduction of crop insurance schemes with mixed public/private financing, or the introduction of measures supporting mutual funds for animal diseases. To ensure that measures linked to the revision of Article 68 do not result in a reversal of the overall path toward decoupling, measures of coupled support under Article 68 are limited to 2.5% of the overall level of direct support.

4.6 Market Issues

4.6.1 The "Safety Net" Debate

Guaranteed minimum prices have been reduced from 1992 levels and, as a result, domestic prices are greatly influenced by developments in world markets. Figures 4.3, 4.4, 4.5, and 4.6 depict changes over time in intervention prices, domestic market prices, and world prices for wheat, beef, butter, and skimmed milk powder. Historically, surplus production of these commodities has tended to depress world market prices.

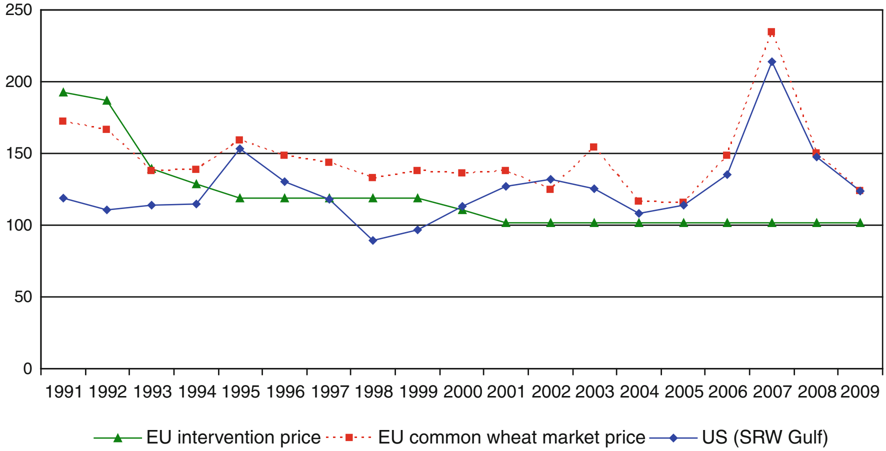

Fig. 4.3 The evolving role of EU support prices – wheat (in euro per metric ton)

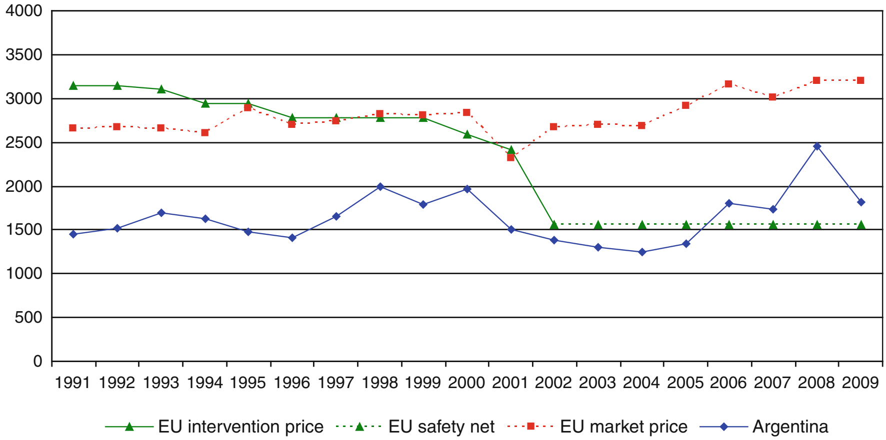

Fig. 4.4 The evolving role of EU support prices – beef (in euro per metric ton)

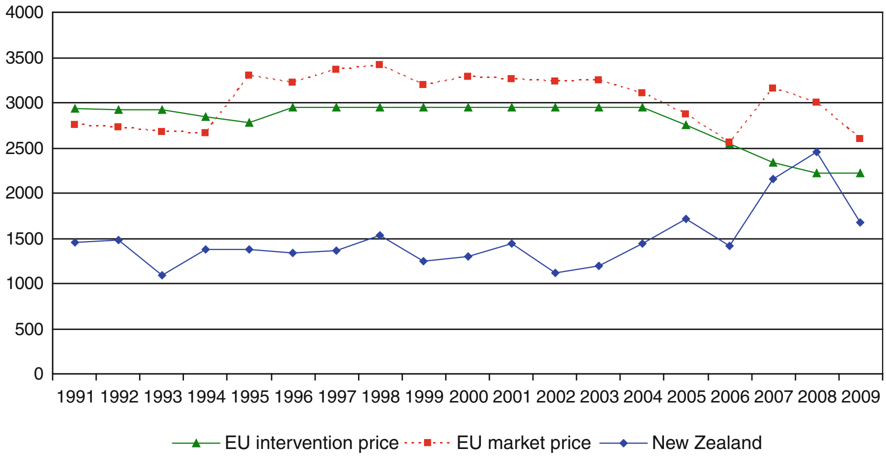

Fig. 4.5 The evolving role of EU support prices – butter (in euro per metric ton)

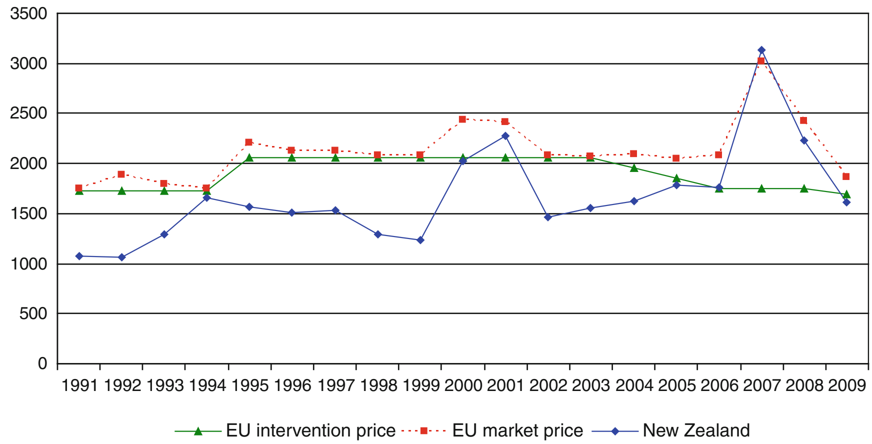

Fig. 4.6 The evolving role of EU support prices – SMP (in euro per metric ton)

Paradoxically, despite the undeniable impact of the reform process, the debate on the future of the CAP is often linked to past instead of present and future challenges (including, for some, the need to restore food security stocks). There is still a sense that support under the CAP will influence domestic prices despite the fact that intervention prices are generally well below current market prices. This debate resurfaced during the Health Check, although this time it focused more on price variability than on actual price levels, since prices of agricultural goods were on the same upward path as those of other commodities.

The argument for “regulating” the market through price support measures has been advanced without much conviction. The experience of CAP reform over the past fifteen years has shown the superiority of fixed payments over price supports in maintaining farm income. The latter often resulted in surplus production, putting downward pressure on world prices.

Of course, direct support was not introduced as a mechanism to manage markets but rather as a means of providing income stability while allowing farmers to respond to market signals, irrespective of the potential for increased price variability.[6] The real issue then is whether the EU needs to introduce some mechanism that would provide counter-cyclical support analogous to that provided to farmers in the United States. Such a program could mimic the counter-cyclical price supports provided in the United States (which would be very difficult given the current price structure in the EU) or it could take the form of a revenue insurance scheme (whose course has been estimated to be both significant and highly variable; see Fig. 4.7). The results of the Health Check suggest the need to steer away from such a scheme since a significant portion of farmers' income is already protected through direct payments.

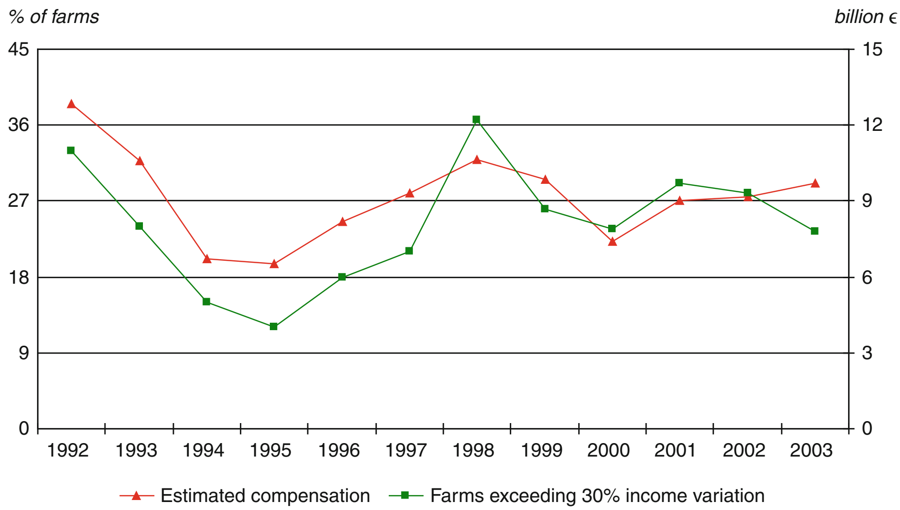

Fig. 4.7 Potential impact of an EU-wide revenue scheme

4.6.2 The Dairy Quota "Soft Landing"

The 2003/2004 reforms pursued reductions in dairy price supports as the "cost" of extending the quota system. In the Health Check, the Commission's approach was to allow quotas to expire in 2015. While there was some difference of opinion among member states, a sizeable majority in the council opposed continuation of the dairy quota, as it effectively prevented certain member states from competing in a growing market for high-value exports.

The main issue that the Health Check had to deal with was how to phase out quotas in such a way that would avoid dramatic price changes. The ensuing debate

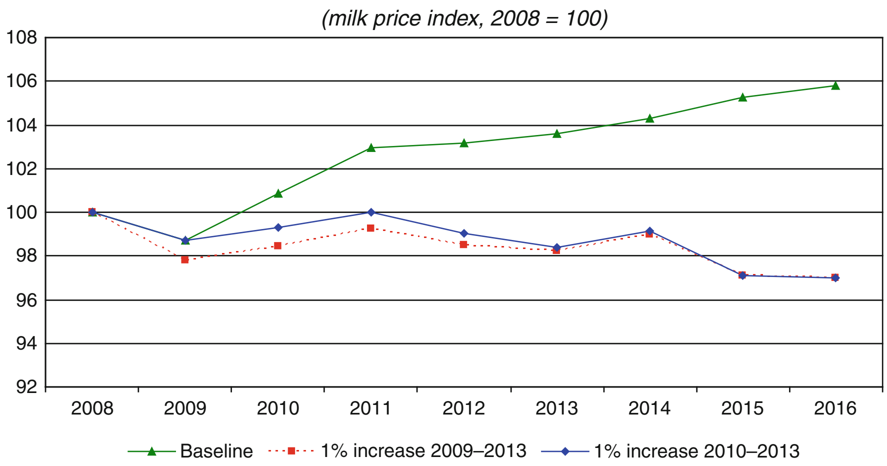

Fig. 4.8 Potential impact of 1% increase in milk quota (milk price index, 2008=100)

about annual increases in the quota (1% versus 2%) was linked to the expected impact on prices, both at the community level (see Fig. 4.8) and, more importantly, at the regional level.

Proposed changes in the quota imply different price paths. While the overall price pattern is clear, the potential for significant price declines in some regions was the basis for the revision of Article 68 (see Section 4.5 above).

4.7 Rural Development Issues

The reforms of the rural development component of the CAP were delayed until 2005. For this reason, one could conclude that there was less reason to make adjustments to the "second pillar" of the CAP. But these adjustments were the ones that provoked the strongest negative response from member states. In summary, the Commission proposed an increase in funding for rural development through "modulation" and targeted that increased funding to so-called new challenges such as those posed by climate change, biofuels, water management, and biodiversity.

The Commission justified its proposal by noting the increased attention these issues have received from member states since the 2005 reforms. The need for additional funds was a direct consequence. But before the required level of funding could be determined three issues had to be addressed. First, it had to be determined whether additions to the policy "toolkit" were necessary. After reviewing the Commission's proposal, it was determined that existing measures were sufficient.

Second, the source of the additional funds had to be identified. The 2007–2013 budget reflected a reduction in funding for rural development from levels initially proposed by the Commission. This left only one option. The additional funding would have to come from the "first pillar" of the CAP. More specifically, these funds would come from direct payments through "modulation".

Finally, the distribution of support among member states had to be determined.[7] Should modulation apply to all member states (as was the case with the Commission proposal, albeit only by 2012 for new member states) and should there be any redistribution of resources among member states? The last option was discarded given the significant level of rural development funds in new member states.

Different variants of modulation were considered before arriving at the proposed method of "progressive modulation". The Commission's proposal is summarized in Table 4.2. A similar (if less progressive) method was advanced by the European Parliament. Progressive modulation achieves the desired effect of redistributing funds from the first to the second pillar of the CAP in a manner that takes into account the distributional impact of support. Large recipients contribute more, while those receiving less than €5,000 are exempt.

Table 4.2 Proposed levels of progressive modulation

Payment threshold (in €)	2009	2010	2011	2012
1–5,000	0%	0%	0%	0%
5,000–99,999	2%	4%	6%	8%
100,000–199,999	5%	7%	9%	11%
200,000–299,999	8%	10%	12%	14%
Above 300,000	11%	13%	15%	17%

Finally, it is worth mentioning that resistance to further modulation has often been based on the assertion that most of the funds leaving the first pillar of the CAP (farmers) end up benefiting non-farm recipients. Whatever the extent of this potential problem (which is currently being evaluated by external studies), the fact is that most of the measures that are considered eligible to meet new challenges are directly linked to farm activities, and thus increase the chances of targeting potential benefits to farmers.

4.8 Conclusions

While the Health Check did not constitute a fundamental reform of the Common Agricultural Policy (CAP), it nevertheless raised a series of questions that will shape the debate on the future of the CAP. These questions focused on the three main legislative areas of the CAP – direct payments, markets, and rural development. We focus on each of these areas in turn. First, the distribution of payments among member states has become central to the debate. It is becoming increasingly clear that a move toward a regional model of support that provides for the same payment per hectare is inevitable. What is less clear is the extent to which such a move will actually affect the distribution of support.

Second, the succession of reforms of the CAP has shifted support away from commodity-based measures and toward direct payments. Although minor adjustments in intervention prices for cereals have been proposed, the main thrust of the Health Check has been to remove supply controls (such as the set-aside and the dairy quota) that limit producers’ ability to respond to market signals. In the case of the dairy quota, the focus has been on determining the annual adjustment path that would minimize price declines in the transition period.

The third policy area addressed in the Health Check was rural development. The Commission proposed an increase in funding for rural development through “modulation” and targeted that increased funding to so-called new challenges such as those posed by climate change, biofuels, water management, and biodiversity.

Notes

1. A Commission Communication outlining the reasons and the issues of the CAP reform Health Check was published on November 20, 2007, while the Commission legal proposals and their accompanying Impact Assessment were published on May 20, 2008. A council decision was taken in November 2008. More information can be found at http://ec.europa.eu/agriculture/analysis/perspec/index_en.htm.
2. In the historic model, the level of payments farmers received in the 2000–2002 period form the basis of their payment entitlements. Future support was fixed at this historic level, provided that the land stayed in agriculture and that farmers adopted environmentally sound production practices. In the regional model, the previous level of support was harmonized at a regional level, with farmers receiving the same level of support per hectare.
3. The Commission opted to deal with high payments by introducing a progressive element in “modulation”, and with very small payments by introducing a lower limit in either eligible area or level of payment.
4. http://ec.europa.eu/agriculture/publi/reports/scenar2020/index_en.htm.
5. The issue emerges even for those considering that there is no justification for support. Any move away from the present system to no support implies huge impacts on land values that would differ both at the farm and at the regional level. Any transition away from support, not much of an issue in the present CAP debate, would also need to address this issue.
6. The example of U.S. policy (concentrated on a few commodities, and generously providing “counter-cyclical” income support) played a role in this debate, as the intervention of some stakeholders during the public consultation of the Health Check communication amply demonstrated. But the prevailing view was that counter-cyclical measures have, by design, the exact opposite effect of fixed, decoupled payments; counter-cyclical payments tend to insulate farmers from the market.
7. Currently, modulation among the EU-15 has a small redistributive element. While new member states do not contribute to the system, this exemption expires in 2012.

Chapter 5
The Incidence of US Farm Programs

Julian M. Alston

Abstract Many economists have argued that all farm subsidies are ultimately capitalized in land values. This chapter shows, both theoretically and empirically, that this is not so, although there is much room for disagreement as to the precise shares that accrue to landowners, farmers, and consumers. A review of econometric models in the literature, multimarket simulations, and the application of a sector model of US agriculture yields a range of results about the share of subsidy payments going to land. The truth probably lies in between the results from the static theoretical models with full adjustment and the general run of the econometric evidence. A significant share of even the so-called decoupled transfers goes to farmers rather than landowners, and both landowners and farm operators receive a significant share of the net benefits from subsidies. In an in-between case, based on 2005 market and policy conditions, for every dollar of government spending on farm subsidies, farmers receive about 50 cents, landlords receive about 25 cents, domestic and foreign consumers receive about 20 cents, and 5 cents is wasted. Additional amounts are wasted collecting the taxes to finance the spending and in administering the policies – perhaps another 20 cents.

5.1 Introduction

This chapter presents analysis and evidence on the commodity and factor market consequences of US farm commodity programs and the gains and losses to different groups, with special attention to landowners as recipients of rents generated by programs. This introduction defines the scope of the analysis and summarizes the main findings.

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Studies in Productivity and Efficiency 7, DOI 10.1007/978-1-4419-6385-7_5,

A host of conceptual and measurement issues are involved in estimating and interpreting measures of the consequences of agricultural policies. These issues are sometimes subtle, with implications that are not always appreciated. In addition to differences in measures intended for a given concept and purpose, differences are found because different measures are appropriate for different purposes. For these types of reasons, there is no single set of widely accepted estimates of consequences of farm subsidy policies or even of the parameters of the underlying economic relationships that determine the consequences. For similar reasons, it is useful to define the terms and scope of any particular analysis.

This chapter examines the overall impact of US farm program policies, in a forward-looking way, to consider the implications of continuation of the current farm programs compared with an alternative in which those programs are eliminated – either instantaneously or in some phased-out fashion. I assume explicitly throughout that the policies of other countries are exogenously fixed, even though it would be more reasonable to think that any substantial reform of US farm program policies would be accompanied by changes in other countries, either as a response to the effects of US policies or as part of an agreement among nations to change policies together. Since the analysis involves joint elimination of multiple policies affecting multiple commodities, we must allow for the multimarket interaction effects of own- and cross-commodity policy changes.

A simple and popular theoretical model of the consequences of farm program policies yields clear qualitative results on some aspects of the question, as shown in Section 5.2 of this chapter. Specifically, using a simple two-factor model it can be shown that output subsidies benefit both consumers of agricultural products and suppliers of other inputs used by farmers, not just landowners, unless extreme assumptions are made about (a) the nature of demand for agricultural products (it is perfectly elastic); (b) the supply of land to agriculture (it is fixed), and (c) the technology of production (land and other inputs are used in fixed proportions). Under more realistic assumptions, the issue is not whether all subsidy benefits go to land, but rather, what is the *share* of the benefits that go to land. To say more than this about the distribution of benefits from output subsidies requires empirical work, and empirical results on this issue are mixed.

Theoretical analysis also suggests that a pure decoupled transfer should have little (if any) effect on input use or output and, if that transfer is tied to land, it should be reflected in land rents and should accrue entirely to landowners.[1] Significant elements of US farm program payments implemented in 1996, and still employed, are widely regarded as essentially decoupled payments tied to land. According to the mainstream theory, the benefits from those "direct payments" should be mostly, if not entirely, reflected in land rents and land values. A range of recent empirical work, however, shows that when direct payments change, only a fraction of those changes in benefits – possibly as little as one-quarter – is reflected in changes in land rents in the current period (see, for example, Kirwan, 2007). Hence, at least in the short run, the payments do not entirely accrue to land. One rationale for this finding is that land rents are specified in multiyear contracts, and it may take some years for the market for land to fully adjust to a change in farm program payments (or any other factor affecting farm profitability). However, direct evidence is not yet available, showing that the payments are fully capitalized into land, even in the long run. The finding that changes in direct payments are not fully reflected in changes in land rents might also mean that they are not fully decoupled (that is, that they have some effects on input use and output). Some econometric and other evidence support that view.

These econometric findings, summarized and reviewed in Section 5.3, are at odds with the predictions from our simple static model and must weaken our confidence in predictions from such models more generally until we understand more about why the particular prediction was rejected. At the same time, it is appropriate to question both forms of evidence – from statistical and econometric models versus calibrated theoretical or simulation models – as we attempt to resolve the difference. Certainly the simple static model does not allow for the multiyear nature of cash-rent contracts, and that fact alone may be sufficient to resolve the issue. At the same time, econometric estimates are always open to some questioning; indeed, the range of published estimates reminds us that the estimates are imprecise.

Section 5.4 presents a more disaggregated set of estimates to show the effects, commodity by commodity, of a comprehensive reform of US farm programs. These results, from ABARE (McDonald et al., 2006), indicate that for most of US agriculture, the complete elimination of US farm commodity programs would result in fairly modest changes in production, prices, and value of production. More aggregative estimates are derived from a sector model of farm program crop production, based on 2005 data and policies, and using an approach proposed by Sumner (2005a) for partitioning the different elements of farm program policies into two components: a fully coupled subsidy equivalent and a fully decoupled residual. This model yields comparable results to those from the ABARE model, though larger effects. It indicates that eliminating policies for program crops would result in a 7.3% decrease in output of program crops. In addition, the same model indicates that the output-reducing consequences from the Conservation Reserve Program (CRP) having removed land from production have partially offset the output-enhancing effects of the subsidy programs. Eliminating both the CRP and program crops policies would result in a net 5.0% decrease in output of program crops.

The results from these models are used to develop some “back-of-the-envelope” estimates of deadweight losses associated with US commodity program policies. Since the subsidies have mostly only modest implications for production and consumption, for the most part only modest net national benefits would be achieved by eliminating the net social costs (or deadweight losses) associated with distortions in resource use and production and consumption of agricultural commodities. Program crop subsidies generate a deadweight loss in the range of 2–5% of the total transfer, or about $400–800 million per year, given subsidy expenditure of $16.5 billion in 2005. The social costs of distortions from taxation to finance the transfers are likely to be five to ten times greater than this amount, such that the overall social cost is around $4 billion. The opportunity cost of that money might be higher again. (For instance, it could be used to finance an increase in agricultural research, which has a very high benefit–cost ratio.)

5.2 Models of Agricultural Policy and Land Rents

It is commonly suggested by agricultural economists that the benefits from agricultural subsidies will ultimately be capitalized mostly, if not entirely, into land, as the fixed factor.[2] However, as shown by Alston and James (2002), this view depends on the use of assumptions that are extreme and likely to be inappropriate for most applications.

5.2.1 A Simple Model of Subsidies and Land Rents

Alston and James (2002, pp. 1715–1721) used a simple but general two-factor model of agricultural production to consider the implications of subsidies for land rents.[3] The model includes a final demand, two factor supply equations, a production function to represent the technology for the production of a homogeneous product, Q, using two factors of production, X_1 and X_2, and equations imposing competitive market clearing. The solutions to the model are equations for proportional (or percentage) changes in the endogenous quantities and prices of the product and the two factors (Q, X_1, X_2, P, W_1, and W_2), each as a function of a set of fixed parameters, and exogenous shift parameters representing the effects of policies. The parameters of the model are the cost shares of the two factors (k_1 and k_2, where $k_1 + k_2 = 1$), the elasticities of demand for the product and supply of the two factors (η, ε_1, and ε_2), and the elasticity of substitution between the two factors (σ).

The supply and shift parameters can be used to represent a subsidy on an input or output. In either case, for moderate rates of subsidy, the benefits to consumers are approximately proportional to the percentage change in quantity consumed – $\Delta CS \approx (d \ln Q)(PQ/\eta)$ – and the benefits to suppliers of each factor are approximately proportional to the percentage change in the use of the factor – $\Delta PS_i \approx (d \ln X_i)(k_i PQ/\varepsilon_i)$. The benefits from the subsidies are shared between landowners, other factor suppliers, and consumers even when the quantity of land (input 1) is fixed, unless key parameters take on extreme values: either the price of non-land inputs (input 2) is fixed and there is no producer surplus for its suppliers (that is, $\varepsilon_2 = \infty$) or the factor proportions are fixed (that is, $\sigma = 0$). Under any other circumstances, the total benefit to factors will be shared between land and other inputs; and, if output changes and the output price is not fixed (that is, $\eta < \infty$), consumers will benefit, too. In general, then, we expect the benefits from subsidies to be distributed among consumers and factor owners, with the proportions depending on parameters and the details of the policy. Some more-specific results regarding the benefits to landowners can be obtained by transforming results from Alston and James (2002). In the case of an output subsidy at a rate τ_Q, or an input subsidy on land at a rate τ_1, the equations for proportionate changes in quantities of land are as follows:

$$d\ln X_1 = \frac{\eta\varepsilon_1(\sigma+\varepsilon_2)}{D}\tau_Q, \tag{5.1}$$

$$d\ln X_1 = \frac{[(k_2\sigma+k_1\eta)\,\varepsilon_2+\eta\sigma]\,\varepsilon_1}{D}\tau_1, \tag{5.2}$$

where $D = \varepsilon_1\varepsilon_2 + \sigma(k_1\varepsilon_1 + k_2\varepsilon_2 + \eta) + \eta(k_2\varepsilon_1 + k_1\varepsilon_2) > 0$.

Substituting these results into $\Delta PS_1 \approx (d \ln X_1)(k_1 PQ/\varepsilon_1)$ and then dividing by the cost of the subsidy expenditure (which is equal to $\tau_Q PQ$ for the output subsidy and $\tau_1 W_1 X_1$ for the input subsidy) yields expressions for the benefit to landowners per dollar of subsidy expenditure:

$$\begin{aligned}\frac{\Delta PS_1}{\tau_Q PQ} &= \frac{d\ln X_1 k_1}{\tau_Q\varepsilon_1} = \frac{k_1\eta(\sigma+\varepsilon_2)}{D}\\ &= \frac{k_1\eta(\sigma+\varepsilon_2)}{\varepsilon_1\varepsilon_2+\sigma(k_1\varepsilon_1+k_2\varepsilon_2+\eta)+\eta(k_2\varepsilon_1+k_1\varepsilon_2)}.\end{aligned} \tag{5.3}$$

$$\begin{aligned}\frac{\Delta PS_1}{\tau_1 W_1 X_1} &= \frac{d\ln X_1}{\tau_1\varepsilon_1} = \frac{(k_2\sigma+k_1\eta)\,\varepsilon_2+\eta\sigma}{D}\\ &= \frac{(k_2\sigma+k_1\eta)\,\varepsilon_2+\eta\sigma}{\varepsilon_1\varepsilon_2+\sigma(k_1\varepsilon_1+k_2\varepsilon_2+\eta)+\eta(k_2\varepsilon_1+k_1\varepsilon_2)}.\end{aligned} \tag{5.4}$$

If all of the subsidy benefits go to landowners, these ratios will be equal to 1, but in each case the ratio is less than 1 in general. To see this more clearly, we can consider some limiting cases. First, suppose the demand for output is perfectly elastic such that consumers cannot obtain any of the benefits. Taking the limits of equations (5.3) and (5.4) as $\eta \longrightarrow \infty$ yields:

$$\frac{\Delta PS_1}{\tau_Q PQ} = \frac{k_1(\sigma+\varepsilon_2)}{\sigma+k_2\varepsilon_1+k_1\varepsilon_2}. \tag{5.3$'$}$$

$$\frac{\Delta PS_1}{\tau_1 W_1 X_1} = \frac{\sigma+k_1\varepsilon_2}{\sigma+k_2\varepsilon_1+k_1\varepsilon_2}. \tag{5.4$'$}$$

By inspection, these ratios are less than 1, in general. In the extreme case where the supply of land is fixed (that is, $\varepsilon_1 = 0$), all of the benefits from an input subsidy on land would accrue to landowners, regardless of the elasticity of factor substitution and regardless of the elasticity of demand. However, in the case of an output subsidy, we require both a fixed output price (that is, $\eta = \infty$) and fixed factor proportions (that is, $\sigma = 0$) as well as a fixed supply of land before the subsidy expenditure will accrue entirely as a benefit to landowners.

This simple model illustrates some key determinants of the extent to which farm program payments accrue to landowners versus others, treating the output from agriculture as a single homogeneous product, produced using homogeneous land, and with a given subsidy applying to all of land or all of the output. US agriculture is more complicated than that, with heterogeneous land used to produce many different outputs that are subject to a variety of complex policies involving multiple instruments. As an approximation, however, we can apply the simple model to

US agriculture in aggregate and look at the incidence of output or input subsidies on landowners. What might be reasonable values for the parameters in this case? Useful direct econometric evidence is not available for any of the parameters, but subjective estimates can be made. First, demand for US agricultural output is probably elastic but not very elastic, reflecting highly elastic demand for some traded goods and inelastic demand for some nontraded goods. Second, the supply of land in total may be essentially fixed, but the supply to agriculture is variable, as it can be allocated between agriculture and forestry and other nonagricultural uses. Third, the supply of "other" inputs to agriculture is more elastic than that of land but less than perfectly elastic, reflecting the specialized nature of some agricultural inputs, including managerial inputs and some capital.

In view of these arguments, and further arguments and econometric evidence presented by Alston (2007, appendix B), the following values seem reasonable for the key parameters of the model: elasticity of demand for US aggregate farm output, $\eta = 1.0$; elasticity of supply of land, $\varepsilon_1 = 0.1$; elasticity of supply of the aggregate "other" input used in agriculture, $\varepsilon_2 = 1.0$; cost share of land in total costs of agricultural production, $k_1 = 0.20$; cost share of "other" inputs in total costs of agricultural production, $k_2 = 0.80$; and elasticity of substitution between land and the aggregate "other" input, $\sigma = 0.10$.[4] Substituting these values into equations (5.3) and (5.4), landowners would receive 39 cents per dollar of output subsidy expenditure and 68 cents per dollar of input subsidy expenditure applied to land. Holding the other parameters constant but assuming a fixed supply of land ($\varepsilon_1 = 0$), the landowner would receive 58 cents per dollar of output subsidy expenditure but 100% of the land subsidy expenditure.

Table 5.1 shows how benefits to landowners as a percentage of subsidy expenditure change as we change the elasticities of demand, factor substitution, and supply of land (η, σ, and ε_1) holding the other parameters (the elasticities of supply of non-land inputs and the factor shares, ε_2 and k_1) constant. In addition, this table includes corresponding estimates of benefits to consumers as a percentage of subsidy expenditure. The residual amount approximates the share of benefits to suppliers of non-land inputs (after allowance for deadweight loss). The results are intuitive. The share of benefits going to land from either an output subsidy or an input subsidy on land increases with reductions in the elasticity of supply of land or with increases in either the elasticity of substitution between land and non-land inputs or the elasticity of demand for agricultural output, either of which implies an increase in the elasticity of the derived demand for land. In the extreme case of a fixed supply of land, landowners receive 100% of the benefits from an input subsidy but only 33–62% of the benefits from an output subsidy. Allowing for some elasticity of supply of land (with $\varepsilon_1 = 0.1$), landowners would receive 60–80% of the benefits from an input subsidy on land or 24–44% of the benefits from an output subsidy, depending on the values for the other parameters.

A more realistic view of the incidence of US agricultural subsidy programs might be obtained by modeling program crops that receive the bulk of subsidy expenditure, as opposed to all of agriculture. Even if the total supply of land were fixed, the supply of land to the cropping industries would not be so. If we reinterpret the model

Table 5.1 Implications of key parameters for the incidence of farm programs

Elasticity			Economic surplus change as a share of subsidy expenditure			
			Input subsidy		Output subsidy	
ε_1	σ	η	Consumers	Landowners	Consumers	Landowners
			%	%	%	%
0.0	0.2	0.5	0	100	44	33
		1.0	0	100	29	43
		1.5	0	100	21	47
	0.1	0.5	0	100	35	48
		1.0	0	100	21	58
		1.5	0	100	15	62
0.1	0.2	0.5	24	71	52	24
		1.0	16	75	35	32
		1.5	12	77	27	37
	0.1	0.5	30	62	49	30
		1.0	20	68	32	39
		1.5	15	70	24	44
0.2	0.2	0.5	37	56	57	19
		1.0	26	60	40	26
		1.5	20	63	30	30
	0.1	0.5	43	45	55	21
		1.0	30	51	38	30
		1.5	23	54	29	34

Note: The parameters varying here are the elasticity of demand for US agricultural output, η, the elasticity of substitution between land and non-land inputs, σ, and the relevant elasticity of supply of land, ε_1; other parameters being held constant are the elasticity of supply of non-land inputs, $\varepsilon_2 = 1.0$, and the share of land rent in total cost of production, $k_1 = 0.20$. The incidence shares for the input subsidy are computed using the equations in Alston (2007, appendix A)
Source: Alston (2007, appendix A)

above as representing the program crop sector of US agriculture, rather than agriculture as a whole, the main implied difference would be to increase the elasticity of supply of land to the sector (say 0.2 rather than 0.1 or zero). The other parameters may be about the same. Using these alternative parameters ($\eta = 1.0$, $\sigma = 0.1$, $\varepsilon_1 = 0.2$, $\varepsilon_2 = 1.0$, $k_1 = 0.20$), landowners would receive 30 cents per dollar of output subsidy expenditure and 51 cents per dollar of input subsidy expenditure applied to crop land.[5]

5.2.2 *Implications of Rental Market Institutions*

As well as simplifying the nature of supply of land to agriculture or to the cropping sector, the analysis presented above has been based on some simplifying implicit assumptions about the function of the land rental markets and farm program policies. Almost half of all US farmland is leased, and US policy specifies how farm program payments – such as direct payments or countercyclical payments – may be distributed in the first instance between farm operators versus farm owners. Sherrick and Barry (2003) reported that in 1999, 45.3% of farmland was leased and, of that amount, 59.4% was for cash rent. If a lease arrangement meets the technical definition of a "cash" lease under federal regulations, then the farm program payments must go entirely to the farm operator; the landlord is not eligible to receive any payments. Otherwise, under a share lease arrangement, the same subsidy payments *must* be divided between the landlord and the tenant. Thus, if subsidy payments increase unexpectedly in the presence of preexisting leases, tenants holding cash leases will capture all of the benefits (and their landlords will receive none), whereas tenants holding share leases will share the same benefits with their landlords. Of course these regulations govern only the initial distribution of the subsidy payments between landlord and tenant, which is different from the final incidence after markets have adjusted in response to the subsidies. Ultimately, other things being equal, one would expect the rates of cash rent eventually to adjust to equivalence with the corresponding share lease rate.

The competitive market model implicitly has rental markets for farmland clearing continuously. However, rental arrangements are typically multiyear in nature (for example, typical contracts may fix a rental rate that will apply every year for a 3-year term) and may reflect long-term personal relationships, often among members of the same family. Competitive pressures might not take full and immediate effect in such a setting.[6] Further, the fact that information on crop yields and sales prices is incomplete and held asymmetrically may mean that landlords do not always have good knowledge of how much their tenants are receiving in government payments or what would be their fair share. In these circumstances, rental payments to landowners (as landlords) may adjust incompletely and sluggishly to changes in farm program payments. Thus, the short-run may differ from the long-run incidence, with less of the incidence on land than predicted by our simple model, and the difference between the short run and the long run may take several years to work through.

5.3 Econometric Evidence on the Incidence of US Farm Program Policies

The recent published literature includes a number of econometric studies of impacts of farm commodity policies on land markets, mainly in the United States. This section reviews the evidence from these studies.[7] An overview of key points that are relevant in interpreting the published work is provided first. Some of these points relate to what our theoretical models suggest about the relationships between policies and land markets; others relate to the econometric problems likely to be encountered in looking for evidence about those relationships.

5.3.1 Key Points for Interpreting the Econometric Findings

First, the details of policies matter. Real-world farm program policies tend to be complicated, involving multiple instruments working in concert, none of which are exactly the same as the stylized textbook counterparts presented here. Hence, even when payments are fully decoupled, whether the payments are fully reflected in land rents or capitalized into land values may depend on other details of the policy. But real-world policies for the most part are not fully decoupled, and their final incidence will also depend on the extent to which the incidence is shifted through changes in input use and output, which will depend in turn on details of the policies and parameters of supply and demand and so on. As a consequence, we have to be careful in generalizing about the likely transmission of subsidies into land rents and land values. Econometric studies often require some aggregation across different types of subsidies in ways that may cause problems if the nature of the subsidies varies across the observations (for example, the mixture of forms of subsidies varies in a cross section or the details of the instruments change over time). To what extent are results influenced by how policies are represented in the models?

Second, formal and informal land rental contracts mean that the transmission of changes in policy into rental prices and asset prices for land is not instantaneous. Sluggish adjustment of rental rates means that the short- and intermediate-run incidence of policies (and the extent to which subsidies are decoupled) will be different from the long-run outcome with complete adjustment. Even without contracting, the market involves lags and dynamics and uncertainty and expectations, from which our simple models typically abstract. Because contracts are established well in advance of market realizations, some of our measures do not precisely correspond to the theoretical constructs they are meant to represent. For instance, our theoretical model might correspond to the relationship between land rents and expected values of subsidies under risk-neutral preferences or certainty, but the land rents are set ex ante and the subsidies we observe are ex post. Further, data on land rents and land values are often based on expert assessments rather than the direct evidence from market transactions. These assessments are likely to understate the true movements in rental prices associated with year-to-year variations in income received from the market or the government. Both these factors will mean that short-term movements in observed rental prices will tend to understate the long-term impact of a permanent change in subsidies. How well have studies dealt with unobservable expectations and what are the implications for their findings?

Third, models that attempt to measure the extent to which subsidies are capitalized into asset prices of land combine the problems associated with modeling impacts of subsidies on land rents with the (probably more serious) econometric problems that arise in modeling the asset price of land. On the other hand, the sluggish short-term adjustment of land rents that confounds the rental market models may be less of an issue in land market models since land prices should reflect longer-term expectations.

Fourth, econometric studies of land-market implications of agricultural subsidies have involved either aggregative time-series data (where the unit of analysis is a state or a nation) or disaggregated cross-sectional data (where the unit of analysis is a farm firm). Both approaches involve some general problems. In aggregate time-series studies, the fundamental problem may be simply lack of data, which compounds a lack of confidence over whether the model structure is right or whether the empirical proxies for theoretical constructs are reasonable, and thus how to interpret the estimated model. In cross-sectional studies, the primary econometric issues appear to be related to dealing with the roles of unobserved factors (such as farm-specific weather and soil fertility that determine the farm's history and thus its eligibility for subsidies as well as its current production mix and productivity) in jointly influencing land rents, land prices, and agricultural subsidies – manifested as identification problems.

Many of these aspects are discussed by various authors who have studied impacts of farm programs on land markets, such as Goodwin et al. (2003b), Lence and Mishra (2003), and Roberts et al. (2003). Much of the work in the literature has been concerned with finding solutions to these conceptual and measurement problems or with drawing inferences for the interpretation of findings. The main findings are discussed next.

5.3.2 Evidence on Farmer Responses to Decoupled Payments

A variety of approaches have been applied to the problem of estimating the impact of decoupled payments on farmer decision making, including simulation models and direct econometric estimation using various types of data. The general conclusion from the relevant empirical literature appears to be that decoupled program payments – such as direct payments – have statistically significant effects on farmer behavior. The magnitude of these effects varies from study to study, however, and econometric issues remain. The crux of the problem is that nonprogram farms will not likely serve as a valid comparison group in any investigation of program impacts, and it is unclear to what extent analysts are able to control for unobserved heterogeneity. Fixed-effects models are certainly an improvement on ordinary cross-sectional regressions, but their conclusions are valid only to the extent that differences between program and nonprogram farms are time invariant; it is not clear that this will be the case. Although the evidence generally indicates that decoupled payments do have some effects on farmer behavior, the evidence is mixed on the size of the effects. In Section 5.4, specific parameterizations are used to represent these effects, allowing for comparatively large effects of so-called decoupled payments, more consistent with the findings of Key et al. (2005).

5.3.3 Effects of Program Payments on Land Rents and Land Prices

The attempts made by analysts to estimate the impact of program payments on land rents and land prices can be broken down into two broad categories. In the first approach, the present value (or asset price) of land is modeled as a function of government payments and other explanatory variables.[8] While estimated elasticities of land prices with respect to program payments from these studies are often small, the total share of land value determined by support payments can be quite large. The second approach uses farm-level variation in government payments and farm revenues to explain variation in land rents, controlling for observable covariates and fixed effects when panel data are available. The studies using this approach face the same hurdles as the nonexperimental, cross-sectional studies of decoupled payments outlined above: econometric problems associated with unobserved heterogeneity, errors in variables, and other potential sources of bias.[9]

The econometric literature on the incidence of farm subsidies on land values indicates that while landowners certainly benefit from support programs, they do not appear to capture the full value of subsidies, at least in the short to medium run. That this is so is not surprising in relation to subsidies generally. However, much of the econometric work relates to forms of subsidies that we would expect to have most if not all of their final incidence on land, and those studies generally have found a surprisingly small share of subsidy benefits going to landowners. The works by Kirwan (2005, 2007) and Roberts et al. (2003) are good examples. The authors have made exhaustive attempts to identify and address potential sources of econometric bias, but their estimates of the multiplier for decoupled subsidies are still well less than half the size that standard theory would predict. One possible interpretation is that the authors are estimating an intermediate-run effect, which is smaller than the long-run effect, because of fixity associated with contracts or because of roles played by expectations or other dynamics. An implication may be that the so-called decoupled subsidies are much less decoupled than is commonly thought: that is, the subsidies are being transmitted to other non-land inputs or consumers with consequences for production and consumption. Alternatively, the estimates may be biased because, notwithstanding their comprehensive efforts, the authors have not fully resolved the econometric issues that they identified.

5.4 Consequences of the Elimination of US Farm Program Policies

This section presents some quantitative results on the potential implications of comprehensive reform of US farm program policies. ABARE staff (McDonald et al., 2006) simulated the consequences of elimination of US farm program policies. An overview of their results is presented first, and then supplemented with a sector model analysis of farm program crop production based on 2005 data.

5.4.1 ABARE Analysis of Omnibus Reforms

McDonald et al. (2006) published an ex ante analysis of the implications of a phased elimination of US farm program policies over 10 years, 2007–2016. They considered various scenarios. For simplicity, consideration here is limited to the scenario in which the policies remained at status quo in all other countries and in which the reform did not engender enhanced productivity growth. The published report does not include full details of the results for the scenarios simulated. However, ABARE staff generously provided unpublished details on the implications for prices and quantities produced and consumed. Table 5.2 reports selected results, showing the impacts in the last year of the simulation, 2016, from elimination of policies beginning in 2007. The results in Table 5.2 reflect assumptions about the baseline of world prices and US policies and thus the extent of the US market adjustments that would be required to accommodate the elimination of the programs. They also reflect modeling details such as elasticities of supply and demand response to price changes, elasticities of price transmission, and the specific mathematical representation of policies, with corresponding assumptions about the extent to which elements of subsidies are decoupled. These details are not known to me. However, the estimated changes in quantities and prices in Table 5.2 seem plausible enough, given a baseline that was established in 2006, before the more-recent commodity price increases.[10]

Table 5.2 ABARE results on consequences of elimination of US policies, 2016

	Output	Price	GVP
	(% difference from baseline)		
Soybeans	−2.86	−1.14	−3.97
Wheat	−7.58	1.52	−6.18
Maize	−3.79	0.26	−3.54
Rice	−11.71	−3.87	−15.13
Cotton	−13.88	−6.10	−19.13
Cane and beet	−33.31	−15.30	−43.51
Fruit and vegetables	4.42	−5.16	−0.96
Beef cattle	1.44	−3.31	−1.92
Pigs and poultry	0.41	−0.01	0.39
Milk	−0.45	−0.01	−0.46

Source: Alston (2007). Underlying data were provided by Vernon Topp, ABARE, December 2006, personal communication. Effects refer to elimination of U.S. farm programs as represented in McDonald et al. (2006), ABARE Research Report 06-10, Scenario 1

Looking across commodities, the pattern of results for 2016 is consistent with expectations based on general knowledge of the US farm program policies. For most of the commodities, the effects of elimination of farm programs on price, quantity, and value of production would be modest: less than 5% of the baseline for corn, soybeans, fruit and vegetables, and all of the livestock products. The effects would be larger for wheat (but still modest, a reduction of less than 10% in quantity and value of production). Only the heavily supported rice, cotton, and sugar industries would experience changes in quantity and value of production greater than 10% of the baseline – and only sugar, more than 15%. The directions of changes in quantity are plausible: reductions in output for all crops except fruit and vegetables; increases in output for livestock products except dairy. The withdrawal of support would result in lower prices as well as lower quantities produced for rice, cotton, sugar, and milk. Some of the other price changes are less obvious, reflecting complex cross-commodity effects as well as own-commodity policy effects in the multimarket setting. For instance, the movement of resources into the fruit and vegetable industry, in response to lower relative profitability of program crops, would result in an increase in production and consequently a lower price of fruit and vegetables; similar patterns apply for beef, pigs, and poultry but for less-clear reasons; the converse is the case for wheat and maize.

5.4.2 A Sector Model Analysis of Farm Program Consequences

An alternative approach to evaluating the impact of subsidies is to use a sector model approach. In this section, a sector model approach is applied to the main program crops, using data on program payments for 2005 combined with an approach proposed by Sumner (2003, 2005a, b) for representing different elements of program payments as equivalent amounts of revenue from the market (or fully coupled output subsidy equivalents) in terms of their production incentive effects. For both corn and upland cotton, Sumner has reviewed, case by case, the types of incentive effects different elements of farm program payments would have, and derived multipliers to be applied to the different forms of subsidy to represent their differential incentive effects relative to revenue from the market.

The case of corn provides a useful introduction to the approach. In this case, Sumner (2005a) argued that loan program payments (including loan deficiency payments, marketing loan gains, and certificate exchange gains) are closely tied to production and could be treated as equivalent to a pure output subsidy. In contrast, direct payments are significantly decoupled from production, but Sumner offers four reasons for why direct payments have effects on production: through lowering a recipient's cost of capital; through increasing a recipient's tolerance of market risk; because of limitations on what may be grown on program acreage; and because of the expectation that payment bases will be updated. He derived a multiplier of 0.40 for direct payments to corn growers, which means that a dollar of direct payments has the same effect on production as 40 cents from the market. In other words, in our models we can represent a dollar of direct payments, equivalently, as a decoupled payment of 60 cents and an output subsidy of 40 cents. Countercyclical payments fall in between these two, and Sumner suggested a multiplier of 0.50 to be applied to countercyclical payments for corn. In each instance, he argued that the multiplier was conservatively small. In what follows, the same multipliers are applied to the other program crops as well.

Table 5.3 shows crop-by-crop details and in total of government subsidy payments to program crops in 2005. Total government payments in 2005 of $24.3 billion included a range of payments (such as ad hoc and emergency program payments or tobacco transition payments) that we would not include in our measure of subsidies in the current context. Subsidies to producers of program crops

Table 5.3 Commodity program payments in crop year 2005, by commodity – subsidy rates

			Subsidy payments[b]					Subsidy rate	
Program crop	Crop acres[a] (A)	Crop value (V)	DP	CCP	LPP	TS_1	TS_2	$(100 \times TS_1/V)$	$(100 \times TS_2/V)$
	millions			*$ millions*				%	%
Corn	75.11	21,041	2,109	2,948	4,600	9,657	6,918	45.9	32.9
Soybeans	71.25	16,928	598	0	19	617	258	3.6	1.5
Upland cotton	13.53	5,204	611	1,376	371	2,358	1,303	45.3	25.0
Wheat	50.12	7,140	1,136	0	1,036	2,172	1,490	30.4	20.9
Rice	3.36	1,789	425	87	130	642	344	35.9	19.2
Other crops[c]	104.43	5,696	375	414	288	1,077	645	18.9	11.3
Total[d]	317.80	57,798	5,254	4,824	6,444	16,522	10,958	28.6	19.0

Notes: *DP* is direct payments, *CCP* is countercyclical payments, *LPP* is "loan program payments," which includes loan deficiency payments, marketing loan gains, and certificate exchange gains

[a]Harvested acres

[b]TS_1 is the simple sum: $TS_1 = DP + CCP + LPP$ and $TS_2 = (0.4 \times DP) + (0.5 \times CCP) + (1.0 \times LPP)$ is the weighted sum, where each weight represents an estimate of the equivalent rate of output subsidy per dollar of payment

[c]Other crops includes other program crops: feed grains (barley, oats, grain sorghum), peanuts, oilseeds (sunflower seed oil, other minor oilseeds, canola, rapeseed, mustard seed, safflower seed, crambe, sesame), lentils, chickpeas, dry edible peas, wool, mohair

[d]The total crop value figure includes the US value of production data for food grains, feed crops, cotton, and oil crops, as reported by USDA

Source: Compiled by the author with assistance from Henrich Brunke using data from the USDA NASS Agricultural Statistics Database (http://www.nass.usda.gov/#top), the USDA Economic Research Service Farm Income Database (http://www.ers.usda.gov/Data/FarmIncome/finfidmu.htm), and the Commodity Estimates Books for the 2007 President's Budget (http://www.fsa.usda.gov/FSA/webapp?area=about&subject=landing&topic=bap-bu-ce)

included \$5.25 billion in the form of direct payments (DP), \$4.82 billion in the form of countercyclical payments (CCP), and \$6.44 billion in the form of loan program payments (LPP, including loan deficiency payments, marketing loan gains, and certificate exchange gains), together totalling \$16.5 billion. Production of program crops had a value in 2005 of about \$58 billion and used 318 million acres such that the payments were equal to 28.6% of the value of production, or \$52 per acre of program crops nationally. In addition to the simple sum of program payments, the total subsidy (TS_1), the table includes a weighted sum of payments (TS_2), given by applying the weights (0.4, 0.5, and 1.0) to the respective elements of payments (DP, CCP, and LPP): $TS_2 = 0.4 \times DP + 0.5 \times CCP + LPP$. These subsidy amounts are expressed relative to the value of production in the last two columns of the table. The entries in the final column, $100 \times TS_2/V$, represent the percentage output subsidy equivalent of the payments. The last entry in that column represents the average rate of subsidy equivalent, in terms of the incentive effects, for the commodities in the table: 19.0%.

Applying that subsidy rate in the two-factor model, with parameters representing program crops as a whole ($\eta = 1.0$, $\sigma = 0.1$, $\varepsilon_1 = 0.2$, $\varepsilon_2 = 1.0$, $k_1 = 0.20$), the implied effect of eliminating the programs would be a reduction in production of these crops by 7.3%.[11] This estimate is comparable to (albeit implying larger effects than) the corresponding estimates from the ABARE (McDonald et al., 2006) model, which ranged from 2.9 to 13.9% for the crops considered here but were only 2.9 and 3.8%, respectively, for soybeans and maize (which together represent two-thirds of the value of production). The implications are similar: the total output effects of elimination of subsidies would be modest, even for the most-subsidized crops.

The direct net benefit (deadweight loss avoided) is correspondingly small. As shown by Alston (2007, appendix E), the deadweight loss from distortions in production and consumption resulting from an output subsidy, expressed as a percentage of the subsidy expenditure, is proportional to the percentage subsidy-induced change in production. Using the same parameters for program crops in the two-factor model (that is, $\eta = 1.0$, $\sigma = 0.1$, $\varepsilon_1 = 0.2$, $\varepsilon_2 = 1.0$, $k_1 = 0.20$) and allowing for the role of international trade, the proportion to be applied to the percentage increase in production is in the range of 0.5–1.0. Thus if elimination of subsidies at an average rate of 19% (in incentive effect) would yield a 7.3% increase in production, it would yield net gains to society in the range of 3.6–7.3% of the amount of effective subsidy expenditure of \$10.96 billion in 2005 (that is, in the range of \$400 million to \$800 million; 2–5% of the actual subsidy expenditure of \$16.52 billion; 0.7–1.4% of the value of program crop production of \$58 billion). Of course, the total deadweight loss is much bigger if we allow for any significant deadweight losses associated with general taxation to raise the government revenues to finance subsidies (that is, a social opportunity cost of government revenues significantly greater than \$1.00 per dollar spent – say \$1.20 per dollar). When these additional deadweight losses are added to the full subsidy expenditure of \$16.52 billion in 2005, the total deadweight loss is about \$4 billion.

5.4.3 CRP Acreage

Suppose, in 2005, the Conservation Reserve Program was eliminated and an additional 35 million acres of CRP land were added to the 442 million acres of cropland used, which is a 7.8% increase in crop acreage. Applying that percentage increase in supply of land in the model from Section 5.2, with parameters representing program crops as a whole (that is, once more, $\eta = 1.0$, $\sigma = 0.1$, $\varepsilon_1 = 0.2$, $\varepsilon_2 = 1.0$, $k_1 = 0.20$), the implied effect would be an increase in production of these crops by about 2.3%. Thus, if the CRP were eliminated along with crop subsidies, the net effects on output would be smaller, compared with eliminating the subsidies alone, but still negative – an output reduction of around 5%.

5.4.4 Incidence on Land Rents

In 2005, cropland rented for about \$80 per acre as a national average (but closer to \$120 per acre in the Midwest, and cropland rents represented about 20–25% of the value of production, which is less than the value of subsidies as a percentage of production. Thus, if all of the payments had been fully reflected in land rents, income from the market would have accounted for only a small (possibly negative!) share of the income to land; government payments would have accounted for the lion's share. However, we would not expect all of the subsidy payments to go to land.

Table 5.4 replicates some information from Table 5.3. It includes, crop by crop, the total subsidy amount (TS_1) and the fully coupled equivalent (TS_2) as well as the difference between these two ($TS_3 = TS_1 - TS_2 = 0.6 \times DP + 0.5 \times CCP$), which represents the amount of the total subsidy that can be treated as a pure decoupled payment that goes to land. Having partitioned the total subsidies into

Table 5.4 Commodity program payments in crop year 2005 – equivalent subsidy per acre

Program crop	Crop acres (A)	Crop value (V)	Subsidy payments[a] TS_1	TS_2	TS_3	TS_4	Subsidy/acre (TS_1/A)	(TS_4/A)
	millions			*\$ millions*			*\$/acre*	
Corn	75.11	21,041	9,657	6,918	2,739	4,815	128.58	64.10
Soybeans	71.25	16,928	617	258	359	436	8.67	6.12
Upland Cotton	13.53	5,204	2,358	1,303	1,055	1,446	174.20	106.85
Wheat	50.12	7,140	2,172	1,490	682	1,129	43.34	22.52
Rice	3.36	1,789	642	344	299	402	190.84	119.51
Other crops	104.43	5,696	1,077	645	432	626	10.31	5.99
Total	317.80	57,798	16,522	10,958	5,564	8,852	51.99	27.85

Notes: See notes to Table 5.3
Source: See Table 5.3

an element that can be treated as a fully coupled output subsidy (TS_2) and a residual that can be treated as a fully decoupled payment (TS_3), we can analyze the impacts on landowners. The total benefits to landowners are equal to the benefits from the fully decoupled element (TS_3) plus the amount going to land from the fully coupled element (μ TS_2, where μ is the share going to land): $TS_4 = TS_3 + \mu\ TS_2$. In the two-factor model, with parameters representing program crops as a whole ($\eta = 1.0$, $\sigma = 0.1$, $\varepsilon_1 = 0.2$, $\varepsilon_2 = 1.0$, $k_1 = 0.20$), the implied value for μ is 30.0%. This value is used to compute the values for TS_4 in Table 5.4. These amounts are expressed relative to the value of production and per acre. Again, the last row expresses these subsidies summed across the program crops included in the table. Taking this approach, the total of \$16.52 billion is equivalent to a decoupled transfer of \$5.56 billion, 100% of which accrues to land, combined with a pure output subsidy of \$10.96 billion, 30% of which accrues to land. The overall incidence is therefore about \$8.85 billion on land and \$7.65 billion on suppliers of non-land inputs and consumers.

We can replicate this kind of analysis at the level of US states, given information on the total government payments, on the value of agricultural production, and on cash rents to land. Appendix Table 5.5 shows the details, state by state and in total. Considering the last three columns, we can compare the cash rent (R) with the total subsidy per acre of cropland (TS_1/A) in the third-last column, or the weighted subsidy per acre of cropland as an estimate of the subsidy accruing to land (TS_4/A) in the second-last column. To facilitate this comparison, Fig. 5.1 plots the unweighted (TS_1/A) and weighted (TS_4/A) payments per acre versus cash rents.

In most (but not all) of the states, the total subsidy per acre of cropland (TS_1/A) is less than cash rents per acre, but often it is large relative to the total cash rents, and sometimes implausibly large as a measure of the incidence of the subsidy on land rents. On that basis, these simple comparisons alone are sufficient to question the view sometimes expressed that all subsidy payments end up in land rents. On the other hand, the estimate of the subsidy accruing to land (TS_4/A) is typically about one-half to one-third of the total cash rent, which is plausible.

These results provide a useful background for the interpretation of the results from econometric studies that have attempted to draw direct statistical inferences about the effects of farm program payments on land rents or land prices and the related econometric work that has attempted to measure the extent to which farm program payments are decoupled from production. The econometric studies in this area have found that subsidies that we might expect to be mostly, if not fully, decoupled do have some effects on production and resource use, although the quantitative effects of these responses were fairly small in some cases. Much of this work is consistent with the view that the so-called decoupled transfers really do not have much effect on production and would be expected to be distributed for the most part as returns to landowners and in land rents. On the other hand, some studies found larger effects of these subsidies on production, and most econometric studies of the land market found surprisingly small effects of subsidies on land rents and land values.

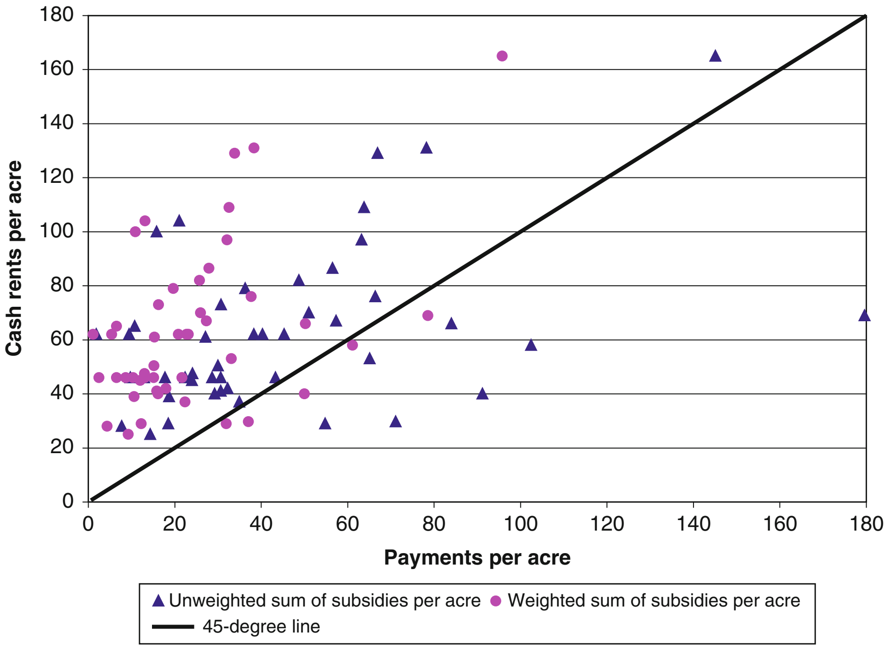

Fig. 5.1 Cash rent versus farm program payments per acre, by State, 2005. *Source*: Based on data in the last three columns of Appendix Table 5.5 Note: Excludes California and Washington

5.5 Conclusion

This chapter has discussed theory and evidence on the incidence of US farm commodity programs. Specifically, it has attempted to answer the question: What are the impacts of agricultural subsidies on consumers, taxpayers, and landowners (as opposed to farm operators, who may be seen by some as the intended recipients of subsidy payments)? The focus of the question is contemporary or forward looking and holistic, referring to the full impact of all of the programs together, allowing for the interactions among all the affected markets for agricultural products and factors.

Simple theoretical models, following Floyd (1965), can be used to illustrate how different types of subsidy policies have different incidence. Analysis with such models indicates that we should expect a fully decoupled payment attached to land to be reflected entirely in land rents and capitalized fully into land. Under extreme assumptions (such as a fixed supply of land), the same would be true of an input subsidy on the use of land. More generally, however, even a subsidy on land will have some effects on input combinations and output and thus the incidence will be shifted partly to suppliers of non-land inputs and consumers. A subsidy on output is expected to have even less of its incidence on land and more of it on consumers and suppliers of non-land inputs, but still it will have a disproportionate incidence on landowners as the suppliers of the least elastic factor of production. Consequently, with some plausible values for the relevant parameters, based on theoretical analysis alone we might rank instruments in terms of their approximate incidence on landowners versus others as follows: decoupled direct payment tied to land, 100% to landowners; land input subsidy, 45–77% to landowners, depending on the details of the case; output subsidies, 1–45% to landowners, depending on the details of the case. The specific details of actual policies matter for incidence. Real-world policies are typically not pure output subsidies or pure input subsidies; they often combine multiple instruments together, and even the direct payments policies may not be fully decoupled. Nonetheless, the abstract theoretical analysis of stylized policies provides some guidance as to the range of incidence outcomes we might expect from real-world policies, and it gives a basis for interpretation of the results from empirical work with models of land markets.

Econometric studies generally have found a surprisingly small share of subsidy benefits going to landowners. The work by Roberts et al. (2003) is a good example. The authors have made exhaustive attempts to identify and address potential sources of econometric bias, but their estimates of the multiplier for decoupled subsidies are still well less than half what the static theory would predict. One possible interpretation is that the authors are estimating an intermediate-run effect, which is smaller than the long-run effect, because of fixity associated with contracts or because of roles played by expectations or other dynamics.

A direct analogy can be drawn between this finding and the more general findings about the elasticity of supply response to output prices. Synthetic models based on theory and assumptions about parameters generally yield much larger elasticities of supply response than econometric models do. A reasonable interpretation is that the synthetically estimated elasticities are too high and that the econometrically estimated ones are too low to represent long-run responses; though they might well represent intermediate-run or short-run responses (for instance, see Cassels, 1933). In the context of supply response, there is no such thing as "the" elasticity; it depends on the length of run. Similarly, perhaps we should not think of "the" multiplier effect of farm programs on land rents and should identify the relevant length of run for particular estimates.

The share of subsidy payments going to land remains uncertain. The truth probably lies in between the results from the theoretical models and the general run of the econometric evidence: A significant share of even the so-called decoupled transfers goes to farmers rather than landowners, and both landowners and farm operators receive a significant share of the net benefits from subsidies. To make matters concrete, the evidence is generally consistent with a view that 40–60% of subsidy payments accrue as benefits to landowners, 20% to consumers, and 15–35% to farmers per se, with a modest amount – say 5% – wasted as a deadweight loss (more if we count benefits to foreign consumers as a loss to the United States, and more again if we count the deadweight loss of taxation).

In round figures, then, perhaps 75% of the subsidy expenditure accrues as a benefit to farm operators and landlords. Given that farmers collectively own about half the land that they farm, farmers receive about half of the total that goes to landowners, leaving 20–30% to nonfarmer landlords. Thus, 45–55% of the total subsidy expenditure accrues as a benefit to farm operators. In short, for every dollar of government spending on farm subsidies, farmers receive about 50 cents, landlords receive about 25 cents, domestic and foreign consumers receive about 20 cents, and 5 cents is wasted. Additional amounts are wasted collecting the taxes to finance the spending and in administering the policies – perhaps another 20 cents. If the purpose is to transfer income to farmers, the mechanism is very inefficient, with less than half of the amount taken from taxpayers ending up with the intended recipients.

Acknowledgments This chapter is drawn from work undertaken in the context of the American Enterprise Institute project, led by Bruce Gardner and Daniel Sumner, The 2007 Farm Bill and Beyond (http://aic.ucdavis.edu/research/farmbill07/aeibriefs/20070515_alstonSubsidiesfinal.pdf), as reported in my AEI paper (Alston, 2007), on which I was assisted by Matt Andersen, Henrich Brunke, Antoine Champetier de Ribes, Conner Mullally, and Sebastien Pouliot.

Notes

1. By definition, "decoupled" transfers are meant not to have any effects on input use and production and therefore should not have any effects on markets for factors or products.
2. For example, see Rosine and Helmberger (1974); Gisser (1993).
3. The model is described by Alston and James (2002, pp. 1715–1721), and Alston (2007, appendix B). An equivalent model was used by Floyd (1965) for a similar purpose; see, also, Gardner (1987, 2003).
4. Floyd (1965, p. 155) suggested values for these parameters of $\eta = 0.25$–0.50, $\sigma = 0.5-1.5$, $\varepsilon_1 = 0$, $\varepsilon_2 = 1.0-3.0$, $k_1 = 0.20$ (and $k_2 = 0.80$).
5. These parameters imply an elasticity of supply of program crops in aggregate of 0.45. If, alternatively, we assume an elasticity of supply of land of 0.3, and a cost share of land of 0.3, the implied elasticity of supply of program crops is 0.5.
6. Uchtman (2006) and Johnson et al. (2007) illustrate the reality of complications with farmland leases and how they may be renegotiated when circumstances change and, reading between the lines, how rental contracts may be expected to adjust sluggishly to changes in the market.
7. Alston (2007, appendix D) provides a more complete discussion of the published work.
8. Examples of this approach include Goodwin and Ortalo-Magné (1992); Weersink et al. (1999); and Shaik et al. (2005).
9. Examples include Gardner (2003); Goodwin et al. (2003a, b); Lence and Mishra (2003); Roberts et al. (2003); and Kirwan (2005, 2007).
10. The baseline is crucial. If the baseline had been set based on an extrapolation out to 2020 of market prices for commodities in 2007 or 2008, which are above support prices because of high oil prices and the enhanced demand for use of program crops for biofuels, then the measured consequences of the US farm program policies would be negligible. The ABARE baseline apparently reflects market conditions that had applied reasonably recently, but not currently, and which may well be an appropriate view of "normal" conditions in the longer-term future to which their estimates apply.
11. These parameters together imply an elasticity of supply of program crops in aggregate of 0.62.

Appendix

Table 5.5 Program payments versus cash rents in crop year 2005, by state

State	Crop acres (A)[a]	Subsidy payments[b]					Subsidy rate[c]		Cash rent (R)
		DP	CCP	LPP	TS_1	TS_4	(TS_1/A)	(TS_4/A)	
	1000s			*$ millions*				*$/acre*	
Alabama	2,037	42.7	80.7	62.3	185.7	101.9	91.2	50.0	40.0
Arizona	730	35.2	66.6	4.2	105.9	69.9	145.1	95.7	165.0
Arkansas	7,559	253.9	79.5	168.3	501.7	285.0	66.4	37.7	76.0
California	4,397	167.0	130.5	256.1	553.6	281.9	125.9	64.1	330.0
Colorado	6,245	75.2	38.2	55.8	169.2	95.7	27.1	15.3	61.0
Connecticut	93	0.7	0.7	1.5	2.8	1.4	30.6	15.2	46.0
Delaware	443	5.7	4.2	9.2	19.2	9.6	43.3	21.7	46.0
Florida	1,061	10.9	22.9	3.3	37.0	23.7	34.9	22.4	37.0
Georgia	3,656	100.5	197.2	76.7	374.5	223.6	102.4	61.1	58.0
Idaho	4,219	59.7	10.5	18.4	88.5	55.3	21.0	13.1	104.0
Illinois	23,711	462.1	379.8	743.5	1,585.4	802.6	66.9	33.9	129.0
Indiana	12,330	233.8	193.0	359.5	786.3	401.6	63.8	32.6	109.0
Iowa	24,730	508.5	441.5	983.8	1,933.8	948.2	78.2	38.3	131.0
Kansas	22,711	332.4	139.7	259.2	731.4	407.9	32.2	18.0	42.0
Kentucky	5,425	55.4	43.1	68.0	166.5	88.3	30.7	16.3	73.0
Louisiana	3,365	122.8	93.5	66.3	282.7	169.1	84.0	50.2	66.0
Maine	290	0.9	1.1	1.8	3.8	1.9	12.9	6.6	46.0
Maryland	1,345	17.3	13.0	23.9	54.3	28.1	40.3	20.9	62.0
Massachusetts	113	0.4	0.6	1.0	2.0	1.0	17.7	8.7	46.0
Michigan	6,538	89.8	71.0	135.5	296.2	151.5	45.3	23.2	62.0
Minnesota	19,377	309.5	235.4	549.2	1,094.1	540.6	56.5	27.9	86.5
Mississippi	4,305	125.0	153.4	494.9	773.3	338.2	179.6	78.6	69.0
Missouri	13,524	185.7	115.5	190.2	491.4	265.8	36.3	19.7	79.0
Montana	9,495	103.7	11.0	20.8	135.4	88.1	14.3	9.3	25.0

Table 5.5 (continued)

State	Crop acres (A)[a]	Subsidy payments[b]					Subsidy rate[c]		Cash rent (R)
		DP	CCP	LPP	TS_1	TS_4	(TS_1/A)	(TS_4/A)	
Nebraska	18,867	338.7	301.4	551.4	1,191.5	605.2	63.2	32.1	97.0
Nevada	479	0.6	0.1	0.1	0.9	0.5	1.8	1.1	62.0
New Hamps.	72	0.3	0.4	0.9	1.6	0.7	22.4	10.4	46.0
New Jersey	323	2.7	2.1	3.0	7.8	4.2	24.1	13.0	47.5
New Mexico	1,138	16.3	16.9	10.5	43.6	25.9	38.3	22.7	62.0
New York	3,088	27.5	25.8	41.1	94.4	48.9	30.6	15.8	41.0
N. Carolina	4,635	66.0	100.3	135.3	301.6	153.3	65.1	33.1	53.0
North Dakota	21,317	224.4	34.0	140.7	399.0	225.9	18.7	10.6	39.0
Ohio	10,103	168.6	118.5	205.1	492.2	259.9	48.7	25.7	82.0
Oklahoma	10,150	125.4	43.6	18.9	187.9	124.3	18.5	12.2	29.0
Oregon	2,169	30.1	2.1	2.1	34.2	23.7	15.8	10.9	100.0
Pennsylvania	3,753	24.5	22.2	43.3	90.1	45.1	24.0	12.0	45.0
Rhode Island	12	0.0	0.0	0.1	0.1	0.0	9.7	2.5	46.0
S. Carolina	1,584	27.2	37.4	22.3	86.8	50.6	54.8	31.9	29.0
South Dakota	16,998	160.6	106.5	243.2	510.3	257.8	30.0	15.2	50.4
Tennessee	4,590	53.0	69.3	140.4	262.8	125.3	57.3	27.3	67.0
Texas	22,265	404.8	513.1	665.0	1,583.0	824.5	71.1	37.0	29.7
Utah	1,003	6.3	2.0	2.4	10.7	6.6	10.7	6.5	65.0
Vermont	335	1.9	2.1	5.5	9.6	4.4	28.6	13.1	46.0
Virginia	2,732	24.0	28.8	26.9	79.7	44.1	29.2	16.1	40.0
Washington	3,615	73.9	7.2	11.4	92.4	61.3	25.6	17.0	190.0

Table 5.5 (continued)

State	Crop acres (A)[a]	Subsidy payments[b]					Subsidy rate[c]		Cash rent (R)
		DP	CCP	LPP	TS_1	TS_4	(TS_1/A)	(TS_4/A)	
West Virginia	645	1.8	1.6	1.6	5.0	2.8	7.7	4.4	28.0
Wisconsin	8,197	114.0	112.7	191.6	418.2	212.8	51.0	26.0	70.0
Wyoming	1,589	7.1	3.2	4.6	14.9	8.6	9.4	5.4	62.0
United States[d]	317,802	5,198.6	4,074.0	7,020.6	16,293.2	8,497.3	51.3	26.7	78.0

Notes: *DP* is direct payments, *CCP* is countercyclical payments, *LPP* is "loan program payments," which includes loan deficiency payments, marketing loan gains, and certificate exchange gains

[a]Harvested acres are for field and miscellaneous crops

[b]Subsidy rates in millions of dollars are divided by millions of acres, whereas the values for A are in thousands of acres

[c]TS_1 is the simple sum: $TS_1 = DP + CCP + LPP$

TS_4 is the weighted sum: $TS_4 = 0.72 \times DP + 0.65 \times CCP + 0.30 \times LPP$, where each weight represents an estimate of the proportion of the subsidy in question that accrues to land

[d]United States total includes Alaska and Hawaii, which have been left out to reduce the size of the table. The US total given here is slightly different from the total in Tables 5.3 and 5.4 because of a difference in sources

Source: Compiled by the author with assistance from Henrich Brunke using data from the USDA NASS Agricultural Statistics Database (http://www.nass.usda.gov/#top), the USDA Economic Research Service Farm Income Database (Government payments, by state and program) (http://www.ers.usda.gov/Data/FarmIncome/finfidmu.htm), and the USDA NASS 2006 summary on Land Values and Cash Rents (http://usda.mannlib.cornell.edu/MannUsda/viewDocumentInfo.do?documentID=1446)

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Part II
Agricultural Policy and Economic Performance

Chapter 6
Impact of Subsidies on Farm Productivity and Efficiency

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Abstract This chapter analyses the impact of subsidy payments on farm productivity and efficiency. More knowledge about how farm productivity and efficiency are affected by subsidies could help policy makers introduce better targeted agricultural policies. In almost all studies, subsidies are treated as exogenous. This chapter examines how subsidy payments influence farm productivity and technical efficiency when subsidies are treated as an endogenous variable in productivity and inefficiency models. The study is based on an unbalanced panel data from Norwegian grain farms during 1991–2006. Results show that subsidies negatively affected farm productivity but had a positive influence on technical efficiency.

6.1 Introduction

Agriculture is subsidised in one form or the other in most of the countries. Subsidies can be coupled to inputs and/or outputs. Since coupling subsidies distorts prices and makes the relevant market non-competitive, the recent tendency is to decouple subsidies. Decoupled subsidies should, by definition, not affect farmers' short-term marginal production decisions if the markets are perfectly competitive, there are no economies of scale and producers are risk neutral. However, in practice, these conditions do not hold, and thus even decoupled subsidies may affect production decisions. This is strongly supported by empirical studies. Coupled and decoupled subsidies may influence production in several ways: by changing the relative prices of inputs and outputs; by affecting income and thus changing on- and off-farm labour supply; by affecting income and therewith investment decisions; and by influencing farm growth and exit. All these effects may change the technical and economic performance on the farms (Zhu and Oude Lansink, 2008).

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Theoretically, an increase in coupled subsidy payment will reduce farm productivity if it provides an incentive to farmers to use less input. One could, however, expect that subsidy payment increases technical efficiency if the subsidies provide farmers with an incentive to innovate or switch to new technologies. On the other hand, technical efficiency may also decrease with increasing subsidies if farmers prefer more leisure time with a higher share of income from subsidies. Thus, the effect of subsidies on technical efficiency is an open empirical question.

Some studies find that subsidies lower productivity. For example, Guan and Oude Lansink (2006) found that subsidies had a significant negative impact on productivity growth in Dutch arable farming for the period 1990–1999. Bezlepkina and Oude Lansink (2006) analysed the impacts of subsidies (and debts) on production, using farm-level data on Russian farms for the period 1995–2000. The results showed a negative relation between subsidy and production. Skuras et al. (2006) found for the Greek food and beverage manufacturing industry that capital subsidies affect productivity growth through technical change and not through scale efficiency.

Several studies have empirically investigated the effect of subsidies on technical efficiency. A study of Hungarian grain and manufacturing firms for the period 1985–1991 found that inefficiency, among other things, could be explained by subsidies (Piesse and Thirtle, 2000). Studies of tobacco farms in Greece during the period 1991–1995 showed that direct income transfers negatively affected technical efficiency (Karagiannis and Sarris, 2005). Hadley (2006) investigated the patterns in technical efficiency and technical change in England and Wales. The analysis used unbalanced panel data for the production years 1982–2002. In the inefficiency effects model, subsidies divided on gross margin were included. Negative effects were found for cereal, sheep, general cropping and mixed farms, meaning that farm efficiency decreased with an increasing proportion of gross margin derived from subsidies. Positive effects were found for dairy and beef farms. Zhu and Oude Lansink (2008) analysed the impacts of the CAP reforms on technical efficiency of crop farms in Germany, the Netherlands and Sweden. Farm-level panel data for the period 1995–2004 were used in their study. The ratio of total subsidy to total farm revenue negatively affected technical efficiency in the three countries investigated. However, coupled subsidies had a positive impact on technical efficiency, while decoupled subsidies had a negative impact. Emvalomatis et al. (2008) analysed the effects of area payments on the technical efficiency scores of cotton producers in Greece, and found that area payments significantly reduced efficiency. They also found, using panel data (for the period 1996–2000) and panel data methods, that ignoring the presence of unobserved heterogeneity will overstate the levels of inefficiency. An analysis of wheat farms in Saskatchewan (Canada) during the period 1987–1995 showed that technical efficiency was negatively related to government income transfers (Giannakas et al., 2001). Kleinhanss et al. (2007) investigated cattle, pig, sheep and goat farms in Spain for 1999–2000 and cattle and pig farms in Germany for 1999–2000. They also found that technical efficiency decreased as the percentage of direct payment increased for all types of farms, years and countries analysed, except for Spanish cattle farms (where efficiencies increased with increased subsidies).

As the above mentioned studies illustrate, two modelling approaches have mainly been used to analyse effects of subsidies on farm performance. *The first approach* treats subsidies as traditional input (e.g., land, labour and capital) in the production function to allow for direct influence on productivity. This approach suffers from certain problems: while traditional inputs are necessary for production, subsidies are not; and subsidies alone cannot produce any output, while traditional inputs can. *The second approach* employs a stochastic production function approach and only allows subsidies to affect productivity through the technical inefficiency function. This approach escapes traditional-input criticism, but it does not simultaneously examine the impact of subsidies on productivity and efficiency changes. For example, subsidised producers are less credit constrained and can invest in research, development and advanced technologies, and thereby achieve technological progress in the long run. This implies that studies that only examine subsidies through technical efficiency are inadequate because the relation between subsidies and productivity should also be included in the model specification.[1]

Recently, a third and a more advanced modelling approach has emerged (McCloud and Kumbhakar, 2008; Sipiläinen and Kumbhakar, 2008). These studies do not treat subsidies as traditional inputs (inputs that are necessary for production) but as "facilitating" inputs (inputs that are not necessary for production). This means that subsidies affect output indirectly by changing productivity of traditional inputs (technology effect), shifting the technology (technical change), and affecting technical efficiency. McCloud and Kumbhakar (2008) empirically investigated the link between subsidies and productivity in Denmark, Sweden and Finland, using an unbalanced data set from dairy farms from 1997 to 2003. In contrast to many earlier studies, they found that subsidies had a positive impact on technical efficiency. Further, they found that subsidies are substitutable with labour, fertilisers and purchased feed but complementary with capital and materials. Using to a large extent the same data set, Sipiläinen and Kumbhakar (2008) found that direct payments affect technological change, and marginal products (input elasticities) of capital and labour, whereas subsidies do not distort the optimal use of variable inputs at the farm level.

In this chapter we merge and extend the first two approaches. Although the recent trend is to decouple subsidies, a farmer can to some extent manipulate the amount of subsidies he/she can receive. If so, subsidies cannot be treated as an exogenous variable. Since the farmers can manipulate the subsidies received we model subsidy as an endogenous variable in the production function as well as in the inefficiency function. The objective of this study is to analyse the effect of subsidies on productivity and technical efficiency in Norwegian grain farming, using an unbalanced panel data set from 1991 to 2006. As far as we know, no studies have investigated the empirical link between subsidies and farm productivity and efficiency in Norwegian agriculture.

The rest of the chapter is divided into four sections. First, we present some key features of Norwegian agricultural policy, followed by a description of the data set, the modelling framework and the econometric estimation method. The subsequent section presents and discusses the main results of the analysis, while the last section contains some concluding remarks.

6.2 Some Key Features of Norwegian Agricultural Policy

Only 3.2% of the total Norwegian land area is farmland. The fields are often scattered and steep. The climate determines which crops can be grown and to a large extent their yield level. The main limiting climatic factors are the length of the growing season and the temperature sum during the growing season. On the other hand, sufficient rainfall and favourable light conditions are beneficial for crop production. The cool climate limits the spread of pests and plant diseases. The climate is also the main reason for grain yields being lower (per hectare) than in most other European countries. In many parts of Norway, fodder growing, mainly grass, is more or less the only crop production. The average farm size was 20.3 ha in 2006. Due to these adverse conditions, Norwegian agriculture is a highly regulated and subsidised industry, and farmers face extensive farm policies with significant effects on the choices of the individual farmer (NILF, 2007).

The two main international agreements affecting the national agricultural policies are the agreement on the European Economic Area (EEA) and the World Trade Organisation (WTO) agreement. The national farm policy is implemented in annual state budgets and in annual negotiations between the two farmers' unions and the government on prices and other financial support to agriculture.

Agriculture is regulated by a large number of laws, regarding for instance, transfer of farms, market regulations, production methods and animal welfare. Broadly speaking, the financial support to agriculture is provided through (1) import tariffs which make it possible for Norwegian farmers and the processing industry to obtain higher market prices than would otherwise have been the case – the tariff rates vary from zero (for products not produced in Norway) to several hundred (300–400) per cent for some products regarded as vital, and (2) budgetary support. This includes price support, acreage and headage (livestock) support, investment grants, support to farm relief, grants for research and extension services, etc. This also includes special tax rules for agriculture (NILF, 2007).

Target prices are set for many products in the agricultural agreement. These prices can be regarded as maximum average prices for the products. The target prices are normally lower than world market prices plus import tariffs. The agricultural marketing cooperatives are granted the power to regulate the markets in such a way that it is possible to obtain target prices. The regulation activities are financed by a levy on all agricultural products.

Since 1983 a milk quota system has been in place. Each dairy farm has a quota. For other products there has been no quota system.

During the last 20 years, agricultural policy has aimed at reducing price support and increasing the level of non-product-specific support (depending on acreage and herd sizes, but not on produced volume) and decoupled payments (not depending on the production at all). However, there is still regionally differentiated price support for milk and meat. Farmers in the most favourable regions receive no such support, while other farmers do receive support. This support is supposed to compensate for cost disadvantages.

In addition to the acreage payment, which is the same per hectare for all agricultural land, there are additional payments depending on type of crop, acreage of crop cultivation and region. The payment is highest in the most remote areas with highest priority for regional policy purposes. Headage payments are differentiated according to animal species and herd size, but not region. Subsidies are degressive with increasing herd size and farmland acreage. There is an upper limit on headage payment per farm enterprise, but not on acreage payment. In order to be eligible for acreage and headage payments (and many other subsidies) a farm needs to have a turnover of at least Norwegian Kroner (NOK) 30,000 per year (ca €3750).

Approximately 70% of the total revenue in Norwegian agriculture stems from farm animal products, with milk and meat being the most important. Grain accounts for about 11% of the revenues. Grain production dominates the lowlands in eastern and central Norway. In grain farming almost all subsidies are now acreage and cultural landscape payments (and grain prices well above world market prices in most years). The support payments today are mainly paid to promote rural viability, maintain cultural landscapes, enhance more environmentally friendly production (e.g., organic farming) and ensure food security for times of crisis (Prestegard, 2004).

Figure 6.1 illustrates the aggregated acreage and cultural landscape payments and aggregated grain area in Norwegian grain farming for the period 1991–2006 (OECD, 2007). While the aggregated grain area had a slightly decreasing trend,

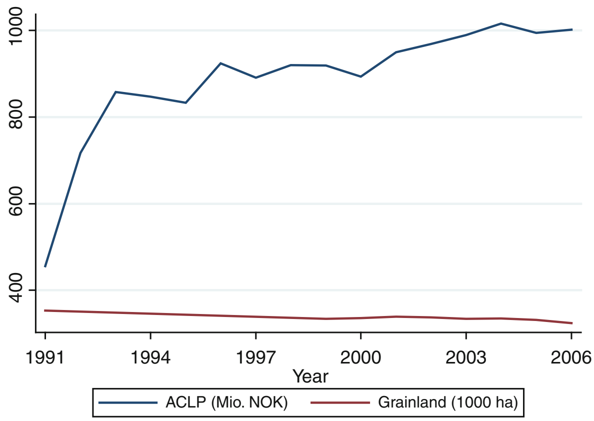

Fig. 6.1 Acreage and cultural landscape payment (ACLP) (in Mio. 2006 deflated NOK) and grain area (in 1,000 ha) in Norwegian grain farming for the period 1991–2006

the aggregated acreage and cultural landscape payment had an increasing trend, especially in the early 1990s. This upward trend coincided with decreasing price supports.

6.3 Data

The data source is the Norwegian Farm Accountancy Survey. This is an unbalanced set of farm-level panel data collected by the Norwegian Agricultural Economics Research Institute (NILF). It includes farm production and economic household data collected annually from about 1,000 farms, divided between different regions, farm size classes and types of farms. Participation in the survey is voluntary. There is no limit to the number of years a farm may be included in the survey. Approximately 10% of the survey farms are replaced every year. The farms are classified according to their main category of farm product, defined in terms of the standard gross margins of the farm enterprises. For example, the main share of the total standard gross margin for farms categorised as grain farms stems from grain production. Small holdings are somewhat under-represented and large farms are slightly over-represented in the survey sample.

The data set used in the analysis is an unbalanced panel with 1,512 observations on 159 grain farms from 1991 to 2006. Only those farms for which at least 3 years of data were available are included in the analysis. In the sample used, the average duration of farms in the survey was 9.5 years. Grain farms usually produce several types of grains (wheat, barley, oats, etc.), and should have little (if any) farm activities besides grain farming. The total output is aggregated and measured in total produced "feed units milk" (a measure of feed used in Norway defined as 6,900 kJ of net energy and approximately equivalent to 1 kg of barley) from crop production per year.

6.4 Analytical Framework

In a situation where subsidies may affect the production decision the model should allow for the fact that outputs are influenced by subsidies (or both are simultaneously determined), in addition to some variables determined outside the model (exogenous variables). To account for this we need a model that allows subsidy payments to affect output; that is, that subsidy payment should be modelled as an endogenous variable.

No model of this kind can be completely specified – mainly due to non-availability of detailed information. Agricultural production is heterogeneous (in topology, soil type, weather, luck, etc.) and farms differ in many ways. It is thus important that heterogeneity is accounted for in production analysis (e.g., Just, 2000; Just and Pope, 2002). In the case of total subsidies received, heterogeneity may also be present across individuals and households because of many farm-specific unobserved variables that are typically not accounted for by explanatory variables. Because we are using farm-level panel data, unobserved heterogeneity is accounted for.

6.4.1 Econometric Model

We use the equation system described below to analyse farm production and the subsidy payments received:

$$y_{1it} = f\left(\mathbf{x}_{it}, y_{2it}, \mathbf{z}_{it}^{p}; \boldsymbol{\beta}\right) + v_{it} - u_{it} \tag{6.1}$$

$$y_{2it} = h\left(\mathbf{z}_{it}; \boldsymbol{\delta}\right) + c_i + \varepsilon_{it} \tag{6.2}$$

where y_{1it} = grain output for farm i at time t; $f\left(\mathbf{x}_{it}, y_{2it}, \mathbf{z}_{it}^{P}; \boldsymbol{\beta}\right)$ is the production technology; $\mathbf{x}_{it}$ is the vector of inputs; y_{2it} is support payments received; $\mathbf{z}_{it}^{P}$ is a vector of control variables (farm and farmer characteristics affecting production) and $\boldsymbol{\beta}$ is the associated vector of technology parameters and parameters associated with the control variables to be estimated; v_{it} is a random noise term (production shocks) that can increase or decrease output (*ceteris paribus*); and $u_{it} \geq 0$ is the inefficiency term. The inefficiency term is specified as $u_{it} = G_t \cdot u_i$, with $G_t = exp\left(\gamma \cdot \tilde{t}\right)$ where $\tilde{t}$ is a time-trend variable; and $u_i \sim N^{+}\left(\mu, \sigma_u^2\right) = N^{+}\left(\mathbf{z}_i^{e}\boldsymbol{\varsigma}, \sigma_u^2\right)$ is a normally distributed random variable truncated at zero from below. The vector of variables that can explain inefficiency is denoted by $\mathbf{z}_{it}^{e}$ and $\boldsymbol{\varsigma}$ is the corresponding parameter vector to be estimated (Kumbhakar and Wang, 2005). In the second equation, $h\left(\mathbf{z}_{it}; \boldsymbol{\delta}\right)$ is a function of $\mathbf{z}_{it}$ variables which constitute farm and owner characteristics and $\boldsymbol{\delta}$ is the associated vector of parameters to be estimated; $c_i = N\left(0, \sigma_c^2\right)$ represents the unobserved farm effect; and $\varepsilon_{it} = N\left(0, \sigma^2\right)$ is the random noise component.

Thus, we have a triangular system in which the first equation has two endogenous variables (y_1 and y_2) and the second equation has one endogenous variable (y_2). The model allows subsidy payments to affect output, but not vice versa.

The system described by equations (6.1) and (6.2) can be estimated jointly. However, consistent estimates can also be obtained by using a two-step procedure because the system is triangular. In stage 1 we estimate the subsidy payments equation. Then, in stage 2, the stochastic production function is estimated to examine how subsidy payments influence productivity and technical efficiency at the farm level. At this stage, we replace subsidy payments by its predicted value for each farm, obtained from stage 1.

The $f\left(\mathbf{x}_{it}, y_{2it}, \mathbf{z}_{it}^{p}; \boldsymbol{\beta}\right)$ function in equation (6.1) uses the following input variables: x_1 is log of productive farmland in hectares; x_2 is log of labour hours used on the farm, measured as total number of hours worked, including management, family and hired workers; x_3 is log of materials and machinery used in farm production (implicit quantity index). The broad machinery and materials variables include cash expenditure items for seeds, fertiliser, lime, pesticides, fuel, electricity, plus the maintenance costs of machinery, buildings, irrigation, land and the cost of hired machinery.[2, 3] Fisher's implicit quantity index is used to specify the materials and machinery variable.[4] In addition to these three "traditional" input variables in a production function, a time-trend index, t (1,...,15), is added to account for neutral technical change in the production function.

Variables in $\mathbf{z}_{it}^{p}$ consist of regional dummies. We defined two regions: the region with most favourable production conditions – labelled as "favourable" (including Eastern Norway – lowlands, Jaeren, and Mid–Norway – lowlands), and the region with average and least favourable production conditions – labelled as "other" (Agder and Rogaland, Western Norway, Mid-Norway – other parts, Eastern Norway – other parts, and Northern Norway). Within each of the regions the growing conditions are reasonably similar. To allow for time-varying efficiency, the vector $\tilde{t}$ in the function in equation (6.1) included the trend variable, $t = (1,...,15)$.

We have chosen to define subsidy payments, y_2 , in equation (6.2) as total subsidies received (implicit quantity index). The $\mathbf{z}_{it}$ variables in equation (6.2) consist of the following: $z_1$is productive farmland in hectares (the same as variable x_1); z_2 is a centrality variable with a value of 1 if the farm is located within a region with a centre of more than 15,000 inhabitants, and 0 otherwise; z_3 equals 1 if the farm is located in Eastern Norway – lowlands, and 0 otherwise; z_4 equals 1 if the farm is located either in Jaeren or in Mid-Norway – lowlands, and 0 otherwise. We also included a time-trend index, $t = (1, \ldots, 15)$ in $\mathbf{z}_{it}$.

The variables in the inefficiency function consist of average (over time) values of farmer-specific farming experience, z_1^e, and farmer-specific debt-to-asset ratio, z_2^e.

In Table 6.1, the descriptive statistics of the variables are listed for both the subsidy payment function and the production function with the error components.

Table 6.1 Descriptive statistic ($N = 1{,}512$)

Variable	Label	Mean	S.E	Min	Max
y_1	Grain output (feed units)	117,149	69,909	5,501	394,141
y_2	Subsidy payments (index)	6.54	4.49	0.25	35.68
x_1	Farmland (ha)	29.5	14.4	4.2	78.5
x_2	Labour used on farm (hours per year)	1,334	896	40	6,200
x_3	Materials and machinery (index)	3.96	2.56	0.47	26.96
z_1^p	Regional dummy	0.30	0.46	0.00	1.00
z_1	Farmland (ha)	29.5	14.4	4.2	78.5
z_2	Centrality dummy (close to urban areas = 1, else = 0)	0.72	0.45	0.00	1.00
z_3	Dummy for region, Eastern Norway – lowlands = 1, else = 0	0.61	0.49	0.00	1.00
z_4	Dummy for region, Jaeren and Mid-Norway – lowlands = 1, else = 0	0.29	0.45	0.00	1.00
z_1^e	Farming experience	17.9	8.5	1.5	40.5
z_2^e	Debt-to-asset ratio[a]	0.38	0.30	0.01	1.95

[a]Calculated as total debt divided by total assets

On average, grain yields, measured as feed units per ha was 3,860 (not reported in Table 6.1). This is lower compared to most of other European countries (NILF, 2007) due to the prevailing climatic conditions in Norway. Subsidy payments at the farm level in the sample (in 2006 prices) were, on average, NOK 89,900, and with an increasing trend for the period 1991–2006. The average subsidy payments share of total farm revenue for the sample was 23%. This share was also increasing during the period.

The average farm size in the sample of 30 ha was higher than the average of all Norwegian grain farms of 21 ha (Koesling et al., 2004). Labour used on the farms was 1,334 h on average. The farmer's and partner's (if any) joint work hours off the farm as a proportion of their total hours worked on and off the farm within a year was 0.56 (on average for the whole sample). The average farmer had 18 years of farming experience. The debt-to-asset ratio, which measures the size of the farm's debt load compared with the total asset value was 38%. The debt-to-asset ratio has since the mid-1990s more or less increased. The ratio was recorded in 2006 at 41%, compared to 35% in 1998.

The geographical distribution of various farm productions does vary with climatic and topological conditions. The prevailing agricultural and rural policies since the end of the 1950s have helped to "channel" grain production to the lowland areas. These areas have the best cereal growing conditions and allow relatively easy access to non-farming employment (since the lowlands are quite close to urban areas and the larger cities). Accordingly, livestock production (which is more labour-intensive and more profitable per area unit than grain production) was channelled to areas with poor growing conditions for grain, where the chances for finding off-farm employment are much lower. As expected under these circumstances about 72% of the farmers were located close to urban areas. Furthermore, in total, 90% (61% plus 29%) of the grain farms in the survey were located in lowland areas.

Prior to estimation, output and x-variables in the translog function were scaled to have unit means, so that the first-order coefficients in the model can be interpreted as elasticities of output evaluated at the mean of the data. Results from both the subsidy and frontier production function are reported in the next section. Note that farm effects in the subsidy function is captured by the "c_i" term which is assumed to be a random variable that is independent of the noise term ε_{it}.

6.5 Results

6.5.1 The Subsidy Payment Function

The random effect regression equation (6.2) was estimated to assess the factors that influence the subsidy payment. Parameter estimates for the model are presented in Table 6.2.

The coefficient representing farm size is statistically significant, suggesting, as expected, that the size of the farms positively influences the level of subsidy

Table 6.2 Estimated coefficients of the subsidy payment equation

Parameter	Label	Estimate	S E	
δ_1	Farmland (ha)	0.207	(0.007)	***
δ_2	Centrality dummy (close to urban areas = 1, else = 0)	−0.628	(0.354)	*
δ_3	Dummy for region, Eastern Norway – lowlands = 1, else = 0	−2.393	(0.515)	***
δ_4	Dummy for region, Jaeren and Mid-Norway – lowlands = 1, else = 0	−1.951	(0.517)	***
δ_5	Time-trend index	0.395	(0.013)	***
δ_0	Intercept	−0.377	(0.506)	
σ_c^2	Variance (random effects)	0.193	(0.117)	***
σ^2	Variance (random error)	0.092	(0.035)	***

Estimates significant at $^{*}P < 0.10$, $^{**}P < 0.05$ and $^{***}P < 0.01$

payments. It should, however, be noted that smaller farms receive relatively (per ha) more support payments than larger farms, but not in absolute terms.

Our results show that distance to the nearest town (centrality) does exert a statistically significant negative influence on farmers' subsidy payments. We find that farmers in the "favourable" regions (including Eastern Norway – lowlands, Jaeren, and Mid-Norway – lowlands) received less subsidy payments than grain farmers elsewhere in Norway, *ceteris paribus*. This just confirms an important part of the subsidy payment system in Norway: the subsidies are partially differentiated according to geographical region. Regions in the "non-favourable" (i.e., the other regions as they mentioned above) have to a large degree received more support than the "favourable" regions (NILF, 2007).

The time-trend variable has a statistically significant and positive coefficient. This shows that subsidy payments increased over time, *ceteris paribus*.

6.5.2 The Production Function Estimates

The estimated parameters of the translog stochastic frontier production function specified in equation (6.1) are reported in Table 6.3 and discussed below. Results from two models are presented. In Model 1 the subsidy payment is included only as a linear term in equation (6.1). In Model 2 we made it more flexible by adding a square term of subsidy payment variable, so the relationship between output and subsidy can be non-linear. The advantage of this flexible specification is that one can test whether the relation is linear or not.

For both Models 1 and 2, the estimated output elasticities with respect to land, farm labour, materials and machinery are all different from zero at the 1% significance level. The elasticity for land was the largest (more than seven times the elasticities with respect to labour and four times the elasticities for machinery and

Table 6.3 Estimates of the parameters in the translog frontier production function for grain yield

Parameter	Label	Model 1			Model 2		
		Estimate	SE		Estimate	SE	
Frontier function							
β_1	x_1 (log of land)	0.954	(0.094)	***	0.957	(0.077)	***
β_2	x_2 (log of farm labour)	0.112	(0.032)	***	0.117	(0.033)	***
β_3	x_3 (log of materials and machinery)	0.214	(0.046)	***	0.214	(0.046)	***
β_t	t (time-trend index)	0.080	(0.009)	***	0.081	(0.008)	***
β_{11}	x_1^2	−0.073	(0.113)		−0.195	(0.106)	*
β_{12}	$x_1 \times x_2$	0.079	(0.044)	*	0.094	(0.046)	**
β_{13}	$x_1 \times x_3$	0.107	(0.076)		0.134	(0.076)	*
β_{1t}	$x_1 \times t$	0.014	(0.006)	**	0.011	(0.006)	*
β_{22}	x_2^2	−0.023	(0.042)		−0.028	(0.043)	
β_{23}	$x_2 \times x_3$	0.018	(0.035)		0.008	(0.035)	
β_{2t}	$x_2 \times t$	−0.005	(0.003)		−0.006	(0.003)	
β_{33}	x_3^2	−0.062	(0.072)		−0.080	(0.072)	
β_{3t}	$x_3 \times t$	−0.008	(0.005)	*	−0.007	(0.005)	
β_{tt}	t^2	−0.003	(0.000)	***	−0.003	(0.000)	***
β_{CI}	Dummy region, others = 1	−0.022	(0.027)		−0.023	(0.027)	
β_S	Subsidies received	−0.048	(0.012)	***	−0.057	(0.011)	***
β_{Ssq}	Squared subsidies received				0.0011	(0.0004)	***
β_0	Intercept	0.078	(0.046)	*	0.076	(0.045)	*
Inefficiency model[a]							
ς_1	Subsidies received	−0.040	(0.016)	**	−0.033	(0.021)	
ς_2	Farming experience	0.0006	(0.003)		0.0015	(0.004)	
ς_3	Debt-asset ratio	0.160	(0.078)	**	0.192	(0.110)	*
ς_0	Intercept	0.209	(0.096)	**	0.063	(0.151)	
Time-variant inefficiency							
γ	Time-trend	0.041	(0.013)	***	0.034	(0.014)	**
Variance parameters							
σ_u	= exp(a)	−3.519	(0.434)	***	−3.281	(0.587)	***
σ_v	= exp(b)	−3.064	(0.039)	***	−3.058	(0.039)	***

Estimates significant at $^{*}P = 0.10$, $^{**}P = 0.05$ and $^{***}P = 0.01$

[a]A negative sign on a parameter indicates a positive impact on efficiency

materials). As expected, the total grain yield depended strongly on the area of land used. Partly in line with our estimate of 0.95 for both models, Wilson et al. (2001) found elasticity for land of 0.76 among wheat farmers in eastern England, and Wilson et al. (1998) found elasticity for land of 0.87 in UK potato production.

Scale economies are computed as the sum of the elasticities of all input variables. On average, the scale elasticity is found to be 1.28 for Model 1 and 1.29 for Model 2. These are statistically different from 1 in both models, indicating that the production function exhibited increasing returns to scale at the mean of the data. For crop farms in Sweden for the period 1976–1988, the estimated returns to scale averaged 1.25, but declined gradually during the period analysed (Heshmati and Kumbhakar, 1997). Zhu and Oude Lansink (2008) found (for the period 1995–2004) that crop farms in the Netherlands and Sweden exhibited increasing returns to scale, whereas farms in Germany had decreasing returns to scale.

Estimates of technological changes are found to be statistically significant and positive for both models. The rate is about 8% per year, indicating reasonable growth in productivity over time. This estimate is also higher than those obtained by Zhu and Oude Lansink (2008) for crop farms in Germany, the Netherlands and Sweden. They found an annual technical change (for the period 1995–2004) of 1.3% for Germany, 2.3% for the Netherlands and 2.0% for Sweden.

Model 1 shows that an increase in subsidy payments reduces farm productivity, and the effect is found to be statistically significant. In other words, removal of subsidies will make Norwegian grain farming more productive, *ceteris paribus*. A possible explanation of this result is that subsidies may create disincentives to farmers and impede competitiveness. Furthermore, the results may suggest that farming practices resulting from subsidy seeking slows down productivity (Guan and Oude Lansink, 2006). This result is in line with earlier studies mentioned in the introduction about subsidies' effect on productivity.

For Model 2, the results show that the effect of subsidy payments on farm productivity has a "U" shaped relationship. In other words, our results show that subsidy payments negatively affect farm productivity. The rate of decline diminished over time. It may not be possible to explain this result without a more thorough analysis. However, one speculation could be that when the subsidies are generous, farmers have the choice of spending more time on other jobs, which in turn negatively affects productivity.

6.5.3 Technical Efficiency Results

For the prediction of technical efficiency it is common to use an output-oriented measure, defined as the ratio of observed output to the corresponding stochastic frontier output, viz.,

$$TE_{it} = \frac{\exp\left(f\left(\mathbf{x}_{it}, y_{2it}, \mathbf{z}_{it}^{p}; \boldsymbol{\beta}\right) + v_{it} - u_{it}\right)}{\exp\left(f\left(\mathbf{x}_{it}, y_{2it}, \mathbf{z}_{it}^{p}; \boldsymbol{\beta}\right) + v_{it}\right)} = \exp(-\, u_{it}) \tag{6.3}$$

This expression relies upon the value of the unobservable u_{it} being predicted, which is achieved by deriving the expression for the expectation of $\exp(-u_{it})$ conditional on the observed value of $(v_{it} - u_{it})$. In practice we replace the "true" parameter values by their estimates and "true" residuals $(v_{it} - u_{it})$ by their predicted values. The exact formula for the conditional mean is given in Battese and Coelli (1988) and in Kumbhakar and Lovell (2000).

The average technical efficiency for the sample in Model 1 is 0.85.[5] The implication is that, on average, crop production could have been 15% higher without using more inputs. However, behind the mean there is large variation between farms, as illustrated in the histogram in Fig. 6.2. Almost 18% of the farmers had a technical efficiency level of less than 0.75, suggesting that they had quite a large potential for improvement. On the other hand, about 16% were (almost) technically efficient, with a technical efficiency score of 0.95 or higher.

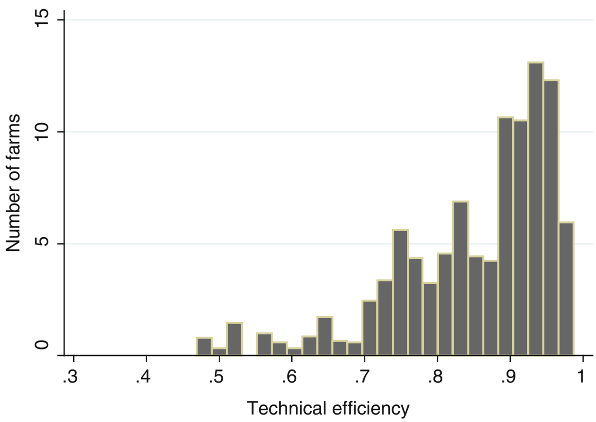

Fig. 6.2 Efficiency distribution of the sample of grain farmers in Norway (based on Model 1)

6.5.4 Explaining Technical Inefficiency

Factors explaining variations in the efficiency score are examined in the lower part of Table 6.3. The estimated parameters indicate the direction of the effects these variables have upon inefficiency levels (where a negative parameter estimate shows that the variable has a positive effect on efficiency).

The predicted subsidies payment received had a statistically significant positive influence on technical efficiency. This result contrasts with the findings by, for example, Giannakas et al. (2001), Karagiannis and Sarris (2005), and Piesse and Thirtle (2000). However, our findings support the study by McCloud and Kumbhakar (2008) of dairy farms in Denmark, Sweden and Finland. Zhu and Oude Lansink (2008) found that coupled subsidies had a positive impact on technical efficiency, while decoupled subsidies had negative impacts. The negative impact of decoupled subsidies may be caused by the fact that these are extra incomes that reduce the motivation of the farmers to work efficiently.

One explanation for our findings could be that subsidy payment is making the utility of the farmer's time less and he/she might be spending more time in organising the operation of the farm. This might be one reason for efficiency improvement. However, one should be careful to draw any firm conclusion on this issue. Furthermore, to get a reliable picture, one may need to be careful when specifying the subsidy variables used in the analysis.

Wilson et al. (1998, 2001) found that managers with more experience are likely to be more efficient than those with fewer years of experience, which contrasts with our failure to find any significant difference in technical efficiency between non-experienced and experienced farmers.

The debt-to-asset ratio shows an increasing trend, implying that increasing debt-to-asset ratio decreases technical efficiency. This finding supports earlier results obtained by Karagiannis and Sarris (2005).

6.6 Concluding Comments

Subsidies in agriculture in the past as well in the future seem to be an important component of farmers' income. Surprisingly little has until recently been done both on modelling the effect of subsidies on agricultural productivity as well as studying the empirical link between subsidies and agricultural productivity. This study partly fills this gap by (1) illustrating an approach that models subsidy as an endogenous variable in a productivity model with an inefficiency part, and (2) providing an empirical analysis of the effect of subsidies in Norwegian grain farming.

Subsidies in this study are treated in a simple manner. It may be useful to distinguish between different types of subsidies (decoupled or not, acreage and head based support versus environmental based support etc.) in the analysis. Furthermore, the analysis might be considered in a broader system or in a household model framework. All these aspects are left for further research.

Our main result is that subsidies affected farm productivity negatively, but they had a positive influence on the technical efficiency of the Norwegian grain farms.

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Notes

1. See McCloud and Kumbhakar (2008) for a more thorough discussion of these two modelling approaches.
2. At the outset, we tried to include an additional input variable, building capital. However, we found it difficult to derive a good measure of building capital from the data because no physical

capital measure was recorded. Moreover, the monetary values of buildings in the data set are based on historical cost, which is a poor basis for deriving the economic value of the services provided from the buildings.

3. In calculating the aggregate measure of machinery and materials, seed costs were deflated by the price index for seeds, fertiliser and lime costs were deflated by the price index for fertiliser, pesticide costs were deflated by the index for total variable costs, fuel costs were deflated by the fuel price index, electricity costs were deflated by the electricity price index, and maintenance costs of machinery, buildings, irrigation and land and the cost of hired machinery were all deflated by the index for fixed costs.
4. In general, when considering several inputs, we observe the vector of prices $\mathbf{w}_j$ and the vector of quantities $\mathbf{x}_{jt}$ (the implicit quantities of the individual items) for $t = 1, \ldots, T$. Then the Fisher index (e.g., Diewert, 1992) for the quantity of inputs used in period t, using period s as a base, is: $x_{jst} = \left[\left(w'_{jt}x'_{jt}/w'_{js}x'_{js}\right) \times \left(w'_{js}x'_{jt}/w'_{jt}x'_{js}\right)\right]^{0.5}$. The first term in the brackets is the cost change between the two periods. The second term is the ratio of two values: period-t quantities valued at period-s prices; and period-s quantities valued at period-t prices. This formula was used to calculate the non-transitive implicit index for machinery and materials.
5. Technical efficiency results for Model 2 were almost the same as for Model 1, and are not reported here.

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Chapter 7
Productivity and Profitability of US Agriculture: Evidence from a Panel of States

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Abstract This chapter investigates the effect of R&D on US agricultural productivity using panel data at the state level for the period 1960–2004. We employ the Bennet-Bowley indicator to measure multifactor productivity based on a multiple input–multiple output technology. Our findings confirm the anticipated positive effect of R&D on agricultural productivity. We also examine the relationship between price change and R&D and between profitability and R&D. We find that R&D has a negative effect on price change while the effect on profit change is positive but not statistically significant.

7.1 Introduction

In a recent paper, Färe et al. (2008) applied time series techniques to relate a Bennet-Bowley productivity series to time series data on R&D in US agriculture. They found that (1) they could not reject the presence of a cointegrated relationship between the two series; (2) they could not reject the hypothesis that R&D does not Granger cause productivity change, and these series are related; and (3) productivity responds positively between 4 and 10 years after an R&D shock.

The purpose of this chapter is to revisit the relationship between agricultural productivity and the factors which affect it. First of all, we take advantage of a richer data set developed at ERS/USDA, which is disaggregated to the state level giving us access to a panel rather than aggregate time series data. We also constructed state level R&D stocks. Finally, we take a broader view of the production process to account for the relationship between productivity change and changes in prices

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and profits. This allows us to decompose changes in profitability in agriculture into a normalized price change indicator and a Bennet-Bowley productivity indicator.

Our findings are quite interesting. We again find a positive relationship between productivity growth and knowledge (the R&D stock), controlling for fixed effects. The relationship between price change and R&D is negative, and there is a positive, albeit insignificant, relationship between R&D and profits, which is consistent with our decomposition of profit change into price and productivity components.

The organization of this chapter is as follows. Section 7.2 details development of the theoretical model. Section 7.3 presents our empirical results, while Section 7.4 concludes.

7.2 Theoretical Underpinning

In this chapter we use the Bennet-Bowley productivity indicator to evaluate productivity change.[1] This indicator is additive in nature,[2] and it can be derived from the Luenberger productivity indicator by invoking the quadratic lemma.[3] We sketch this derivation below.

Let $x \in R_+^N$ denote inputs and $y \in R_+^M$ denote outputs. The technology consists of all feasible input and output pairs (x,y)

$$T = \{(x, y) : x \,\text{can produce}\, y\}\,. \tag{7.1}$$

Standard assumptions are imposed on T.

Let $g = (g_x, g_y) \in R_+^{N+M}$ be a directional vector, a vector which determines the direction in which the data are projected and technical efficiency is evaluated. Then the directional technology distance function is given as

$$\vec{D}_T(x, y; g) = \sup\left\{\beta : (x - \beta g_x, y + \beta g_y) \in T\right\}. \tag{7.2}$$

This function inherits its properties from the technology set T, and in addition it satisfies the translation property

$$\vec{D}_T(x - \alpha g_x, y + \alpha g_y; g) = \vec{D}_T(x, y; g_x, g_y) - \alpha, \alpha \in R. \tag{7.3}$$

Note that the more familiar Shephard output distance function

$$D_o(x, y) = \inf\{\theta : (x, y/\theta) \in T\}\,, \tag{7.4}$$

is a special case of $\vec{D}_T(\cdot)$. To see this choose $g = (g_x, g_y) = (0, y)$, then

$$\vec{D}_T(x, y; 0, y) = \frac{1}{D_o(x, y)} - 1. \tag{7.5}$$

Consider two time periods, $\tau = t, t + 1$, and define

$$\vec{D}_{T^\tau}(x^\tau, y^\tau; g) = \sup\left\{\beta : (x^\tau - \beta g_x, y^\tau + \beta g_y) \in T^\tau\right\}. \tag{7.6}$$

Then the Luenberger productivity indicator is defined as:

$$L_t^{t+1} = \frac{1}{2}(\vec{D}_{T^t}(x^t, y^t; g) - \vec{D}_{T^t}(x^{t+1}, y^{t+1}; g) + \vec{D}_{T^{t+1}}(x^t, y^t; g) - \vec{D}_{T^{t+1}}(x^{t+1}, y^{t+1}; g)). \tag{7.7}$$

To derive the Bennet-Bowley indicator from the Luenberger, recall that a function $F : R^J \to R$ is quadratic if

$$F(q) = \alpha_0 + \sum_{j=1}^{J} \alpha_j q_j + \sum_{i=1}^{J}\sum_{j=1}^{J} \alpha_{ij} q_i q_j. \tag{7.8}$$

Given two vectors, q^0, q^1, the quadratic lemma states

$$F(q^1) - F(q^0) = (1/2) \times \left[\nabla F(q^0) + \nabla F(q^1)\right] \times \left[q^1 - q^0\right]. \tag{7.9}$$

Applying this lemma to the Luenberger productivity indicator with quadratic distance functions yields the Bennet-Bowley indicator, namely:

$$\begin{aligned}(BB)_t^{t+1} = &\frac{1}{2}\left[\frac{p^t}{p^t g_y + w^t g_x} + \frac{p^{t+1}}{p^{t+1} g_y + w^{t+1} g_x}\right]\left[y^{t+1} - y^t\right] \\ &- \frac{1}{2}\left[\frac{w^t}{p^t g_y + w^t g_x} + \frac{w^{t+1}}{p^{t+1} g_y + w^{t+1} g_x}\right]\left[x^{t+1} - x^t\right].\end{aligned} \tag{7.10}$$

The Bennet-Bowley indicator is thus a price weighted arithmetic mean of the difference in output and input changes. The price weights are normalized by the value of the direction vector.[4] For details see Balk (1998), Chambers (1996, 2002).

Note that the researcher must choose the directional vector $g = (g_x, g_y)$. Here we use a common direction vector which is set equal to: $g = (g_x, g_y) = (\bar{x}, \bar{y})$. This amounts to using price share weights evaluated at the mean of the input and output data in the computation of the Bennet-Bowley indicator which also bears similarities to the way the Törnqvist productivity index is constructed.

An important feature of the Bennet-Bowley indicator is its direct association with the change in (normalized) profits. Following Färe and Grosskopf (2005), we can establish the link between profitability and productivity by introducing the price change (PC) indicator

$$\begin{aligned}(PC)_t^{t+1} = &\frac{1}{2}\left[\frac{y^{t+1}}{p^{t+1} g_y + w^{t+1} g_x} + \frac{y^t}{p^t g_y + w^t g_x}\right]\left[p^{t+1} - p^t\right] \\ &- \frac{1}{2}\left[\frac{x^{t+1}}{p^{t+1} g_y + w^{t+1} g_x} + \frac{x^t}{p^t g_y + w^{t+1} g_x}\right]\left[w^{t+1} - w^t\right]\end{aligned} \tag{7.11}$$

and defining the normalized change in profits by

$$(\Pi C)_t^{t+1} = \left[\frac{\Pi^{t+1}}{p^{t+1}g_y + w^{t+1}g_x}\right] - \left[\frac{\Pi^t}{p^t g_y + w^t g_x}\right]. \tag{7.12}$$

From equations (7.10), (7.11), and(7.12) we can immediately see that

$$\Pi C = \mathrm{BB} + \mathrm{PC} \tag{7.13}$$

The decomposition given by equation (7.13) is quite important in that it identifies the distinct contributions of productivity change and price change to the change in profits. Furthermore, the price component includes the separate contributions of output prices that have a favorable effect on profits and input prices that have a negative effect on profits.

7.3 Empirical Results

The data used in this study are described in Ball et al. (1999, 2004) and in the appendix. The sample includes the 48 contiguous states and covers the 1960–2004 period. Our specification includes multiple outputs (crops, livestock and products, and farm related output) and inputs (land, labor, capital, and materials) and their associated prices, which are used to estimate the decomposition of profit change into total factor productivity change (the Bennet-Bowley productivity indicator) and the change in real prices. We report these results in several forms. In Fig. 7.1, we plot the cumulated productivity, price, and profit changes by production region. The averages of productivity, price, and profit changes over the entire sample period and two subperiods are presented in Table 7.1.

From Fig. 7.1 it is clear that there have been significant improvements in total factor productivity over the 1960–2004 period. Real prices exhibited a downward trend over the same period, while the pattern of change in profits change was nearly flat. Thus, our first conclusion is that there has been little long-term change in profitability of US agriculture despite strong gains in total factor productivity. The price depressing effects of increased output largely offset productivity gains. This result is consistent with Cochrane's (1958, 1993) "technology treadmill" where he posits that early adopters profit from an innovation, but the innovation is quickly adopted by competitors, thereby dissipating profits. Producers must adopt to survive, hence the treadmill. The lack of growth in profits suggests that consumers have been the beneficiaries of increases in productivity rather than producers.

Table 7.2 reports the results of Maddala-Wu Fisher-type panel unit root tests derived from Augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) tests. The series include our Bennet-Bowley productivity change, price change and profit change indicators, and the (log) R&D series. Here we find that all of the series are stationary, therefore we do not need to pursue panel cointegration and error correction models.[5]

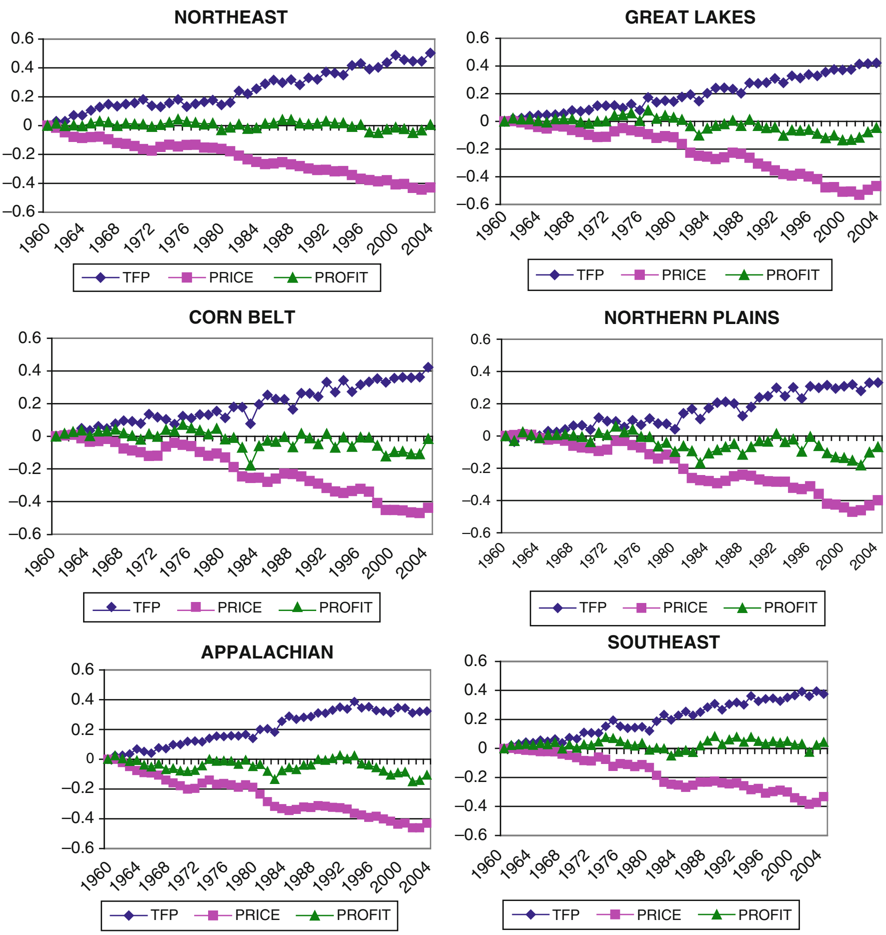

Fig. 7.1 Productivity change, price change, and profit change

Our next task is to investigate the relationships between public R&D and estimates of productivity change, price change, and change in profitability for our panel of states. We estimated both static and dynamic models, as well as a static model with an AR(1) correction. Detailed results are available on request. Here we report results from a dynamic specification which includes R&D stocks and the Palmer drought index. We control for cross-sectional and period-fixed effects (See Table 7.3).

Starting with the results for the Bennet-Bowley productivity indicator we see that (log) R&D has a positive and significant effect on productivity change. This is, of course, consistent with the idea that R&D fosters technical change which is a key component of productivity change. The Palmer drought index (used to control for the effects of extremes in weather) is negatively related with productivity change.

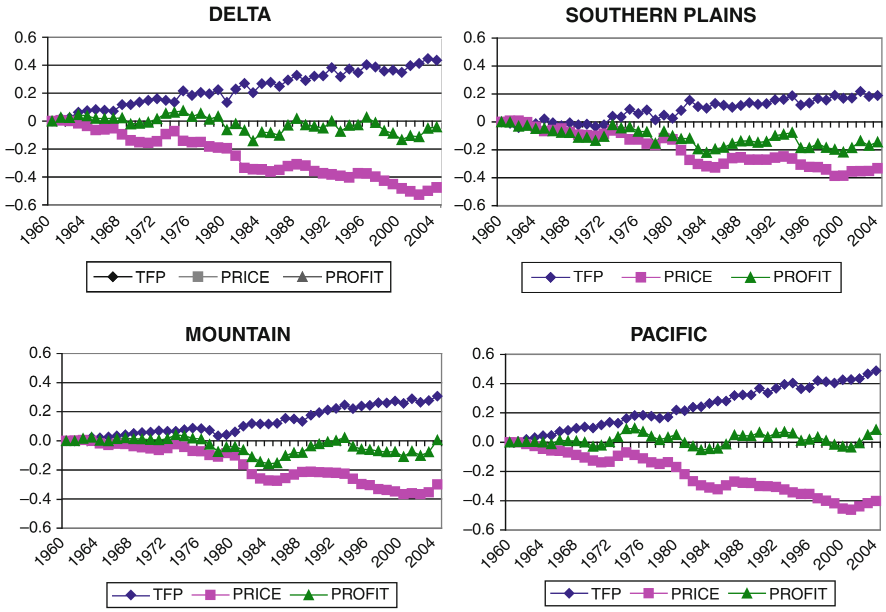

Fig. 7.1 (continued)

Turning to the price change component we find that R&D has a significant negative effect on real prices. The Palmer drought index has a small negative but insignificant effect on price change.

Finally, we turn to the change in profits. Recall that profit change is equal to the sum of two components: productivity change and change in real prices. Thus we would expect the effect of R&D on profits to reflect the offsetting effects of R&D on productivity change and price change. Indeed the coefficient on R&D is positive but insignificant. The effect of the Palmer drought index is negative and significant: extremes in weather lower profitability.

7.4 Conclusions

Our analysis confirms a positive relationship between investment in R&D and changes in total factor productivity. We also show that our measure of productivity change (the Bennet-Bowley productivity indicator) is a component (along with changes in real prices) of the change in profits. We find that the contributions of these two components are largely offsetting, with the long-term trend in profitability of the sector nearly flat. R&D has a negative effect on real prices; the net effect on profit change is small and positive, albeit statistically insignificant. This suggests that the benefits of public R&D expenditures accrue largely to the consumer through lower real prices. We also find that extremes in weather have an adverse impact on both productivity and profitability of agriculture.

Table 7.1 Productivity change, price change, and profit change, 1960–2004

	Productivity change			Price change			Profit change		
	1960–2004	1960–1982	1982–2004	1960–2004	1960–1982	1982–2004	1960–2004	1960–1982	1982–2004
Northeast									
CT	0.0114	0.0109	0.0120	−0.0099	−0.0062	−0.0136	0.0015	0.0047	−0.0017
DE	0.0093	0.0077	0.0109	−0.0072	−0.0097	−0.0046	0.0021	−0.0020	0.0063
MA	0.0123	0.0115	0.0131	−0.0122	−0.0111	−0.0133	0.0001	0.0004	−0.0002
MD	0.0088	0.0075	0.0101	−0.0094	−0.0099	−0.0089	−0.0006	−0.0024	0.0011
ME	0.0092	0.0109	0.0074	−0.0113	−0.0133	−0.0093	−0.0021	−0.0024	−0.0019
NH	0.0115	0.0120	0.0109	−0.0096	−0.0097	−0.0095	0.0019	0.0023	0.0015
NJ	0.0078	0.0050	0.0105	−0.0110	−0.0099	−0.0120	−0.0032	−0.0049	−0.0015
NY	0.0075	0.0065	0.0084	−0.0079	−0.0067	−0.0090	−0.0004	−0.0002	−0.0006
PA	0.0087	0.0078	0.0096	−0.0086	−0.0083	−0.0089	0.0001	−0.0004	0.0007
RI	0.0141	0.0192	0.0089	−0.0120	−0.0121	−0.0118	0.0021	0.0071	−0.0029
VT	0.0084	0.0097	0.0072	−0.0084	−0.0071	−0.0097	0.0000	0.0025	−0.0025
Great Lakes									
MI	0.0117	0.0141	0.0092	−0.0109	−0.0133	−0.0085	0.0008	0.0009	0.0008
MN	0.0089	0.0067	0.0112	−0.0107	−0.0111	−0.0104	−0.0018	−0.0044	0.0008
WI	0.0082	0.0057	0.0106	−0.0103	−0.0066	−0.0140	−0.0021	−0.0009	−0.0033
Corn Belt									
IA	0.0090	0.0059	0.0121	−0.0094	−0.0105	−0.0083	−0.0004	−0.0045	0.0038
IL	0.0099	0.0085	0.0112	−0.0107	−0.0132	−0.0082	−0.0008	−0.0047	0.0031
IN	0.0108	0.0100	0.0117	−0.0107	−0.0121	−0.0093	0.0001	−0.0021	0.0024
MO	0.0076	0.0060	0.0092	−0.0089	−0.0105	−0.0073	−0.0013	−0.0045	0.0019
OH	0.0106	0.0101	0.0111	−0.0101	−0.0098	−0.0103	0.0006	0.0004	0.0007

Table 7.1 (continued)

	Productivity change			Price change			Profit change		
	1960–2004	1960–1982	1982–2004	1960–2004	1960–1982	1982–2004	1960–2004	1960–1982	1982–2004
Northern Plains									
KS	0.0053	0.0043	0.0062	−0.0080	−0.0086	−0.0074	−0.0027	−0.0043	−0.0012
ND	0.0092	0.0122	0.0061	−0.0114	−0.0187	−0.0042	−0.0023	−0.0065	0.0020
NE	0.0078	0.0073	0.0084	−0.0076	−0.0084	−0.0069	0.0002	−0.0011	0.0015
SD	0.0078	0.0066	0.0090	−0.0092	−0.0117	−0.0067	−0.0014	−0.0051	0.0023
Appalachian									
KY	0.0078	0.0125	0.0030	−0.0099	−0.0135	−0.0063	−0.0021	−0.0010	−0.0033
NC	0.0096	0.0098	0.0095	−0.0087	−0.0114	−0.0061	0.0009	−0.0016	0.0034
TN	0.0052	0.0092	0.0013	−0.0100	−0.0130	−0.0071	−0.0048	−0.0038	−0.0058
VA	0.0072	0.0077	0.0067	−0.0102	−0.0120	−0.0083	−0.0030	−0.0043	−0.0016
WV	0.0070	0.0075	0.0064	−0.0100	−0.0149	−0.0052	−0.0031	−0.0074	0.0013
Southeast									
AL	0.0068	0.0074	0.0061	−0.0062	−0.0104	−0.0020	0.0006	−0.0030	0.0041
FL	0.0095	0.0109	0.0081	−0.0093	−0.0120	−0.0065	0.0003	−0.0010	0.0016
GA	0.0100	0.0127	0.0073	−0.0074	−0.0093	−0.0056	0.0025	0.0034	0.0017
SC	0.0079	0.0114	0.0044	−0.0073	−0.0109	−0.0037	0.0006	0.0005	0.0007
Delta									
AR	0.0107	0.0106	0.0107	−0.0098	−0.0120	−0.0075	0.0009	−0.0014	0.0032
LA	0.0093	0.0136	0.0049	−0.0128	−0.0190	−0.0066	−0.0035	−0.0055	−0.0016
MS	0.0097	0.0126	0.0068	−0.0099	−0.0147	−0.0052	−0.0002	−0.0020	0.0017
Southern plains									
OK	0.0028	0.0074	−0.0018	−0.0071	−0.0132	−0.0010	−0.0043	−0.0058	−0.0027
TX	0.0057	0.0067	0.0048	−0.0080	−0.0116	−0.0045	−0.0023	−0.0049	0.0003

Table 7.1 (continued)

	Productivity change			Price change			Profit change		
	1960–2004	1960–1982	1982–2004	1960–2004	1960–1982	1982–2004	1960–2004	1960–1982	1982–2004
Mountain									
AZ	0.0088	0.0058	0.0119	−0.0078	−0.0110	−0.0046	0.0010	−0.0052	0.0073
CO	0.0057	0.0050	0.0064	−0.0053	−0.0072	−0.0035	0.0004	−0.0022	0.0029
ID	0.0104	0.0070	0.0138	−0.0079	−0.0083	−0.0074	0.0026	−0.0013	0.0064
MT	0.0073	0.0078	0.0068	−0.0101	−0.0161	−0.0040	−0.0028	−0.0083	0.0027
NM	0.0068	0.0045	0.0091	−0.0064	−0.0117	−0.0010	0.0005	−0.0072	0.0081
NV	0.0062	0.0066	0.0057	−0.0049	−0.0087	−0.0010	0.0013	−0.0021	0.0048
UT	0.0073	0.0047	0.0099	−0.0064	−0.0098	−0.0030	0.0009	−0.0051	0.0068
WY	0.0032	0.0019	0.0046	−0.0059	−0.0105	−0.0013	−0.0027	−0.0086	0.0033
Pacific									
CA	0.0102	0.0108	0.0097	−0.0068	−0.0106	−0.0030	0.0035	0.0002	0.0067
OR	0.0123	0.0101	0.0146	−0.0107	−0.0141	−0.0073	0.0016	−0.0040	0.0073
WA	0.0107	0.0116	0.0098	−0.0100	−0.0117	−0.0082	0.0007	−0.0001	0.0016

Table 7.2 Panel unit roots 1961–2004

	Bennet-Bowley		Price change		Profit change		(log) R&D	
	ADF[a]	PP[a]	ADF[a]	PP[a]	ADF[b]	PP[b]	ADF[b]	PP[b]
Chi-sq.[c]	462.459	551.107	250.659	266.480	310.408	306.136	394.513	134.196
Prob.	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.006
Intermediate ADF and PP test results								
	ADF Prob.	PP Prob.	ADF Prob.	PP Prob.	ADF Prob.	PP Prob.	ADF Prob.	PP Prob.
Northeast								
CT	0.057	0.064	0.890	0.631	0.095	0.130	0.000	0.502
DE	0.031	0.024	0.000	0.000	0.036	0.011	0.732	0.994
MA	0.073	0.072	0.088	0.071	0.016	0.020	0.862	0.936
MD	0.007	0.006	0.004	0.003	0.005	0.003	0.410	0.805
ME	0.005	0.005	0.001	0.001	0.005	0.005	0.068	0.861
NH	0.011	0.011	0.012	0.010	0.006	0.008	0.032	0.987
NJ	0.326	0.441	0.010	0.011	0.144	0.201	0.164	0.798
NY	0.353	0.415	0.017	0.014	0.017	0.024	0.013	0.629
PA	0.054	0.050	0.087	0.079	0.000	0.000	0.735	0.986
RI	0.086	0.074	0.073	0.054	0.016	0.015	0.004	0.715
VT	0.084	0.084	0.183	0.142	0.009	0.010	0.347	0.995
Great Lakes								
MI	0.955	0.008	0.101	0.101	0.095	0.104	0.000	0.029
MN	0.000	0.000	0.076	0.081	0.141	0.183	0.992	0.979
WI	0.728	0.102	0.395	0.395	0.286	0.354	0.777	0.963
Corn Belt								
IA	0.001	0.000	0.082	0.063	0.015	0.015	0.845	0.980
IL	0.000	0.000	0.189	0.150	0.047	0.061	0.958	0.911
IN	0.000	0.000	0.048	0.048	0.003	0.003	0.513	0.987

Table 7.2 (continued)

	Bennet-Bowley		Price change		Profit change		(log) R&D	
	ADF[a]	PP[a]	ADF[a]	PP[a]	ADF[b]	PP[b]	ADF[b]	PP[b]
Chi-sq.[c]	462.459	551.107	250.659	266.480	310.408	306.136	394.513	134.196
Prob.	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.006
MO	0.000	0.000	0.049	0.049	0.064	0.082	0.000	0.273
OH	0.000	0.000	0.074	0.086	0.003	0.003	0.001	0.956
Northern Plains								
KS	0.305	0.006	0.012	0.010	0.142	0.195	0.414	0.480
ND	0.000	0.000	0.412	0.314	0.071	0.090	0.001	0.671
NE	0.001	0.001	0.060	0.061	0.003	0.003	0.000	0.495
SD	0.001	0.001	0.078	0.086	0.151	0.194	0.000	0.034
Appalachian								
KY	0.029	0.026	0.244	0.271	0.010	0.010	0.001	0.969
NC	0.572	0.465	0.029	0.045	0.108	0.100	0.008	0.078
TN	0.928	0.033	0.060	0.063	0.149	0.192	0.089	0.001
VA	0.897	0.389	0.212	0.224	0.041	0.109	0.271	0.002
WV	0.695	0.717	0.027	0.030	0.017	0.019	0.648	0.994
Southeast								
AL	0.007	0.007	0.048	0.045	0.013	0.013	0.000	0.822
FL	0.098	0.088	0.122	0.109	0.166	0.169	0.133	0.935
GA	0.000	0.000	0.003	0.002	0.259	0.004	0.624	0.013
SC	0.000	0.000	0.287	0.001	0.001	0.001	0.000	0.951
Delta								
AR	0.000	0.000	0.072	0.076	0.061	0.052	0.001	0.030
LA	0.051	0.084	0.115	0.115	0.456	0.481	0.008	0.009
MS	0.000	0.000	0.111	0.136	0.046	0.046	0.052	0.334

Table 7.2 (continued)

	Bennet-Bowley		Price change		Profit change		(log) R&D	
	ADF[a]	PP[a]	ADF[a]	PP[a]	ADF[b]	PP[b]	ADF[b]	PP[b]
Chi-sq.[c]	462.459	551.107	250.659	266.480	310.408	306.136	394.513	134.196
Prob.	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.006
Southern Plains								
OK	0.018	0.020	0.207	0.229	0.011	0.013	0.488	0.994
TX	0.003	0.003	0.306	0.290	0.193	0.225	0.921	0.995
Mountain								
AZ	1.000	0.092	0.090	0.053	0.357	0.415	0.006	0.119
CO	0.034	0.034	0.322	0.280	0.086	0.073	0.756	0.953
ID	0.383	0.383	0.080	0.066	0.015	0.011	0.477	0.135
MT	0.004	0.004	0.249	0.249	0.228	0.264	0.742	0.866
NM	0.164	0.233	0.828	0.758	0.297	0.336	0.010	0.984
NV	0.075	0.070	0.621	0.494	0.099	0.074	0.297	0.874
UT	0.399	0.383	0.084	0.089	0.151	0.133	0.232	0.826
WY	0.023	0.028	0.051	0.126	0.297	0.283	1.000	1.000
Pacific								
CA	0.001	0.000	0.547	0.482	0.010	0.296	0.000	0.000
OR	0.049	0.047	0.396	0.396	0.068	0.196	0.008	0.140
WA	0.936	0.890	0.220	0.186	0.631	0.620	0.018	0.001

[a]Exogenous variables: individual effects, individual linear trends
[b]Exogenous variables: individual effects
[c]Fisher ADF and PP (Phillips-Perron) Test Statistics (Probabilities for Fisher tests are computed using an asymptotic Chi-square distribution)

Table 7.3 Panel estimates 1961–2004 (Fixed cross section and period effects)

	Dependent variable (Y)		
	BB	PC	ΠC
$Y(-1)$	0.703	0.737	0.725
	(35.252)	(40.897)	(37.635)
log(R&D)	0.036	−0.026	0.007
	(3.843)	(−2.831)	(0.637)
PALMER	−0.008	−0.004	−0.012
	(−2.488)	(−1.430)	(−3.372)
Const.	−0.435	0.283	−0.114
	(−2.910)	(1.925)	(−0.670)
Adj-R-sq.	0.950	0.959	0.862

BB = Cumulative Bennet-Bowley productivity indicator
PC = Cumulative Bennet-Bowley price change
ΠC = Cumulative profit change
PALMER = absolute value of the Palmer Index
Numbers in brackets are t-ratios of estimated coefficients
computed using robust panel corrected standard errors (PCSE)

7.5 Data Appendix

The Economic Research Service (ERS) of the US Department of Agriculture has for some time been engaged in projects to develop data that can support research efforts like those pursued in this chapter. Given the limited illustrative objective of this part of the chapter, only a brief overview of the data is provided.

The production accounts for each state are derived form a panel of annual observations. State-specific aggregates of output and labor, capital, and materials inputs are formed as Törnqvist indexes over detailed output and input accounts. Törnqvist output indexes are formed by aggregating over agricultural goods and services using revenue-share weights based on shadow prices. The changing demographic character of the agricultural workforce is used to build a quality-adjusted index of labor input. Estimates of capital input are obtained by representing capital stock at each point of time as a weighted sum of past investments, where the weights are the relative efficiencies of assets of different ages. The same pattern of decline in efficiency is used for both the capital stock and the rental price of capital services so that the requirement for internal consistency of a measure of capital input is met. The contribution of feed and seed, energy, and agricultural chemicals is captured in the index of intermediate inputs. An important innovation is the use of hedonic price indexes in constructing measures of fertilizer and pesticide consumption. Finally, considerable effort was expended to develop output and input prices that have spatial as well as temporal integrity. The result is a true panel that can be used for both cross-sectional and time series analysis. A full description of the underlying data series, sources, and aggregation procedures are provided in Ball et al. (1999, 2004).

The data are used to construct "indicators" of productivity change. We then investigate the effects of public investment in R&D on patterns of change. In studies of the impact of research in manufacturing, the stock of research is frequently constructed from research expenditures using the perpetual inventory method. However, Griliches (1998) concludes that the usual declining balance or geometric depreciation does not fit well with the likely gestation, blossoming, and eventual obsolescence of knowledge. Alternatively, a few researchers have included lagged research expenditures, but one does not get very far in causal inference with non-experimental data unless a significant amount of structure is imposed on the analysis (Klette et al., 2000).

To approximate the likely impacts on state productivity of discoveries from public agricultural research expenditures Huffman and Evenson (1993, 1994) impose a trapezoidal lag structure. After an initial gestation period during which the impacts of research are negligible, blossoming is assumed to occur with increasing weights. This period of increase is followed by a period of maturity during which the weights are constant. Finally we observe a period of obsolescence and declining weights. We adopt Huffman and Evenson's trapezoidal weights to derive proxy variables for public agricultural research stocks.

Annual data on agricultural research expenditures are taken from Huffman et al. (2001). Nominal expenditure data are deflated by an agricultural research price index reported in Huffman and Evenson (1993) for the period 1927–1990, and their methods are employed to extend this series to 2004. This index assumes that roughly 70% of research expenditures are labor costs, an assumption that is broadly consistent with available data on the composition of research expenditures.

Notes

1. Here we follow Diewert (2005) and refer to measures defined in terms of differences as indicators and measures defined in terms of ratios as indexes.
2. This indicator is due to Chambers (1996). Its properties are discussed in Chambers et al. (1996).
3. The quadratic lemma is due to Diewert (1976).
4. Note that this is the same normalization as for a profit efficiency measure (see Färe et al. 2008). It follows from the duality between the profit function and the directional distance function.
5. Note that rejection of the null hypothesis of a unit root in a panel does not necessarily imply that all individual series are stationary. In fact, as shown in Table 7.2, the intermediate results indicate that a number of individual series may be non-stationary. In particular, it appears that productivity shocks may be quite persistent in the Appalachian region and price shocks in the Great Lakes, Southern Plains, and Pacific regions.

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Part III
Energy and Agricultural Policy

Chapter 8
Biofuels Expansion in a Changing Economic Environment: A Global Modeling Perspective

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Abstract This chapter examines the impact of expanding biofuels production and use on agricultural commodity markets. It also examines the continued biofuels expansion under declining energy prices. The analysis uses a Partial Equilibrium Agricultural Trade Simulation (PEATSim) model, a dynamic multi-commodity, multi-country global trade model of the agriculture sector to analyze the interaction between biofuel, crop, and livestock sectors. The ability of countries to achieve their energy goals will be affected by future direction of petroleum prices. A 30% decline in petroleum prices (absent of mandates) would result in rapid decline in biofuel use worldwide accompanied by a decline in feedstock and biofuel prices.

8.1 Introduction

Rapid changes in crude oil and agricultural commodity prices have increased the uncertainty regarding the effects of increased biofuels production on commodity markets and the feasibility of achieving biofuel targets. The biofuels sector is confronted by a changed and uncertain economic environment. The high energy price environment that stimulated the biofuels boom in 2006–2008 has been transformed into a low and fluctuating energy price environment. Nevertheless, at least for the present, government policies continue to influence the biofuel sectors in many countries of the world, including the United States, the EU member countries, Brazil, Canada, Argentina, China, countries of the former Soviet Union, Malaysia,

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and Indonesia. These countries continue to institute programs to promote biofuel production and pursue specific biofuel targets.

In the United States, for example, the Energy Independence and Security Act (EISA) enacted in December 2007 mandates the use of 36 billion gallons of biofuels by 2022, with as much as 15 billion gallons coming from corn-based ethanol by 2015. In addition, such factors as a blenders' tax credit, import tariffs, and the elimination of methyl tertiary butyl ether (MTBE) as an additive in gasoline have provided economic incentives for biofuel expansion. As different countries use different feedstock sources, the challenge is to capture and properly model both the demand for biofuels and the supply response specific for each country.

Accordingly, this chapter will examine the impact of biofuels policy on agricultural commodity markets. In particular, the specific objectives of this chapter are as follows:

- Capture the links between the market for biofuels, feedstock, and by-products using the Partial Equilibrium Agricultural Trade Simulation (PEATSim) model;
- Analyze the impact of shifts in the demand for ethanol and biodiesel on agricultural commodity production, prices, and trade in the United States, the European Union, Brazil, and the rest of the world; and
- Evaluate the effects of a decline in petroleum prices on the demand for biofuels and on global agricultural commodity markets.

We accomplish these objectives by incorporating a biofuels module in PEATSim for several key countries and regions (e.g., the United States, Brazil, and the EU). These are three major consumers and producers of ethanol and biodiesel globally. Since each country uses different feedstock, the challenge is to model both demand and supply response in each country. A "stylized" representation of biofuels production would fail to capture the complexities of the biofuels sector. For this reason, it is important that each country's biofuel sector be represented explicitly.

8.2 Literature Review

Baker et al. (2008) developed a stochastic and dynamic General Equilibrium (GE) model that captures the uncertain nature of key variables such as crude oil prices and commodity yields. They show that the subsidies for corn ethanol, biodiesel, and cellulosic ethanol need to be increased to raise their production.

Schmitz et al. (2007) used a welfare economic framework to address distributional issues and determined gainers and losers from ethanol production. The authors estimated the impact of ethanol subsidies on corn used for ethanol.

Gardner (2007) developed a vertical market model of ethanol, by-products and corn to analyze social costs of ethanol subsidies or mandates. The study indicated that ethanol subsidies are unlikely to generate net social gains.

Gallagher et al. (2006) indicate that without tariffs both the United States and Brazil would exhibit periods of competitive advantage in producing ethanol from corn and sugarcane, respectively. Furthermore, they indicate that a US tariff-free quota for ethanol imports from Caribbean countries often would be filled, but the United States would also exhibit competitive export position in the ethanol market.

Von Lampe (2006) evaluated various scenarios using the OECD's AGLINK model. The first scenario assumed a constant rate of growth in biofuel production from the 2004 level. The second scenario assumed biofuel growth rates for various countries in line with articulated policy goals. The third scenario incorporated adjustments in energy prices which affected the cost of agricultural production and the profitability of biofuel production. All of these scenarios resulted in increased grain prices and expanded land use in biofuel production.

Elobeid and Tokgoz (2007) provided the first comprehensive model of the biofuels economy. They analyzed the impact of liberalizing the US ethanol market and removing the US federal tax credit. Trade liberalization resulted in an increase in US net ethanol imports and a decrease in the demand for corn for ethanol production. Removal of US tariff on ethanol and a reduction in the blending tax credit increase US imports of ethanol by about 130%. US ethanol production falls by about 9%, while production of ethanol in Brazil increases by slightly more than 6%.

Tokgoz et al. (2007) provided estimates of the impacts of higher oil prices, drought, and removal of land from US Conservation Reserve Program. The study filled some gaps and included work on equilibrium prices of co-products of the biofuel industries, most importantly distillers' grains. The study found that exogenous corn and sugar price increases reduce the production of ethanol, while increased prices for gasoline increase the production of ethanol.

Earlier studies incorporated exogenous assumptions about the biofuel sector, with most recent ones incorporating an assumed (i.e. exogenous) demand for biofuels. Very few studies have addressed the impact of stronger biofuels demand on global agricultural markets, nor have they dealt with declining energy prices. In this study, we extend the PEATSim model to address these issues by incorporating detailed ethanol and biodiesel markets and linking them to the domestic and international agricultural commodity markets.

8.3 Methodology and Modeling Framework

Analysis of biofuels and agricultural markets is inherently a multi-sector problem. For this reason, we use the PEATSim model as a tool to analyze the complex facets of this problem.[1]

PEATSim is a dynamic, partial equilibrium, multiple-commodity, multiple-region model of global agricultural policy and trade. The model accounts for simultaneous interaction between livestock and crops while maintaining identities such as supply, utilization and consumption. PEATSim contains major crop and oilseed markets, as well as oilseed product, sugar, livestock, dairy, and liquid fuels (ethanol and biodiesel) markets. It also contains explicit representation of each country's domestic and trade policies pertaining to agricultural commodities.

PEATSim, unlike other trade models, has the unique ability to model different sets of production activities, linkages among various crop and livestock sectors, and interaction of producers, processors, and consumers at a global level. The model's innovative and flexible specification gives it the capability to incorporate a variety of domestic and trade policy instruments.

The PEATSim model is written in GAMS (General Algebraic Modeling System) programming language utilizing PATH, a Mixed Complementarity Problem (MCP) algorithm developed by Dirkse and Ferris (1995a, 1995b). MCP allows PEATSim to handle discontinuities, such as production quotas, tariff rate quotas (TRQs), and discontinuous demand functions created by mandates, targets, and other policy instruments.

8.3.1 Model Structure

PEATSim includes variables for production, area, yields, consumption, exports, imports, stocks, world prices, and domestic producer and consumer prices. Identities such as supply and utilization, consumption and its components (food, feed, fuel, crush, etc.) hold for all commodities and regions in the model. The behavioral equations have the same functional form (constant elasticity specification) for all countries/regions in the model. Constant elasticity functions were selected because of their underlying properties and because of ease of interpretation. They can be viewed as first-order approximations to underlying supply and demand relationships.

8.3.2 Country Coverage

PEATSim includes thirteen countries or regions: the United States, the European Union (EU-25), Japan, Canada, Mexico, Brazil, Argentina, China, India, Australia, New Zealand, South Korea, and the rest of the world (ROW).

8.3.3 Commodity Coverage

There are thirty-two agricultural commodities: 9 crops (rice, wheat, corn, other coarse grains, soybeans, sunflowers, rapeseed, cotton, and sugar); 10 oilseed, oil, and meal products (soybean, sunflower seed, rapeseed, and other oils); four livestock products (beef and veal, pork, poultry, and raw milk); six dairy products (fluid milk, butter, cheese, nonfat dry milk, whole dry milk, and other dairy products). In addition, there are two biofuel commodities and one by-product – ethanol, biodiesel, and distillers' dried grains (DDGs).

8.3.4 Trade Flows

The model balances supply and demand with the condition that world imports equal world exports. For commodity i in region r in year t, net trade (exports minus imports) is equal to:

$$\mathrm{NET}_{irt} = \mathrm{PRD}_{irt} - \mathrm{FOO}_{irt} - \mathrm{FEE}_{irt} - \mathrm{CRU}_{irt} - \mathrm{FUE}_{irt} - \mathrm{RMD}_{irt} - \mathrm{OTH}_{irt} - \mathrm{STK}_{irt},$$

where:

PRD_{irt} = production of commodity i in region r in time t;
FOO_{irt} = food demand of commodity i in region r in time t;
FEE_{irt} = feed demand of commodity i in region r in time t;
CRU_{irt} = crush demand of commodity i in region r in time t (zero for all commodities except oilseeds);
FUE_{irt} = fuel demand of commodity i in region r in time t;
RMD_{irt} = processing demand of commodity i in region r in time t (zero for all commodities except raw milk);
OTH_{irt} = other use demand of commodity i in region r in time t; and,
STK_{irt} = net increase in ending stocks between years.

8.3.5 Equilibrium Condition

Global market equilibrium requires that the sum of net trade across regions be equal to zero for each internationally traded commodity. Therefore, the market clearing condition requires:

$$\sum_{r \in \text{all regions}} \mathrm{NET}_{irt} = 0 \text{ for } i \in \text{ traded commodities}$$

8.3.6 Supply/Production

Production of grains, oilseeds, and cotton (PRD_{irt}) is the product of acreage harvested (AHV_{irt}) and yield (YLD_{irt}). Area harvested is specified as a constant-elasticity function of the producer price and the producer prices of other crops (PRP_{irt}). Yield is a constant-elasticity function of previous period yields and producer prices. Vegetable oil and meal production are specified as products of oilseed crush demand and extraction rates. Crush demand is specified as a function of lagged crush demand and the oilseed crushing margin (product value divided by seed value times yield). Livestock production is a function of lagged production and producer prices for livestock, and of a feed cost index. Production of dairy products is specified as a function of lagged production, lagged raw milk production, and dairy product prices. Stocks are functions of product prices. Biofuel production is a function of its price and of a feedstocks cost index.

8.3.7 Demand

Total consumption of each commodity in the model is the sum of food demand (FOO_{irt}), feed demand (FEE_{irt}), crushing demand (CRU_{irt}), fuel demand (FUE_{irt}), processing demand (RMD_{irt}), and other use (OTH_{irt}). Food demand exists for all commodities except raw milk and oilseed meals. Feed demand is determined by the production of livestock in the model. Oilseed demand is for crushing, and the products are meals and oils. Fuel demand exists for biofuels such as ethanol and biodiesel. Since milk in its raw form is not consumed, there is a processing demand for raw milk to produce dairy products. Other use demand which includes seed use and waste is generally small.

8.3.8 Price

Prices in the model are based on the world market clearing price (PWD_{irt}). Import prices (PIM_{irt}) are defined as:

$$\mathrm{PIM}_{irt} = \mathrm{PWD}_{irt}(1 + \mathrm{TRQ}_{irt}) + \mathrm{TRANS}_{irt} + \mathrm{DUT}_{irt}$$

where:

PIM_{irt} = import price;
TRQ_{irt} = the *ad valorem* tariff;
TRANS_{irt} = transportation cost;
and,
DUT_{irt} = specific duties.

The world reference price is the price that permits world net trade for commodity i in time t to equal zero. It is denominated in US dollars. The domestic price for a traded good in a country or region in any year is equal to the world reference price (in US dollars) plus transportation costs and tariffs and levies. All domestic prices are denominated in national currencies. Exchange rates are treated as exogenous. All prices in the model are linked through the domestic price to the world reference price. As such, they represent price levels which achieve global market equilibrium.

8.3.9 Data

The data in PEATSim are from USDA Agricultural Projections to 2017 for area, yield, production, consumption, stocks, trade, and world prices. Dairy and sugar information from OECD and biofuel information from FAPRI supplements the data set. Parameter values in the model are drawn from the literature and other trade models. The version of the model used in this study calibrates to the USDA baseline and the results of the scenario analyses are reported as percentage or differences from the baseline.

The USDA's long-term projections were used as the base run of the model. The USDA's projections reflect a conditional, long-run scenario about what's expected to happen under a continuation of current farm legislation and specific assumptions. It assumes that there are no shocks due to abnormal weather, outbreaks of plant or animal diseases, or other uncommon factors affecting global supply and demand. The USDA Agricultural Projections to 2017 assumes normal economic growth; depreciation of the US dollar through 2011 and slow appreciation afterward; oil prices to drop modestly in 2010 through 2013 and projected to rise slightly afterward; the 2002 Farm Act and the Agricultural Reconciliation Act of 2005 to continue while the area enrolled in the Conservation Reserve Program (CRP) to decline; the tax credits remain in effect; and over 12 billion gallons of ethanol to be produced by 2010 and over 14 billion by the end of the projection period (USDA, 2008).

8.3.10 Biofuel Sector in PEATSim Model

For this analysis the PEATSim model was extended by incorporating a detailed representation of ethanol and biodiesel markets, which were linked to the domestic and international agricultural markets. Currently, the PEATSim model has a fully operational endogenous biofuel sector for the United States (*corn-ethanol*), Brazil (*sugar-ethanol*), and the European Union (*rapeseed oil-diesel*).

The biofuel sector in each of these countries is represented by a set of demand and supply equations. The quantity of biofuel produced is specified as a function of its own price and feedstock cost. The demand for ethanol is specified as a function of its own price, the price of crude oil (petroleum), and income (gross domestic product). An additional set of supply and demand equations are also specified for by-products produced, specifically distillers dried grains (DDGs) from corn-based ethanol production. The supply of DDGs is specified as a fixed proportion of ethanol produced and the demand for DDGs is specified as a function of its own price, livestock production, and the price of other feeds.

8.4 Results and Analysis

The dynamic PEATSim model is calibrated to the 2009–2017 results from the USDA baseline projections. Alternative hypothetical scenarios were simulated and sensitivity analyses conducted. The shocks are introduced to the model to determine how production, consumption, trade, and prices will adjust.

8.4.1 Hypothetical Scenarios

The United States, Brazil, and the European Union are major players in the biofuel sector. Brazil and the United States together account for almost 90% of ethanol production worldwide, while the European Union accounts for over 80% of global biodiesel production and consumption. There is continued emphasis on increasing availability of alternative fuel sources in these countries and globally. EU member countries aim to increase the biofuel share of total transportation fuel to 5% by 2012 and 10% by 2020 as per the EU's Renewable Energy Directive. In addition, Brazil continues to emphasize energy independence and laid out ethanol production targets in its Energy Plan to 2030 (EPE, 2007). Nonetheless, this expanding demand for biofuel will be occurring in an uncertain crude oil price environment. If the recent declines in petroleum prices represent a long-term shift, biofuels could be operating in a much more competitive environment with gasoline and diesel.

We modeled three hypothetical scenarios for this study, namely:

- Scenario 1 – shift US ethanol demand curve to meet RFS requirements for corn-based ethanol use. We also add a twist to Scenario 1. We increase US corn yield and determine the corn yield (threshold yield) needed to fully offset the increase in corn price caused by the increase in ethanol demand.
- Scenario 2 – simultaneous global biofuel demand increases (demand curve shifts), with shift in US ethanol demand to meet RFS requirements as in Scenario 1, shift in Brazil's ethanol demand to achieve ethanol production and targets as laid out in its national energy plan to 2030, and shift in EU biodiesel demand to increase renewable fuel share to 5% of total transportation fuel more in line with the EU Renewable Energy Directive.
- Scenario 3 – global biofuel demand increases as in Scenario 2, accompanied by 30% reduction in petroleum prices. The drop in crude oil prices after the July 2008 record highs demonstrates that the high energy cost environment that stimulated the development of the biofuels sector may not last. A twist to this scenario is to determine the necessary shift in US ethanol supply curve to keep ethanol consumption at global (Scenario 2) levels.

Each scenario was modeled by shifting the intercept in each relevant equation or by changing the technology parameter to change feedstock yields. All other equations and exogenous data (including macroeconomic information such as exchange rates and GDP) remain the same as in the base run. All scenario results are reported as percentage deviations from the baseline or other specified levels.

8.4.2 Hypothetical Scenario 1 – US Ethanol Demand Increase

An increase in demand for ethanol in the United States causes demand for ethanol feedstocks, primarily corn, to increase. As a result, corn world reference price and US producer price increase by 3 and 1%, respectively, while US corn production increases slightly – about 1% (Table 8.1). The slight increase in US corn production suggests that the potential for increasing corn plantings through crop substitution and utilization of idle lands are limited.

Table 8.1 Scenario 1: Impact of a U.S. ethanol demand shift, 2017

Commodity	World ref. price	U.S. production	U.S. exports
	% change from base		
Corn	3.1	0.8	−11.0
Wheat	0.7	−0.1	−0.8
OCG	0.9	−0.0	−2.0
Soybeans	1.0	−0.3	−0.6
Soy meal	0.6	−0.2	0.5
Soy oil	1.1	−0.2	−2.4
Beef	1.2	−1.1	0.4
Pork	0.8	−0.6	−1.3
Poultry	1.0	−0.6	−1.2

Most of the adjustments in US demand for corn come from a reduction in exports, reflecting corn's high value as a livestock feed. US exports of corn fall by 11% (Table 8.1). Despite this decline, the United States remains the largest corn exporter.

Increases in corn price are partially offset by a decline in the price of DDGs. As a result, feed costs increase only slightly. The slight increase in feed costs causes US livestock production to decline. Still, US exports of beef increase as a result of higher feed costs in other countries. This competitive advantage reflects the availability of DDGs to US livestock producers, particularly cattle producers, which dampens the effect of the increased cost of corn on their production costs.

In addition, we conducted a modeling exercise to see how much corn yield needs to increase to offset the increase in demand for ethanol in the United States. Increasing corn yields by 1.4% above projected yields by 2017 would suffice to offset the projected corn price increase.

8.4.3 Hypothetical Scenario 2 – Global Biofuel Demand Increase

Scenario 2 deals with global expansion of ethanol and biodiesel use. The global demand shifts in this scenario result in the United States achieving the RFS requirements for corn-based ethanol. The EU-25 also moves closer to achieving the 5% target for biofuels use in total transportation fuel. Lastly, Brazil increases its ethanol use consistent with the national energy plan to 2030.

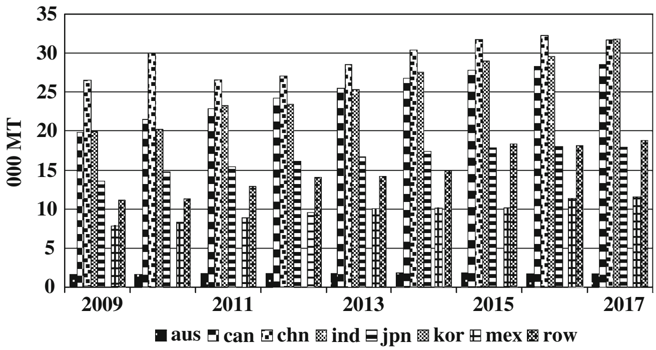

Fig. 8.1 Scenario 2: change in global rapeseed oil production with global biofuel demand shifts.*
Source: PEATSim model results
*Excluding EU Results

Prices for feedstocks (corn, sugar, and rapeseed), ethanol, and biodiesel increase. As expected, global rapeseed oil production expands (Fig. 8.1). Production of rapeseed meal, a by-product of the crushing process, also expands, driving down its price.

The effects of the increase in US ethanol demand on agricultural commodity markets are more dramatic than those described under the first scenario. In the EU-25, production, price, and imports of rapeseed oil increase (Table 8.2). Consumption of rapeseed oil increases by about 5%. However, imports are the primary source of this increase. Rapeseed oil production increases by about 2%, while rapeseed oil imports increase about 21%.

Table 8.2 Scenario 2: Impact of a gloabal biofuel demand shift, European Union, 2017

Commodity	World ref. price	Imports	Production	Domestic use
	% change from base			
Rapeseed				
Seed	5.4	9.8	1.8	1.8
Oil	9.2	20.9	1.8	4.9
Meal	−2.8	2.9	1.2	2.1

8.4.4 Hypothetical Scenario 3 – Petroleum Price Decline

This scenario deals with the same global ethanol and biodiesel demand shifts as in Scenario 2, but this time it is accompanied by a lower petroleum price. The 30% reduction in price of petroleum causes biofuels use to fall significantly (Fig. 8.2). Ethanol use in Brazil falls less than in the United States, reflecting Brazil's lower costs of production.

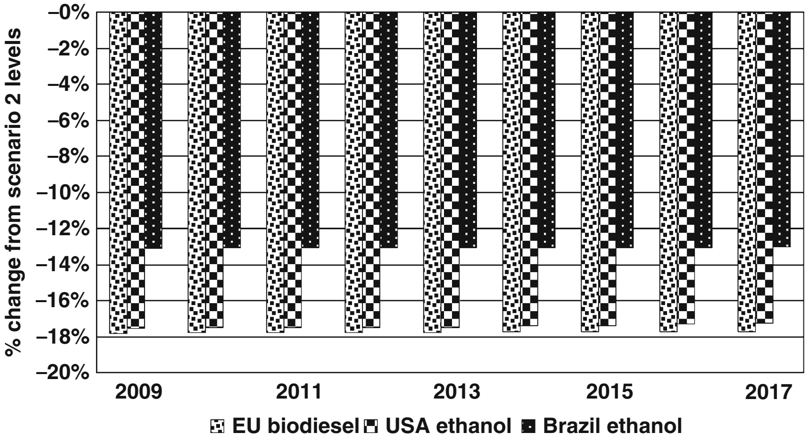

Fig. 8.2 Scenario 3: change in biofuel use with global demand shifts and decrease in petroleum price. *Source*: PEATSim model results

8.5 Summary and Conclusion

The results of our analysis indicate that hypothetical increases in the demand for biofuels would put upward pressure on agriculture commodity prices – in particular, the prices of corn, sugarcane, and rapeseed, and the major biofuel feedstocks in the United States, Brazil, and the European Union. However, increasing US corn yields by about 1.4% per year above current projections would likely offset the impact of increased US demand for ethanol to meet RFS requirements.

A 30% decline in petroleum prices would result in a rapid decline in biofuel use worldwide. This would be accompanied by a decline in feedstock and biofuel prices.

Supplying sufficient biofuels to meet prescribed targets will continue to have a major impact on agricultural commodity markets. This impact will be lessened if yields from current ethanol feedstocks increase or more productive (greater ethanol yield per acre) feedstocks, such as switchgrass, become feasible. At the same time, the ability of countries to achieve their energy goals will be affected by future direction of petroleum prices.

Note

1. The original version of the model, so-called ERS/WTO Penn State model, was developed by the Economic Research Service (ERS) at USDA, in collaboration with Pennsylvania State University. Since 2004, the model has been augmented and improved and has a fully endogenous biofuel sector.

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Chapter 9
Ethanol and Corn Prices: The Role of US Tax Credits, Mandates, and Imports

Harry de Gorter and David R. Just

Abstract The recent global increases in agricultural commodity prices can be attributed to a number of factors, but one of the most important was the large increase in US ethanol production. We argue that without a complex web of ethanol policies, little ethanol would be produced in the United States. This is likely the case for biofuel production in the EU, Canada, and other developed countries as well. It is increasingly evident that developing countries have a comparative advantage in the production of biofuels and their feedstock. Yet policies have been enacted that discriminate against trade. The result is little international trade in biofuels. This chapter puts into perspective the effects of US ethanol policies on commodity prices, as well as their impact on US terms of trade.

9.1 Introduction

Biofuel policy has become the subject of criticism because of rapidly escalating food prices that have stressed many developing countries and poor households (Runge and Senauer, 2007). Agricultural commodity prices have increased sharply since 2002, and especially in the past 2 years when grains and oilseeds prices doubled (Mitchell, 2008). Many factors have contributed to these higher commodity prices, like US dollar exchange rates, rising oil prices, increased demand due to rising incomes, supply shocks, agricultural policies, and biofuel policy (Abbott et al., 2008; Collins, 2008). Mitchell (2008) argues that without the increases in biofuel production in developed countries, cereal stocks would not have declined as much and the effects of other factors like droughts would be much less while export bans and speculative activities would probably not have occurred because they were largely responses to rising prices.[1] The approach taken in this chapter is to simply look at the direct effect of ethanol policy on corn prices and not speculate as to how

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the resulting increase in price may have triggered other actions that exacerbated the price rise.

This chapter explains how US ethanol policy has affected corn prices, which peaked at just under $8 per bushel in 2008 and have dropped to around $4 per bushel recently. We argue that ethanol policies are still having a significant impact on corn prices, especially given the fact that the demand for commodities has plummeted with the synchronized global financial and economic crisis of depression era proportions and that corn prices averaged $2 per bushel as recently as 2006 when world incomes were booming. This in itself provides some evidence that a new factor may be at work, namely, ethanol policy. We argue that without a complex web of ethanol policies, little ethanol would be produced in the United States. We conjecture that this is probably also the case for biofuel production in the European Union, Canada, and other developed countries. It is increasingly evident that developing countries have a comparative advantage in the production of bio-fuels and their feedstocks. Brazil currently is the least cost supplier of ethanol, and the lowest-cost biodiesel is derived from palm oil produced in Asia (Kojima et al., 2007).

A number of recent studies point to large welfare gains from a dismantling of trade distorting agricultural policies (Anderson and Martin, 2006; Hertel and Winters, 2006). It is well established that import barriers represent the largest share of market interventions in agriculture (Anderson et al., 2006a, b; Hoekman et al., 2004). These studies also conclude that the bulk of the benefits from trade liberalization go to developing countries. However, these studies have not included biofuel policy in their analysis. Current US biofuel production is due to deliberate government measures, especially tax credits and mandates (policies that by themselves do not discriminate against trade). However, complementary policies have been enacted that do discriminate against trade: import tariffs and quotas; production subsidies for biofuels and feedstocks; and sustainability thresholds.[2] The result is little international trade in biofuels (Howse et al., 2006). With the significant increase in oil prices and the adoption of these specific biofuels policies, the benefits to developing countries from trade liberalization in biofuels, like in agriculture, are also likely to be large.[3]

The purpose of this chapter is to put into perspective the effects of US ethanol policies on market prices of corn, particularly tax credits, mandates and import tariffs. Section 9.2 gives a more detailed analysis of how US ethanol tax credits and mandates impacted corn prices, while Section 9.3 discusses the role of US ethanol import tariffs and its impact on the terms of trade. Section 9.4 concludes.

9.2 The Impact of US Ethanol Policies on the Market Prices of Corn

The increase in US ethanol production has not only increased the demand for corn but has also led to large land use changes, which reduced supplies of wheat and other crops that compete with corn used for ethanol. Figure 9.1 shows the share

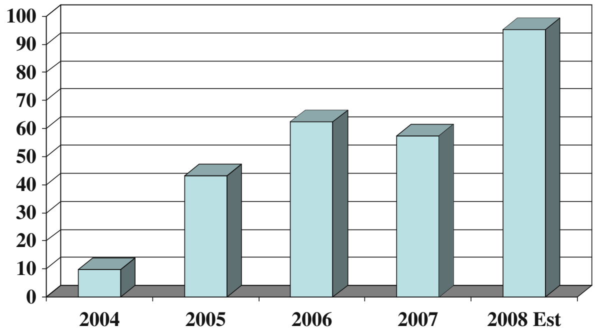

Fig. 9.1 Share of increase in global maize consumption going to US ethanol. *Source*: USDA PS&D database processed by Don Mitchell, personal communication

of the increase in global corn consumption each year since 2004 that went for US ethanol production. The 2008 number is the USDA's August 12th estimate released at the same time as their new crop production estimate. US ethanol is projected to take 95.2% of the increase in global corn consumption in 2008, and all other uses (food, feed, seed, and other industrial uses) will account for only 4.8%. In 2006 and 2007, US ethanol accounted for 62.5 and 57.3% of the increase in global corn consumption.

In addition to the declining US exchange rate and the increase in production costs due to higher oil prices, the empirical evidence in Mitchell (2008) suggests that the large increase in US and EU biofuel production has been a major contributor to commodity price increases directly and indirectly in that the ensuing export controls and speculative activities were a direct result of rising prices in the first place. If other actions that exacerbated commodity price increases are attributed to the initial price hike due to biofuel policy, then it is even more important to understand the direct link between biofuel policy and commodity prices. To this end, let us examine the specific case of the US tax credit for ethanol. The market price for ethanol P_E is given by:

$$P_E = \lambda(P_G + t) - t + t_C, \tag{9.1}$$

where λ is the ratio of miles per gallon of ethanol relative to gasoline (or 0.70), P_G is the price of oil-based gasoline, t denotes the *volumetric* fuel tax on both gasoline and ethanol, and t_C is the tax credit for ethanol.[4] To take advantage of the government subsidy offered them, blenders of ethanol and gasoline will bid up the price of ethanol until it is above the market price of gasoline by the amount of the tax credit (57 cents per gallon in the United States if we include state tax credits).

The first term on the right hand side of equation (9.1) is the price consumers are willing to pay for ethanol. The middle term in equation (9.1) shows how blenders have to pay the full tax t, but consumers are only willing to pay λt. Hence, the difference $(1-\lambda)t$ is a penalty on ethanol production. The tax t is a disproportionate tax on ethanol because it is levied on a volume basis while demand is on a mileage basis.

Several important conclusions can be drawn from equation (9.1). First, domestic and foreign producers of ethanol benefit alike from this tax credit. Second, increasing the fuel tax reduces the market price for ethanol, while the opposite occurs with a tax credit. Third, the world market price of ethanol is linked to the price of oil by the tax credit in the country with the *lowest net tax* (the combination of the lowest fuel tax and highest biofuel tax exemption). Because total ethanol production has a relatively small impact on the price of oil, a lower net tax on ethanol creates a wedge between the world price of oil and the domestic price for ethanol. The country with the lowest net tax creates the largest wedge and will, therefore, attract world ethanol production until the world price for ethanol rises to equal the marginal revenue from imports.

The United States establishes the world market price for ethanol. This means the tax exemption for all other countries does not directly increase the price of the biofuel relative to oil. Instead, tax exemptions in other countries act as a consumption subsidy for the biofuel, lowering the domestic consumer price of gasoline and biofuel blends (de Gorter et al., 2008). The only impact on the biofuel price is indirect insofar as the change in ethanol consumption affects world oil prices and, hence, biofuel market prices in the country with the combination of the lowest fuel tax and highest tax exemption. This result holds even though the prices of the biofuel, biofuel feedstock, and gasoline are linked to each other within a country and across countries through international trade. The equation for the market price of ethanol given in (9.1) above predicts US ethanol prices very accurately (some evidence of which is given in Fig. 9.2) but not ethanol prices in Brazil. This is because the market price of ethanol in Brazil equals the US market price less tariffs and transportation

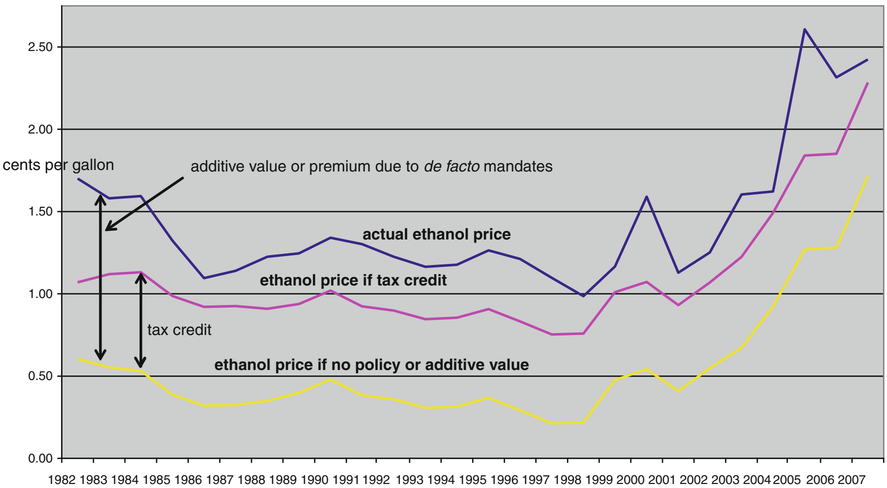

Fig. 9.2 Ethanol prices: Actual; tax credit only; or no policy

costs. Unlike in the United States, market prices for either ethanol or its feedstock (sugar) are not affected directly by the tax exemption in Brazil.

9.2.1 The Link Between the Corn and Ethanol Markets

Having established how ethanol prices are determined in relation to a tax credit, the next question is how this affects the corn price. The change in the price of corn is given by:

$$\Delta P_{\mathrm{CORN}} = \left(\frac{\beta}{1-\delta}\right) t_{\mathrm{C}} \tag{9.2}$$

where β denotes the gallons of ethanol produced from one bushel of corn (or 2.8 gallons) and δ denotes the proportion of the value of corn returned to the market in the form of by-products (0.31 as estimated by Eidman, 2007). The resulting value of bracketed term in (9.2) is 4.06. This means the corn price is very sensitive to a change in the price of ethanol (induced by either a change in the tax credit or world oil price). A tax credit of 57¢/gallon translates into approximately a $2.31 per bushel increase in the price of corn. The intuition for why one divides β by $(1 - \delta)$ in equation (9.2) is that $(1 - \delta)$ units of corn must be removed in order to increase ethanol production by β.Thus, this ratio represents the simple slope of the constant returns production function.

From Table 9.1 below, the contribution of the tax credit to corn prices ranges from 39 to 87%, depending on base values and current corn prices. The same outcome is realized if a consumption mandate is used instead to generate the same price premium. At $6 per bushel corn, Abbott et al. (2008) attribute 25% of the price increase to biofuels. Our data in Table 9.1 indicate it would be 58–63%, depending on the base price used. Other studies, however, obtain much lower estimates. Elobeid and Tokgoz (2008) conclude that biofuel policy adds $0.05 per bushel to the corn price, while FAPRI (2008) assigns a $0.14 per bushel price increase due to biofuels. The only study that used equation (9.2) is Collins (2008), thereby attributing a higher share of the commodity price increase to biofuel policy than any study other than Mitchell (2008).

Table 9.1 Share of increase in corn price due to tax credit

	Base corn price	
	2006 $2/bu	1982–2007 $2.35/bu
Corn prices		
$5/bu	0.77	0.87
$6/bu	0.58	0.63
$7/bu	0.46	0.50
$8/bu	0.39	0.41

Some argue that increased biofuel production reduces oil prices, thereby mitigating the impact on the price of corn (e.g., Du and Hayes, 2008).[5] This argument ignores the fact that there is only a 20% net energy savings with biofuel production according to life cycle accounting by Farrell et al. (2006) and that biofuel as a percent of world oil consumption is less than 1%. Biofuels constitute an even smaller share of world primary energy consumption. Furthermore, OPEC maybe reacting in such a way as to counter the price-decreasing effect of biofuels. Hence, any moderating effect of reduced oil prices (due to increased production of ethanol) on the price of corn prices is likely to be very modest.

To assess the impact of past ethanol policies, we plot in Fig. 9.2 three price series: the actual ethanol price, the ethanol price if there was only the tax credit (see equation (9.1) above), and the price of ethanol if there was neither ethanol policy nor additive value for ethanol. There are several important conclusions reached when analyzing this historical experience in the United States. First, the price premium for ethanol over gasoline has exceeded the tax credit in each of the past 25 years. This is shown in Fig. 9.2 where the actual ethanol price is higher than the price that would be observed if only a tax credit affected ethanol prices and consumers purchased ethanol only for its contribution to mileage. Since the actual price of ethanol is above the predicted price only if the tax credit is operational, we conclude that the tax credit was dormant in past years.[6] An explanation for why the ethanol price premium was greater than the tax credit is that ethanol was purchased historically because of *de facto* mandates in the form of environmental regulations like the Clean Air Act of the 1990s or the recent implicit ban on Methyl Tert-Butyl Ether (MTBE) (Tyner, 2007). Some observers view ethanol as a complementary product to gasoline as an oxygenator and octane enhancer (Miranowski, 2007). This means the demand for ethanol was proportional to gasoline consumption, equivalent to a blend mandate model. The result was price premium above that which would prevail if only a tax credit was operational.

Historically, the implied increase in the price of corn of $2.31 per bushel due to the tax credit was often greater than the market price of corn itself. The only way this could occur is if gasoline prices were extremely low, the cost of ethanol production was very high, or the opportunity cost of corn in non-ethanol use was very high. This means the intercept of the ethanol supply curve was far above the price of oil. We term this vertical distance "water". In order to impact production, the tax credit must exceed the "water." This "water" in the tax credit means that the taxpayer costs were mostly wasted in the "rectangular" deadweight loss–transfers that did not accrue to any group in society. Hence, farmers historically have not been able to take advantage of the large subsidy implied by the tax credit because a significant part of the tax credit was redundant.[7]

Consider Fig. 9.3 where the supply of ethanol, S_{Ethanol}, is derived from the horizontal difference between the supply of corn, S_{Corn}, and non-ethanol demand (domestic and export) for corn, D_{NE}. The intersection of S_{Ethanol} and D_{NE} defines the vertical intercept of the ethanol supply curve. Below this price, no ethanol is produced because the opportunity cost from other uses is too high. We denote the intercept of the ethanol supply curve as P_{NE}. Using the same relationship

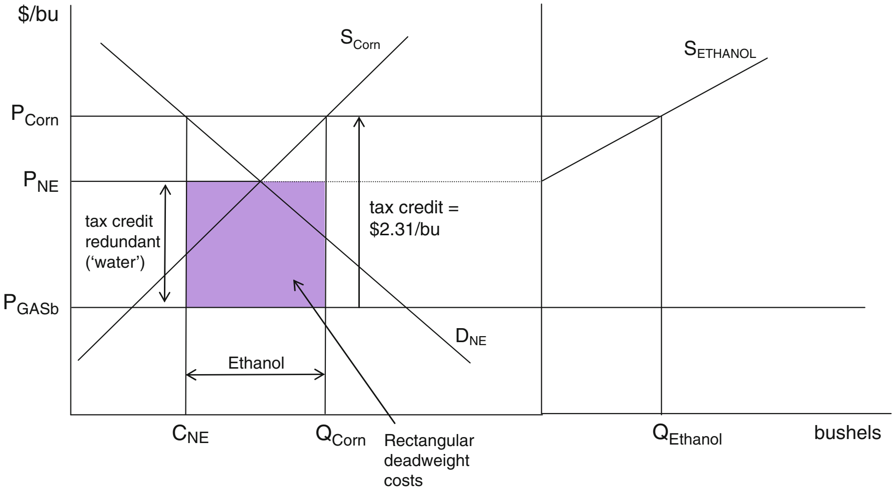

Fig. 9.3 The effects of a tax credit on corn prices with "water"

exploited in (9.2), we can calculate the bushel-equivalent price of gasoline. The bushel-equivalent price of gasoline is the maximum price of corn for which conversion to ethanol is profitable. If corn is used in both ethanol and non-ethanol consumption, then equilibrium requires

$$P_{\mathrm{E}} = \left[\beta/(1-\delta)\right] P_{\mathrm{CORN}} - c_0, \tag{9.3}$$

where c_0 is the fixed price of converting corn into ethanol. The bushel-equivalent price of gasoline can be obtained by replacing P_{CORN} in (9.3) with P_{GASb}, and then substituting the resulting relationship into (9.1). This results in

$$P_{\mathrm{GASb}} = [P_{\mathrm{GAS}} + t(1-\lambda) + \lambda(t_c + c_0)](1-\delta)/\lambda\beta \tag{9.4}$$

In Fig. 9.3, because the gasoline price in bushel equivalents P_{GASb} is less than P_{NE}, there would be no ethanol production without the tax credit. The distance between corn production Q_{Corn} and non-ethanol consumption C_{NE} is corn devoted to ethanol. Taxpayer costs of the tax credit are given by the production of ethanol times the tax credit (where the tax credit = $[\beta/(1-\delta)]t_{\mathrm{C}}$). Because of water in the tax credit, part of the tax cost is rectangular deadweight cost given by the shaded area. Water in the tax credit and associated rectangular deadweight costs increase with higher ethanol production costs and opportunity costs of corn in non-ethanol uses and with lower oil prices.

Not only was the intercept of the ethanol supply curve above the price of gasoline, but it was also above the price of corn. The only way this can happen is with production subsidies for corn and/or ethanol. These subsidies are the only reason for ethanol production in these cases. In other words, even with the tax credit or ethanol price premiums due to its value as an additive there would be no ethanol production unless there were production subsidies for corn and/or ethanol as well.

Only when oil prices increased sharply in the last few years did the tax credits have a measurable impact on corn prices. With higher oil prices, the gap between oil prices and the intercept of the ethanol supply curve narrowed. The tax credit then had a larger impact on corn prices. If the price of oil is above the intercept of the ethanol supply curve, then the tax credit has full impact on corn prices. Because the per unit tax credits are fixed, a spike in oil prices will lead to a spike in corn prices (with a lag because it took some time to get ethanol processing facilities online). Clearly then a fixed per unit tax credit in the face of an oil price spike causes instability in the corn market. And because the corn market is linked to other commodity markets (as a substitute good and as a competitor for productive resources), this price instability is quickly transmitted to other markets. This is part of the reason for the current food crisis. But mandates are more likely to transmit instability to the corn market if the shocks originate in the supply or demand for corn. It is, therefore, better to have a mandate conditional on the price of corn than a tax credit conditional on the price of oil. Conditioning the mandate on prices can reduce or eliminate the price transmission between markets.

The rapid expansion in ethanol productive capacity in recent years was due to a confluence of forces, including two key policy changes. The first was the 2005 Renewable Fuel Standard (RFS), which mandates the production of 7.5 billion gallons of biofuels by 2012. The second was the *de facto* ban on MTBE, a lower-cost substitute for ethanol as a fuel additive. Ethanol prices spiked. Once ethanol production surpassed the infra-marginal amount of ethanol required as an additive, ethanol prices plummeted. In the meantime, oil prices spiked. This led to a spike in corn prices. The fixed tax credit increased demand for corn used in ethanol, while production costs increased with the price oil, effectively shifting the supply curve for corn to the left. Finally, plans for a new RFS were finalized in December of 2007, emboldening investors to further expand ethanol productive capacity. Therefore, a link between the corn, ethanol, and oil markets was forged after 2006 through the tax credit. Instability from the oil market was transmitted to the corn market with the fixed tax credit being the link. If a blend mandate was used instead, then instability from the oil market would not have been passed on to the corn market. Indeed, a spike in oil prices would have reduced the price of corn as total demand for fuel, including the demand for ethanol, contracted.

To summarize, several factors determine the impact of biofuel policy on corn prices. These include the level of the tax credit itself, the technology parameter β (gallons of ethanol per bushel of corn), the by-product value parameter δ, the impact of increased ethanol production on oil prices, and the level of "water" in the tax credit. The level of "water" in the tax credit is determined by the level of oil prices, the cost of producing ethanol, and the opportunity cost of corn in non-ethanol uses, with the latter increasing with any upward shift in the supply of corn or outward shift in the demand for corn for uses other than ethanol.

9.3 The Role of Import Tariffs

One of the most controversial policies is the tariff on ethanol imports of 54 cents per gallon (plus an *ad valorem* tariff of 2.5%). The total *ad valorem* equivalent tariff is about 50%, which translates into 57 cents per gallon and is roughly equal to the tax credit. The tariff was originally implemented to offset the tax credit. Because ethanol from Brazilian sugarcane Brazil contributes far more to the reduction of greenhouse gases than does ethanol from corn, the tariff on imports is inconsistent with the policy goal of mitigating climate change while gaining energy security in an environment of increasingly unstable oil markets, dwindling oil reserves, and political instability in oil-exporting countries. Clearly, other political goals such as enhancing farm incomes, reducing the tax costs of farm subsidy programs, and promoting rural development are also very important. But we will show that in most circumstance, tariffs have little impact on US ethanol prices, while they have a large impact on the price of ethanol in exporting countries like Brazil.

Through the Caribbean Basin Initiative, the importation of up to 7% of domestic US ethanol consumption is tariff free. Total US imports of ethanol in calendar year 2006 were 653.3 million gallons. Most of these imports were from Brazil, and approximately one-third of the imports were routed through the Caribbean to avoid the import tariff. Brazil exports ethanol with a 5% water content to the Caribbean where it is reprocessed so that the water content is only 1%. It is then exported to the United States as a different product, thereby overcoming any problems with rules of origin in preferential trading agreements (Yacobucci, 2005). Imports from the Caribbean were only 65% of the maximum allowed so apparently the costs of obtaining tariff free status through the Caribbean are significant.

Because most countries employ both biofuel tax credits and mandates, it is important to evaluate the economic effects of an import tariff with or without mandates and tax credits. Because of key policy interaction effects, the standard analysis of an ethanol import tariff will not be adequate. Indeed, the impacts of a tariff depend not only on whether a mandate or tax credit is in place but also if both policies are in place simultaneously (de Gorter and Just, 2007b).

With a tax credit in place, an equal US import tariff on ethanol causes ethanol exporters to lose much of the benefits of the US tax credit, and they will lose all of it if gasoline prices do not change as a result. The US ethanol price, however, will change very little because the market price is determined in relation to the price of gasoline and because a change in ethanol imports due to the import tariff will have only a small effect on the world price of oil. While the increase in US ethanol production will not fully offset the decrease in Brazilian ethanol production, the net reduction in world ethanol supply will be too small to significantly impact world oil prices.

An explanation is required for why an import tariff reduces the world price of ethanol by almost the full amount of the tariff. If the world oil price changes little, then why is the export price (e.g., Brazil) not tied to the price of oil, like in the United States? Normally, the market price of ethanol is determined in relation to the price of gasoline (itself tied to the price of oil) and little else can change that relationship (see above discussion of equation (9.1)). But the price of ethanol in Brazil is not tied to the price of oil because the world market price of ethanol is determined by the market with the highest tax credit. The Brazilian market price of ethanol is, therefore, equal to the US market price less the import tariff and transportation costs. The tax credit in Brazil only subsidizes ethanol consumption in Brazil and confers no benefits to producers of sugar or ethanol (de Gorter et al., 2008).

In summary, ethanol exporters like Brazil would benefit if a tax credit was the only policy intervention in the United States (or a mandate that generates an equivalent ethanol price premium over gasoline). But Brazil would be better off with no US policy compared to a policy of both a tax credit and an offsetting import tariff. Eliminating the US import tariff while maintaining the tax credit would result in large gains to exporters like Brazil because the expected change in oil prices is very small and so Brazil retains the benefit of the tariff elimination. But US producers do not lose very much as domestic ethanol prices are determined by equation (9.1), and the net change in world ethanol production with the elimination of the tariff would have negligible effects on the price of gasoline. Therefore, exporters like Brazil are unfairly penalized by an import tariff that offsets the US tax credit.[8]

Now consider the case of a tariff with a consumption mandate for ethanol. Imposing an import tariff results in a larger increase in domestic prices than does a tax credit because domestic supplies have to increase in order to maintain the mandate, even with an exogenous oil price. Therefore, an import tariff in the presence of a mandate will have a smaller negative impact on world ethanol prices (for the same benefit to corn farmers in the United States).

When a tax credit is added to a binding mandate, the former acts as a subsidy to consumers of gasoline, resulting in lower fuel prices and higher levels of gasoline consumption (de Gorter and Just, 2007a). A tax credit in this case only indirectly benefits ethanol producers if gasoline prices increase due to increased demand for gasoline; because the relative change in gasoline consumption is small, the price increase is also expected to be small. Eliminating the tax credit in this situation therefore would have little effect on market prices of ethanol. Because domestic and foreign producers alike benefit very little from a tax credit in this situation, exporters like Brazil would prefer the elimination of the tax credit and the so-called offsetting import tariff when a mandate is binding.

9.4 Terms of Trade

There are three potential sources of improvements in the terms of trade for the United States due to the ethanol tax credit and tariff: (1) as an importer of oil, (2) as an importer of ethanol, and (3) as an exporter of corn. The mechanism by which each occurs is unique, given the way in which the tax credit and tariff affect the corn, ethanol, and, hence, oil markets. Market prices for oil decline with a tax credit even though domestic oil production declines. Normally, an optimal import tariff acts as a subsidy on domestic gasoline production and a tax on domestic gasoline consumption. Domestic gasoline consumption declines because it is displaced by ethanol production. Hence, the optimal tax credit is inferior in terms of improving the terms of trade compared to an optimal import tariff on oil. The terms of trade improvement in corn exports, on the other hand, occurs even though domestic corn production increases and domestic consumption declines. Normally an optimal export tax does the opposite; that is, it taxes production and subsidizes domestic consumption. Although total corn production increases, those devoted to non-ethanol uses decline and, hence, the terms of trade improve. Again, the optimal tax credit is expected to be inferior to an optimal export tax on corn. The question now becomes what are the terms of trade effects of the ethanol import tariff?

An ethanol import tariff alone improves the terms of trade in ethanol imports and corn exports but decreases the terms of trade in oil imports (de Gorter et al., 2008). But if one adds a tax credit, the initial improvements in the terms of trade due the import tariff are offset (when the tax credit equals the import tariff as in the United States). There is a trade-off between the social costs of taxpayer-financed tax credits (or consumer-financed mandates) and the improved terms of trade in oil imports. In theory, import subsidies for ethanol (in addition to or instead of tax credits) can be socially optimal, particularly if one takes into account the fact that greenhouse gas emissions are substantially lower with sugarcane-based ethanol production in Brazil (compared to corn-based ethanol in the United States).

9.5 Concluding Remarks

The recent increase in corn prices can be attributed to a number of factors, but we argue that one of the most important was the large increase in US ethanol production. We argue that much of US ethanol production is the result of tax credits and (actual or *de facto*) mandates. The tax credit is estimated to increase the price of corn by 39–87%, depending on the base price used. However, the ethanol price premium exceeded the tax credit in many years, suggesting an even larger impact on corn prices. But because of "water" in the ethanol price premium due to either tax credits or mandates, high oil prices are required before ethanol policy has maximal impacts on corn prices.

This occurred in the face of deliberate policies that discriminated against imports of lower-cost ethanol derived from sugarcane. We show that import tariffs have only a moderate effect on corn prices if the tax credit determines ethanol prices because any change in world ethanol production due to the tariffs will have a negligible impact on the world oil price (and hence little impact on the ethanol and corn price). If the mandate is binding, however, increased ethanol imports due to the elimination of the tariff will reduce the ethanol price premium in the United States until the mandate becomes "unbinding" and the tax credit takes over in determining the market prices for ethanol and hence for corn.

Future corn prices will depend on the supply response in the rest of the world to offset the amount of land used for ethanol production in the United States and on changes in biofuel policy. For example, the EU has slashed their biofuel mandate by 40%. Technological developments to increase agricultural productivity are also important as recent high prices may induce farmers to adopt higher-yielding varieties while enabling companies to invest more to improve them. Perhaps the recent price rise will also persuade governments to relax restrictions on biotechnologies and expand public support for new agricultural R&D in developing countries. Future levels of energy prices will also be a major determining factor, not only in affecting costs of corn production but also the level of "water" in the ethanol price premium due to policy.

Notes

1. About 22–32 countries reacted to the price increases with various policy changes including controls or subsidies on food prices, decreased taxes and import tariffs, and export taxes and bans (Gürkan, 2008). Each of these policy reactions fueled the price increases by either restricting access to supplies (as in the case of export measures) or increased demand for the product more than otherwise (as in the case of policies that lower consumer prices). These "beggar thy neighbor" policies further insulated each country from international prices and shifted the adjustment costs onto other countries.
2. The U.S. sustainability threshold requires biofuels to reduce greenhouse gases by at least 20% relative to oil-based gasoline using life cycle accounting methods. California requires a 15% reduction, while the EU directive calls for a 35% reduction.
3. As we will show later, traditional farm subsidies are also important in discriminating against biofuel trade. Although U.S. production subsidies for corn lower the input price for corn-based ethanol production worldwide, it discriminates against sugarcane, which is the feedstock for ethanol production in Latin America.
4. For a more detailed derivation of equation (9.1), see de Gorter and Just (forthcoming 2009, 2008) and the Appendix of this chapter.
5. Du and Hayes (2008) estimate that growth in ethanol production has caused retail gasoline prices to be up to 0.40 cents per gallon lower than would otherwise have been the case. This means that over two-thirds of our estimate of a $2.31 per bushel increase in the corn price due to the 57 cents per gallon tax credit (assuming no water in the tax credit) is negated in the form of lower gasoline prices.
6. Actually, the tax credit was subsidizing oil-based gasoline consumption – see de Gorter and Just (2007a).
7. Indeed, the intercept of the ethanol supply curve in the United States has been approximately $70–90 per barrel. In other words, unless oil prices are $70–90 per barrel, there would be no ethanol production in the United States without either biofuel policies (including subsidies and tariffs) or corn subsidies. Tax credits and mandates by themselves would have generated little, if no, ethanol production. Tax credits therefore had minimal impacts on corn prices at low levels of oil prices.
8. Note that this all hinges on the United States having the combination of low fuel taxes and high tax credits such that the export price in Brazil is set in relation to it. If the EU eliminates import tariffs on ethanol and was serious in fulfilling its mandates (likewise in Japan), and depending on transportation costs, it is very possible that Brazil would not export to the United States (in fact, the United States may export ethanol itself).

Appendix: Price Relationships Between Corn, Ethanol, and Gasoline

A bushel of corn can be converted into ethanol at a constant cost of c_0, resulting in β gallons of ethanol and δ bushels of by-product, which can be sold back in to the corn market. Estimated values of β and δ are 2.8 and 0.31, respectively (Eidman, 2007).

A bushel of corn can be purchased for the market price of corn, P_C, and converted to ethanol and corn, resulting in revenue of $\beta P_{\mathrm{E}} + \delta P_{\mathrm{C}}$, where P_E is the market price of ethanol per gallon. This results in a total marginal profit of $\pi' = \beta P_{\mathrm{E}} + (\delta - 1) P_{\mathrm{C}} - c_0$. Given that markets function well, if marginal profits from converting corn to ethanol are positive, $\pi' > 0$, then producers will continue to demand corn for ethanol until the price of ethanol is bid down and the price of corn bid up, resulting in zero marginal profit. Thus, in equilibrium, the price of ethanol and corn must follow the relationship

$$P_{\mathrm{C}} = (\beta P_{\mathrm{E}} - c_0)\big/(1 - \delta) \tag{9.5}$$

so long as ethanol is produced in equilibrium. Otherwise, $P_{\mathrm{C}} > (\beta P_{\mathrm{E}} - c_0)/(1 - \delta)$, implying negative marginal profits from converting corn to ethanol.

Ethanol can be mixed with gasoline to produce fuel. We treat ethanol as a perfect substitute for gasoline. While fuel containing high concentrations of ethanol (such as E85) can currently only be used by a small percentage of the cars on the road in the United States, nearly all automobiles can use fuel containing lower levels of ethanol (such as E10). Hence, our treatment of ethanol as a perfect substitute for gasoline is an abstraction. However, less than 1% of ethanol is sold in concentrations higher than that found in E10. Thus, for the concentrations of fuel found in the market, ethanol can be reasonably expected to perform as a perfect substitute.

The energy content of ethanol is substantially lower than that of gasoline (by about 30%). We suppose that individuals value ethanol and gasoline for their contributions to vehicle miles traveled. Hence, in equilibrium,

$$P_{\mathrm{E}} = \lambda P_{\mathrm{G}} \tag{9.6}$$

where P_G is the market price of gasoline per gallon, and λ is the ratio of miles per gallon derived from ethanol to miles per gallon derived from gasoline (estimated to be 0.70). Again, if this equality did not hold, consumers would be led to adjust their consumption of ethanol and gasoline until equilibrium was achieved. This together with (9.1) implies that

$$P_{\mathrm{C}} = (\beta \lambda P_{\mathrm{G}} - c_0)\big/(1 - \delta) \tag{9.7}$$

if ethanol is produced.

The introduction of taxes and tax credits fundamentally alter the equilibrium price relationships given in equations (9.6) and (9.7) by altering the profit incentives and the marginal cost of vehicle miles. Let t represent the volumetric tax on all fuel and t_c the tax credit awarded to blenders for use of ethanol. Then, we can rewrite equations (9.6) and (9.7), respectively, as

$$P_{\mathrm{E}} + t - t_c = \lambda \left(P_{\mathrm{G}} + t \right) \tag{9.8}$$

and

$$P_{\mathrm{C}} = \left(\beta \left[\lambda P_{\mathrm{G}} + (\lambda - 1)\, t + t_c \right] - c_0 \right) \big/ (1 - \delta) \equiv P_{\mathrm{Eb}} \tag{9.9}$$

where P_{Eb} can be thought of as the bushel-equivalent price of ethanol. Further, it is convenient to define $P_{\mathrm{Gb}} \equiv \left(\beta \left[\lambda P_{\mathrm{G}} + (\lambda - 1)\, t \right] - c_0 \right) \big/ (1 - \delta)$ as the bushel-equivalent price of gasoline. The implication of equation (9.9) is that for every one cent per gallon change in the price of ethanol, the corn price changes by 4.06 in $ per bushel. This means the corn price is very sensitive to a change in the tax credit or oil price.

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Chapter 10
Modeling the Effects of U.S. Biofuel Policies on Commodity and Energy Markets

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Abstract The Renewable Fuel Standard under the Energy Policy Act of 2005 redefines ethanol as a renewable domestic fuel supply, rather than just a fuel oxygenate, while the American Job Creation Act of 2004 creates biofuel tax credits and the Energy Independence and Security Act of 2007 mandates biofuel blending. We formulate an integrated economic simulation model of corn/soybean and biofuel production to simultaneously evaluate the impacts of U.S. biofuel policies on domestic commodity and energy prices. The model is used to demonstrate that first, while ethanol production increases due to both the ethanol tax credit and a blending mandate, conventional gasoline production would decline as a result of the blending mandate. These results are supported by current energy data. Therefore, there is no evidence that blended gasoline price would be higher without mandated ethanol production. Second, both domestic corn and ethanol production as well as ethanol imports would slightly decline due to the blenders' market power effects when the tax credit for ethanol is reduced to $0.45 per gallon (beginning in January 2009), but the blended gasoline price would be higher at the pump so that total gasoline consumption would decline.

10.1 Introduction

Commodity programs have been the traditional policy tool used to support farm income. However, newly enacted biofuels-related programs, such as the American Jobs Creation Act (AJCA) of 2004, the Energy Policy Act (EPA) of 2005, import tariffs, and the Energy Independence and Security Act (EISA) of 2007, are, arguably,

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now much more influential policies affecting commodity prices.[1] While ethanol was originally blended with conventional gasoline as a fuel oxygenate, and subsequently expanded to replace the oxygenate methyl tertiary butyl ether (MTBE), the EPA and EISA have now redefined ethanol and bio-diesel as renewable domestic fuels. From an economic analysis perspective, the introduction of these programs has created numerous complexities in modeling the commodity price adjustment process for both corn and soybeans, as well as for blended gasoline.

Excise tax credits, blending mandates, and tariffs are critical policy instruments contained in current biofuel legislation. Under the AJCA, the federal ethanol tax incentive was set at $0.51 per gallon of ethanol used for fuel, replacing the prior excise tax exemption with an excise tax credit (Koplow, 2006; Yacobucci and Schnepf, 2007).[2] The same act sets the tax incentive at $1.00 per gallon for bio-diesel produced from virgin vegetable oils or animal fats. While the mandate under the EPA was set as a total renewable fuels requirement, allowing for ethanol and bio-diesel production substitution to meet the mandate, the EISA now has provisions for mandating the volume of each biofuel. Under the EISA, blenders must blend 10.5 billion gallons of ethanol in 2009, with the mandate rising to 15 billion gallons in 2015 and thereafter, while the use of bio-diesel must be increased from 0.5 billion gallons to 1.0 billion gallons by 2012.[3]

Under the Energy Policy Act of 2005, the U.S. Environmental Protection Agency (U.S. EPA) promulgates and enforces the regulations that ensure that gasoline sold in the U.S. contains a minimum volume of renewable fuel. The U.S. EPA has set the 2008 Renewable Fuels Standard (RFS) at 7.76% which is intended to lead to the use of 9 billion gallons of renewable fuel in 2008. Any organization that produces gasoline for use in the United States, including refiners, importers, and blenders, is considered an obligated party (OP). An OP is required to purchase enough renewable fuel to meet its renewable volume obligation (RVO), which is based on its annual conventional gasoline volume. Any OP found liable for failure to meet its RVO is subject to civil penalties of up to $32,500 per day for each violation (U.S. EPA, 2008).

Blenders are paid the tax credit for blending ethanol with conventional gasoline, whether ethanol is domestically produced or imported. The United States produced nearly 6.5 billion gallons of ethanol and also imported nearly 0.45 billion gallons in 2007. Ethanol imports from Brazil accounted for 44% of 2007 U.S. ethanol imports, while imports from Caribbean and Central American countries accounted for 54% (Renewable Fuels Association, 2008b). The U.S. import tariff on ethanol includes two types of tariffs: first, a 2.5% *ad valorem* tax, and second, a $0.54 per gallon import duty. Caribbean and Central American countries enjoy import duty–free treatment under the Caribbean Basin Initiative (CBI) tax legislation of 1984.

There are at least three relevant questions concerning the impacts of U.S. biofuel policies on commodity and fuel markets. The first question is, who benefits the most from the federal tax credit of $0.51 per gallon of ethanol and how it affects ethanol price? Taheripour and Tyner (2007) assumed that the ethanol industry receives most of the ethanol subsidies, while the Renewable Fuel Association (2008a) stated that "the tax credit is taken by (conventional) gasoline producers and marketers. It is not taken by ethanol producers." Furthermore, economic modelers lack sufficient information on ethanol market prices. While researchers (e.g., see Westhoff, 2008) use spot market ethanol prices, Hartwig (2006) points out that such prices reflect a very small number of short-term sales between refiners (and not between ethanol producers and refiners), and that these spot prices do not represent the average price that ethanol producers receive. He further stated that between 85 and 95% of ethanol in the United States is sold under longer-term contracts (6–12 months) negotiated between ethanol producers and the oil refiners or gasoline blenders. In our research, therefore, ethanol price is assumed to be determined under contracts between distillers and blenders.[4] While the blenders pay the sum of the unit ethanol price and the tax credit to distillers (zFacts, 2008), they are also paid the tax credit by the government so that their net cost of ethanol is the contract ethanol price (net of any tax credits).

The second question is whether ethanol and conventional gasoline are independent goods in production under the blending mandate as implicitly assumed in recent studies (de Gorter and Just, 2007a; Du and Hayes, 2008; Kim et al., 2008; Schmitz et al., 2007) so that blended gasoline supply would increase and, thereafter, lower its price. We consider conventional gasoline and ethanol as substitutes in production, due to the blending requirement, as well as in consumption.[5] Under our assumption, we demonstrate that refiners reduce their supply of conventional gasoline, while distillers increase ethanol production.[6] Therefore, the total supply of blended gasoline could be greater (less) than the conventional gasoline supply without the blending mandates, depending on whether the reduction in conventional gasoline production is less (greater) than the increase in ethanol production.

Finally, the third question is, what are the effects of lowering the ethanol tax credit to $0.45 per gallon in 2009 on commodity and energy markets? Our results indicate that ethanol production, ethanol imports, and the corn demand for ethanol production would decline due to the blenders' market power effects. However, both blended and conventional gasoline prices would rise, and therefore, blended gasoline consumption would decline.

The primary objective of our study is to model equilibrium market prices for corn and soybeans and energy price impacts under various U.S. biofuel policies. Determining who gains and who loses, and by how much, from the U.S. biofuel policy depends largely on the changes in equilibrium market prices for these agricultural and biofuels commodities. We present an economic simulation model of the corn/soybean and biofuel production markets to simultaneously evaluate the impacts of various U.S. biofuel policies on crop and energy prices. Both refiner and blender profit-maximization models are presented, where blenders have a choice between domestically produced ethanol and imported ethanol.

This chapter is organized as follows. The next section describes the commodity markets associated with corn demand for ethanol production and soybean demand for bio-diesel production. Equilibrium crop prices and production are derived under alternative biofuel policies. Section 10.3 presents the blender's profit-maximizing behavior under U.S. biofuel and trade policies to investigate how biofuel tax credits and tariffs affect the blender's choice between domestically produced and imported ethanol. Section 10.4 presents the refiner's and distiller's profit-maximizing behavior under U.S. biofuel policies. We demonstrate that the ethanol blending mandate reduces refiners' conventional gasoline production, while distillers increase ethanol production. However, the level of blended gasoline production depends on the relative amounts of refiners' reduction in conventional gasoline production and the increase in mandated ethanol production. In Section 10.5, we demonstrate how the reduction of the tax credit to \$0.45 per gallon under the 2008 Farm Bill affects corn price, ethanol production, ethanol imports, and the blended gasoline price. Section 10.6 concludes.

10.2 Commodity Markets

Our model begins by specifying a series of demand–supply relationships necessary to model the economic and policy environments between the biofuel and commodity markets. These relationships, specified separately for the ethanol/corn markets (Section 10.2.1) and the bio-diesel/soybean markets (Section 10.2.2), consist of biofuel production functions (equations (10.1) and (10.1′)), by-product production functions (equations (10.2) and (10.2′)), demands for corn and soybeans for ethanol and bio-diesel production (equations (10.4) and (10.4′)), domestic demands for corn and soybeans (excluding that for biofuel production) (equations (10.5) and (10.5′)), export demands for corn and soybeans (equations (10.6) and (10.6′)), corn and soybean supply functions (equations (10.7) and (10.7′)), and corn and soybean market equilibrium conditions (equations (10.8) and (10.8′)). Biofuel and by-product production functions are assumed to be quadratic, and all demand and supply functions for each crop are assumed to be linear.

10.2.1 Ethanol Production and the Corn Market

The effects of tax credits on the demand for corn for ethanol production can be explained with Fig. 10.1. Let corn price per bushel be represented by P_c, so that distillers producing ethanol as a fuel oxygenate (without a tax credit) would demand Q_c quantity of corn. As a result of the ethanol tax credit of \$0.51 per gallon (which is equivalent to \$1.43 per bushel of corn assuming that 2.8 gallons of ethanol is produced from one bushel of corn), corn demand for ethanol production increases to Q_e (Gardner, 2007).

First, we establish the ethanol–corn market relationships. In particular, ethanol and its by-product production functions, as well as associated corn demand functions, corn supply function, and the corn market equilibrium condition are defined in equations (10.1), (10.2), (10.3), (10.4), (10.5), (10.6), (10.7), and (10.8). Subscripts e, d, and x here represent corn demand for ethanol production, total domestic corn demand by the consumer and livestock sectors, and corn export demand, respectively (see Table 10.1 for the definitions for all other variables).

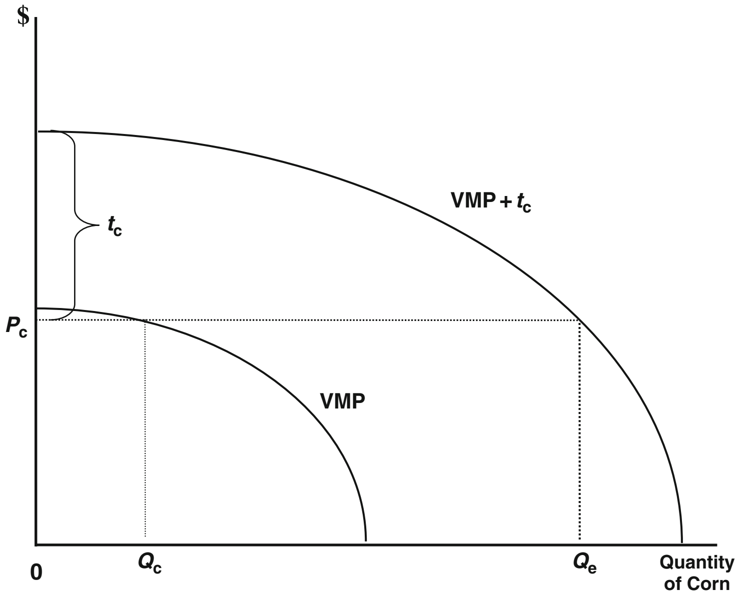

Fig. 10.1 Corn demands for ethanol production (with a tax credit $t_c = \$1.43$/bushel, which is equivalent to $t_e = \$0.51$/gallon)

Table 10.1 Definition of variables

E_{do}	Domestically produced ethanol (gallon).
E_m	Imported ethanol (gallon).
Q_e	Corn demand for ethanol production (bushel).
h_{do}	Domestically produced bio-diesel (gallon).
q_h	Soybean demand for bio-diesel production (bushel).
m	By-product of ethanol production (ton).
n	By-product of bio-diesel production (ton).
P_e	Unit contract price of ethanol excluding tax credit (\$/gallon), where ε is the supply flexibility of domestically produced ethanol.
t_e	Ethanol tax credit (\$/gallon).
P_h	Unit price of bio-diesel (\$/gallon).
t_h	Bio-diesel tax credit (\$/gallon).
P_m	Unit price of the by-product from ethanol production (\$/ton).
P_n	Unit price of the by-product from bio-diesel production (\$/ton).
P_c	Unit price of corn (\$/bushel).
P_s	Unit price of soybeans (\$/bushel).
Q_d	Domestic demand for corn (bushel).
Q_x	Export demand for corn (bushel).
Q_{cs}	Corn supply (bushel).
q_d	Domestic demand for soybeans (bushel).
q_x	Export demand for soybeans (bushel).

Table 10.1 (continued)

q_s	Soybean supply (bushel).
δ	*Ad valorem* tax (\$/gallon).
T_m	Import tariff (\$/gallon).
t_e	Tax credit on ethanol production (\$/gallon).
t_h	Tax credit on bio-diesel production (\$/bushel).

Ethanol production function:

$$E_{do} = u_0 Q_e - \tfrac{1}{2} u_1 Q_e^2. \tag{10.1}$$

Dry distiller's grains soluble (DDGS) production function:

$$M = v_0 Q_e - \tfrac{1}{2} v_1 Q_e^2. \tag{10.2}$$

Marginal value product of corn for both ethanol and DDGS:

$$[P_e + t_e][u_0 - u_1 Q_e] + P_M[v_0 - v_1 Q_e] = P_c. \tag{10.3}$$

Corn demand for ethanol production:

$$Q_e = \frac{(P_e + t_e)u_0 + P_M v_0 - P_c}{(P_e + t_e)u_1 + P_M v_1}. \tag{10.4}$$

Domestic demand for corn:

$$Q_d = a_d - b_d P_c. \tag{10.5}$$

Export demand for corn:

$$Q_x = a_x - b_x P_c. \tag{10.6}$$

Corn supply function:

$$Q_{cs} = (a_s - k_s P_s) + b_s P_c. \tag{10.7}$$

Corn market equilibrium condition:

$$Q_{cs} = Q_e + Q_d + Q_x. \tag{10.8}$$

10.2.2 Bio-diesel Production and the Soybean Market

Second, we establish the bio-diesel–soybean market relationships. Similar to the case for the corn market, bio-diesel fuel and its by-product production functions, as well as associated soybean demand functions, soybean supply function, and the soybean market equilibrium condition are defined in equations (10.1′), (10.2′), (10.3′), (10.4′), (10.5′), (10.6′), (10.7′), and (10.8′). Subscripts h, d, and x here represent soybean demand for bio-diesel production, total domestic soybean demand by the consumer and livestock sectors, and soybean export demand, respectively (again, see Table 10.1 for definitions for all other variables).

Bio-diesel production function:

$$h_{\mathrm{do}} = w_0 q_{\mathrm{h}} - {}^1\!/_2 w_1 q_{\mathrm{h}}^2. \tag{10.1′}$$

By-product of bio-diesel production function:

$$n = z_0 q_{\mathrm{h}} - {}^1\!/_2 z_1 q_{\mathrm{h}}^2. \tag{10.2′}$$

Marginal value product of soybeans for bio-diesel:

$$(P_{\mathrm{h}} + t_{\mathrm{h}})[w_0 - w_1 q_{\mathrm{h}}] + P_{\mathrm{n}}[z_0 - z_1 q_{\mathrm{h}}] = P_{\mathrm{s}}. \tag{10.3′}$$

Soybean demand for bio-diesel production:

$$q_{\mathrm{h}} = \frac{[(P_{\mathrm{h}} + t_{\mathrm{h}})w_0 + P_{\mathrm{n}} z_0] - P_{\mathrm{s}}}{[(P_{\mathrm{h}} + t_{\mathrm{h}})w_1 + P_{\mathrm{m}} z_1]}. \tag{10.4′}$$

Domestic demand for soybeans:

$$q_{\mathrm{d}} = \alpha_{\mathrm{d}} - \beta_{\mathrm{d}} P_{\mathrm{s}}. \tag{10.5′}$$

Export demand for soybeans:

$$q_{\mathrm{x}} = \alpha_{\mathrm{x}} - \beta_{\mathrm{x}} P_{\mathrm{s}}. \tag{10.6′}$$

Soybean supply function:

$$q_{\mathrm{s}} = (\alpha_{\mathrm{s}} - \gamma_{\mathrm{c}} P_{\mathrm{c}}) + \beta_{\mathrm{s}} P_{\mathrm{s}}. \tag{10.7′}$$

Soybean market equilibrium condition:

$$q_{\mathrm{s}} = q_{\mathrm{h}} + q_{\mathrm{d}} + q_{\mathrm{x}}. \tag{10.8′}$$

10.2.3 Impact of a Biofuel Tax Credit on Commodity Market Equilibrium

The impact of a biofuel tax credit on commodity equilibrium price and quantity can be explained using Fig. 10.2, where the curve Q_e^0 represents the corn demand for ethanol production before enacting the AJCA of 2004, Q_e^t represents the corn demand for ethanol production with tax-credits, Q_x represents corn export demand, Q_T represents the total demand for corn (excluding corn demand for ethanol production), while the difference between Q_T and Q_x represents corn demand for domestic consumption, and Q_{cs} represents the supply of corn. Prior to the introduction of biofuel tax credits, the corn market equilibrium is attained at the price P_0 and the quantity Q_0, where the total demand for corn equals the supply of corn. As corn demand for ethanol production shifts to the right toward Q_e^t as a result of providing ethanol tax credits, the slope of the new aggregate demand curve for corn, represented by $Q_T + Q_e^t$, becomes flatter than the slope of the aggregate corn demand curve without ethanol production, Q_T. A new corn market equilibrium is attained at price P_1 and quantity Q_1, as a result of ethanol production assuming an ethanol tax credit. Corn production increases by $(Q_1 - Q_0)$ and corn price rises by $(P_1 - P_0)$ as a result of providing a tax credit for ethanol production.

Therefore, an initial corn market equilibrium price P_c is obtained by substituting equations (10.4), (10.5), (10.6), and (10.7) into the corn market equilibrium condition in equation (10.8) as follows:

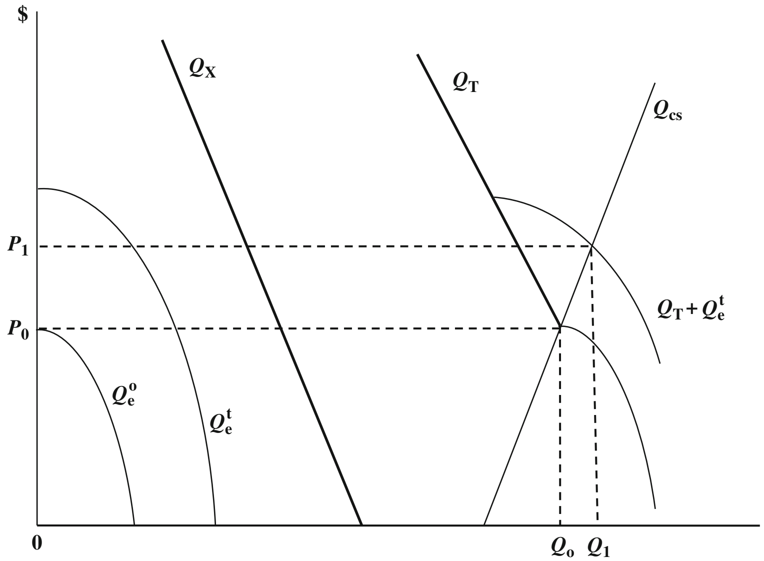

Fig. 10.2 Corn market equilibrium under a constant biofuel tax credit

$$P_c = \frac{[N_0 + (A_c + k_s P_s)N_1]}{(1 + B_c N_1)} \tag{10.9}$$

where $A_c = (a_d + a_x - a_s), B_c = (b_s + b_d + b_x),\ N_0 = [(P_e + t_e)u_0 + P_M v_o]$, and $N_1 = [(P_e + t_e)u_1 + P_M v_1]$.

Similarly, an initial soybean market equilibrium price is obtained by substituting equations (10.4′), (10.5′), (10.6′), and (10.7′) into the soybean market equilibrium condition in equation (10.8′) which results in the following:

$$P_s = \frac{[H_0 + (A_h + \gamma_c P_c)H_1]}{(1 + B_h H_1)}, \tag{10.9$'$}$$

where $A_h = (\alpha_d + \alpha_x - \alpha_s), B_h = (\beta_s + \beta_d + \beta_x), H_0 = [(P_h + t_h)w_0 + P_n z_0]$, and $H_1 = [(P_h + t_h)w_1 + P_M z_1]$.

Solving equations (10.9) and (10.9′) simultaneously for corn and soybean prices, the multi-market equilibrium prices for corn and soybeans, P_c (where $P_c = P_1$ in Fig. 10.2) and P_s, respectively, are represented for this scenario as follows:

$$P_c = \frac{(1 + B_h H_1)(N_0 + A_c N_1) + k_s N_1 (H_0 + A_h H_1)}{(1 + B_h H_1)(1 + B_c N_1) - k_s \gamma_c N_1 H_1}, \tag{10.10}$$

where $\dfrac{\partial P_c}{\partial t_e} > 0$ and $\dfrac{\partial^2 P_c}{\partial t_e^2} < 0$, and

$$P_s = \frac{(1 + B_c N_1)(H_0 + A_h H_1) + \gamma_c H_1 (N_0 + A_c N_1)}{(1 + B_h H_1)(1 + B_c N_1) - k_s \gamma_c N_1 H_1}, \tag{10.10$'$}$$

where $\dfrac{\partial P_s}{\partial t_h} > 0$ and $\dfrac{\partial^2 P_s}{\partial t_h^2} < 0$.

For a constant ethanol tax credit under the AJCA, equation (10.10) reveals that the equilibrium market price for corn, P_c, is an increasing function (but at a diminishing rate) of the tax credit, t_e, because the ethanol production function is assumed to be a quadratic.

The equilibrium quantity of corn demand for ethanol production (Q_e) (where $Q_e = Q_1$ in Fig. 10.2) is obtained by inserting equation (10.10) into equation (10.4) as follows:

$$Q_e = \left(\frac{N_0}{N_1}\right) - \frac{1}{N_1}\left[\frac{(1 + B_h H_1)(N_0 + A_c N_1) + k_s N_1 (H_0 + A_h H_1)}{(1 + B_h H_1)(1 + B_c N_1) - k_s \gamma_c N_1 H_1}\right], \tag{10.11}$$

where N_0, N_1, H_0, H_1, A_c, A_h, B_c, and B_h are as defined in equations (10.9) and (10.9′).

Similarly, the equilibrium quantity of soybean demand for bio-diesel production (q_h) is obtained by inserting equation (10.10′) into equation (10.4′) as follows:

$$q_h = \left(\frac{H_0}{H_1}\right) - \frac{1}{H_1}\left[\frac{(1 + B_c N_1)(H_0 + A_h H_1) + \gamma_c H_1 (N_0 + A_c N_1)}{(1 + B_h H_1)(1 + B_c N_1) - k_s \gamma_c N_1 H_1}\right]. \tag{10.11$'$}$$

Furthermore, domestic demand for corn (Q_{d}), export demand for corn (Q_{x}), and U.S. corn supply (Q_{cs}) are obtained by inserting equation (10.10) into equations (10.5), (10.6), and (10.7). Similarly, the equilibrium quantity of domestic soybean demand (q_{d}), export demand for soybeans (q_{x}), and U.S. soybean production (q_{s}) are estimated by inserting equation (10.10′) into equations (10.5′), (10.6′), and (10.7′).

Finally, the equilibrium level of domestic ethanol production (E_{do}) is estimated by inserting the equilibrium quantity of corn demand for ethanol production from equation (10.11) into the ethanol production function in equation (10.1). Similarly, the equilibrium domestic bio-diesel production (h_{do}) is estimated by inserting the equilibrium quantity of soybean demand for bio-diesel production from equation (10.11′) into the bio-diesel production function in equation (10.1′). These results are expressed in equation (10.12) for equilibrium domestic ethanol production:

$$\begin{aligned}E_{\mathrm{do}} = {} & \left(\frac{N_0}{N_1}\right)\left[u_0 - \frac{1}{2}\,u_1\left(\frac{N_0}{N_1}\right)\right] - \left(\frac{1}{N_1}\right)\left[u_0 - u_1\left(\frac{N_0}{N_1}\right)\right] \\ & \left[\frac{(1+B_{\mathrm{h}}H_1)(N_0+A_{\mathrm{c}}N_1)+k_{\mathrm{s}}N_1(H_0+A_{\mathrm{h}}H_1)}{(1+B_{\mathrm{h}}H_1)(1+B_{\mathrm{c}}N_1)-k_{\mathrm{s}}\gamma_{\mathrm{c}}N_1H_1}\right] \\ & -\left(\frac{u_1}{2N_1^2}\right)\left[\frac{(1+B_{\mathrm{h}}H_1)(N_0+A_{\mathrm{c}}N_1)+k_{\mathrm{s}}N_1(H_0+A_{\mathrm{h}}H_1)}{(1+B_{\mathrm{h}}H_1)(1+B_{\mathrm{c}}N_1)-k_{\mathrm{s}}\gamma_{\mathrm{c}}N_1H_1}\right]^2,\end{aligned} \tag{10.12}$$

and in equation (10.12′) for equilibrium domestic bio-diesel production:

$$\begin{aligned}h_{\mathrm{do}} = {} & \left(\frac{H_0}{H_1}\right)\left[w_0 - \frac{1}{2}\,w_1\left(\frac{H_0}{H_1}\right)\right] - \frac{1}{H_1}\left[w_0 - w_1\left(\frac{H_0}{H_1}\right)\right] \\ & \left[\frac{(1+B_{\mathrm{c}}N_1)(H_0+A_{\mathrm{h}}H_1)+\gamma_{\mathrm{c}}H_1(N_0+A_{\mathrm{c}}N_1)}{(1+B_{\mathrm{h}}H_1)(1+B_{\mathrm{c}}N_1)-k_{\mathrm{s}}\gamma_{\mathrm{c}}N_1H_1}\right] \\ & -\left(\frac{w_1}{2H_1^2}\right)\left[\frac{(1+B_{\mathrm{c}}N_1)(H_0+A_{\mathrm{h}}H_1)+\gamma_{\mathrm{c}}H_1(N_0+A_{\mathrm{c}}N_1)}{(1+B_{\mathrm{h}}H_1)(1+B_{\mathrm{c}}N_1)-k_{\mathrm{s}}\gamma_{\mathrm{c}}N_1H_1}\right]^2,\end{aligned} \tag{10.12′}$$

where N_0, N_1, H_0, H_1, A_{c}, A_{h}, B_{c}, and B_{h} are as defined in equations (10.9) and (10.9′).

10.3 Blenders' Decision on Blended Gasoline Production

Most ethanol used for blending in the United States is domestically produced, but ethanol imports are increasing due to an expanded blending mandate. Blenders receive the tax credit for blending both domestically produced and imported ethanol with conventional gasoline. The selection between domestically produced and imported ethanol depends largely on the price blenders have to pay for ethanol. Blenders should be willing to pay up to \$0.51 more per gallon for ethanol than the wholesale spot price per gallon of conventional gasoline; that is, up to the amount of the ethanol tax credit (zFacts, 2008). For example, de Gorter and Just (2007b, 2008) represented the wholesale price per gallon of ethanol as the sum of the wholesale price per gallon of conventional gasoline and the ethanol tax credit per gallon.

We first let blended gasoline be represented by F such that:

$$F = (1-\theta)G + \theta E,\ 0 < \theta < 1, \tag{10.13}$$

where G is conventional gasoline in gallons, E is ethanol in gallons (which is the sum of domestically produced ethanol (E_{do}) and imported ethanol (E_{m}), such that $E = E_{\mathrm{do}} + \Sigma E_{\mathrm{m}}^{\mathrm{i}}$), and θ is a fractional coefficient. To derive the optimum economic conditions for blenders, we now let the blender's profit to be maximized under a blending mandate be represented as follows:

$$\begin{aligned}\mathrm{Max}\,\pi(F) = {} & P_{\mathrm{F}}F(G, E(E_{\mathrm{do}}, E_{\mathrm{m}})) - P_{\mathrm{g}}G - [P_{\mathrm{e}}E_{\mathrm{do}} + \sum_{\mathrm{i}}(P_{\mathrm{m}}^{\mathrm{i}}(1+\delta) - t_{\mathrm{e}} + T_{\mathrm{m}}^{\mathrm{i}})E_{\mathrm{m}}^{\mathrm{i}}] \\ & + \mu[F - (1-\theta)G - \theta(E_{\mathrm{do}} + \sum_{\mathrm{i}} E_{\mathrm{m}}^{\mathrm{i}})],\end{aligned} \tag{10.14}$$

where G is conventional gasoline, F is blended gasoline, P_F is the price of blended gasoline per gallon, P_{g} is the price of conventional gasoline per gallon, P_{e} is the price of ethanol per gallon (without a tax credit), t_{e} is the unit tax credit on blending ethanol with conventional gasoline, $P_{\mathrm{m}}^{\mathrm{i}}$ is an import price of ethanol from the ith country (c.i.f.), δ is the *ad valorem* tax per gallon of imported ethanol, $T_{\mathrm{m}}^{\mathrm{i}}$ is a tariff imposed on imported ethanol from the ith country (other than Caribbean and Central American countries), and the Lagrangian variable μ represents the shadow value of the blenders' marginal profits of increasing blended gasoline production.

The necessary conditions for profit maximization in this market are then represented as follows:

$$P_F\left(\frac{\partial F}{\partial G}\right) = P_{\mathrm{g}} + (1-\theta)\mu, \tag{10.15}$$

$$P_F\left(\frac{\partial F}{\partial E_{\mathrm{do}}}\right) = P_{\mathrm{e}}(1+\varepsilon) + \theta\mu,\ \text{where} \tag{10.16}$$

$\varepsilon = \left(\dfrac{\partial P_{\mathrm{e}}}{\partial E_{\mathrm{do}}}\right)\left(\dfrac{E_{\mathrm{do}}}{P_{\mathrm{e}}}\right)$ is the price flexibility of domestic ethanol supply.

$$P_F\left(\frac{\partial F}{\partial E_{\mathrm{m}}^{\mathrm{i}}}\right) = [P_{\mathrm{m}}^{\mathrm{i}}(1+\delta) - t_{\mathrm{e}} + T_{\mathrm{m}}^{\mathrm{i}}] + \theta\mu, \tag{10.17}$$

$$F = (1-\theta)G + \theta(E_{\mathrm{do}} + \Sigma E_{\mathrm{m}}^{\mathrm{i}}). \tag{10.18}$$

Equation (10.15) states that conventional gasoline would be utilized up to the point where the marginal value product of conventional gasoline equals the sum of its unit price and the shadow value of the blending mandate (weighted by its blending rate). Equation (10.16) states that domestically produced ethanol would be used up to the point where the marginal value product of domestically produced ethanol equals the sum of the marginal factor cost associated with the use of domestically produced ethanol and the shadow value of the blending mandate (weighted by its blending rate). Equation (10.17) shows that the marginal value product of imported ethanol must equal the sum of its net import price (the import price less the tax credit) and the shadow value of the blending mandate (weighted by its blending rate).

Under the assumption that domestically produced and imported ethanol are perfect substitutes for blending with conventional gasoline, an efficient selection between domestically produced and imported ethanol is presented in equation (10.19), which is obtained from equations (10.16) and (10.17), as follows:

$$P_{\mathrm{e}} = \frac{P_{\mathrm{m}}^{\mathrm{i}}\,(1+\delta) - t_{\mathrm{e}} + T_{\mathrm{m}}^{\mathrm{i}}}{(1+\varepsilon)} \tag{10.19}$$

These results indicate that even though there are no contracts between domestic blenders and foreign ethanol exporters, the net import price of imported ethanol must equal the marginal factor cost of domestically produced ethanol and, therefore, market power effects are effectively transmitted to ethanol exporters. In the presence of the blenders' market power, equation (10.19) shows that the unit price of domestically produced ethanol is lower than the net price of imported ethanol and, therefore, blenders use domestically produced ethanol first and imported ethanol is used by blenders as a residual to meet the blending mandates.

Additionally, due to current U.S. energy policy, an import duty, $T_{\mathrm{m}}^{\mathrm{i}}$, is imposed to offset the tax credit provided to blenders when they use imported ethanol. Therefore, the recently passed 2008 Farm Bill which lowered the tax credit for ethanol to \$0.45 per gallon (beginning in January 2009), while the import duty for sugar-based ethanol remains at \$0.54 per gallon, would make imported ethanol relatively more expensive. Consequently, it is more likely that both domestic ethanol production and ethanol imports from Brazil would initially decline, while subsequently the demand for domestically produced ethanol increases, consistent with the blenders' need to meet the blending mandate, which then ultimately leads to a domestic ethanol price rise. (The economic impacts of lowering the tax credit to \$0.45 are discussed further in Section 10.5)

10.4 Impacts of a Blending Mandate on Gasoline and Ethanol Production

Since the Renewable Fuel Standard under the Energy Policy Act (EPA) of 2005 redefined ethanol as a renewable fuel and the Energy Independence and Security Act (EISA) of 2007 mandated biofuel production levels, the introduction of ethanol into the U.S. fuel market would undoubtedly have an effect on domestic blended gasoline prices. Accordingly, several studies have recently reported that the tax credit and mandated ethanol production increase the domestic fuel supply, leading to a reduction in the price of gasoline at the pump (Blanch, 2008; Cooper, 2008; de Gorter and Just, 2007a; Du and Hayes, 2008; Schmitz et al., 2007). Blanch (2008) referenced a Merrill Lynch study indicating that conventional gasoline prices would be 15% higher without mandated ethanol production. Du and Hayes (2008) reported that the growth in ethanol production has caused retail blended gasoline prices to be \$0.29–\$0.40 per gallon lower than they would otherwise have been. Schmitz et al. (2007) reported that the increase in ethanol production lowers the price of gasoline by 4.3–6.0 cent per gallon, depending on the relative size of the elasticity of demand for gasoline. The Renewable Fuels Association (2008a) summarized the impacts of ethanol on gasoline prices, claiming an ethanol savings ranging between \$0.20 and \$0.50 per gallon of gasoline.

These authors implicitly assumed that ethanol and conventional gasoline are substitute goods for consumers, but that they are independent goods in production for distillers and refiners. However, conventional gasoline and ethanol are substitutes for blenders due to the blending mandate and, therefore, a mandate to blend ethanol with conventional gasoline may have a negative impact on conventional gasoline production by refiners, while it has a positive impact on ethanol production by distillers. This is illustrated below. A refiners' profit to be maximized under a blending mandate is then represented by:

$$\text{Max } \pi(G) = P_{\text{g}}G - C(G) + \lambda[F - (1 - \theta)G - \theta E]. \tag{10.20}$$

The necessary conditions for profit-maximization in this market are represented as follows:

$$P_{\text{g}} = \left(\frac{\partial C(G)}{\partial G}\right) + \lambda(1 - \theta), \text{ where } G > 0, \tag{10.21}$$

$$F = (1 - \theta)G + \theta E, \text{ and } \lambda \lesseqgtr 0. \tag{10.22}$$

The Lagrangian variable λ represents the shadow value of the refiners' marginal profits of increasing conventional gasoline production associated with an increase in blended gasoline production. Since the output price must be greater than or equal to its marginal cost at market equilibrium, based on equation (10.21), the shadow value λ must be positive. Therefore, equation (10.21) indicates that refiners produce conventional gasoline up to the level where the unit price of conventional gasoline equals the sum of the marginal costs of producing conventional gasoline and the shadow value of a blending mandate.

Using equation (10.21), the impacts of a blending mandate on the supply of conventional gasoline can be evaluated as follows:

$$\frac{\partial\left(\frac{\partial C(G)}{\partial G}\right)}{\partial \theta} = \lambda > 0, \tag{10.23}$$

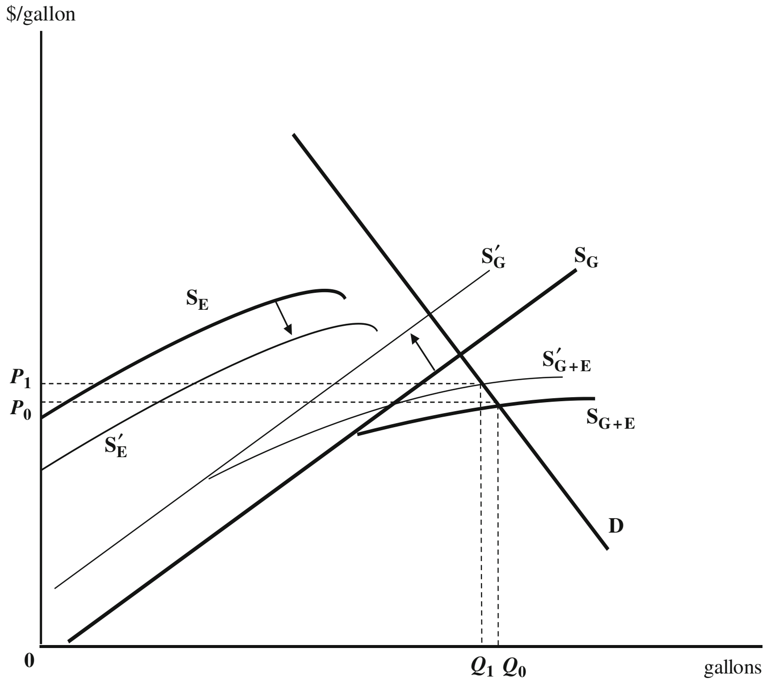

Fig. 10.3 The impacts of a blending mandate on ethanol and gasoline production

which implies that the marginal costs of producing conventional gasoline increases as the rate of the blending mandate increases so that refiners reduce conventional gasoline production, as indicated by the conventional gasoline supply curve S_{G} shifting to the left toward S'_{G} in Fig. 10.3.

Similarly, the impacts of a blending mandate on the supply of ethanol can be evaluated by maximizing the distiller's profit function such that:

$$\text{Max}\ \pi(E_{\mathrm{do}}) = (P_{\mathrm{e}} + t_{\mathrm{e}})E_{\mathrm{do}} - C(E_{\mathrm{do}}) + w[F - (1-\theta)G - \theta E], \tag{10.24}$$

where, $E = E_{\mathrm{do}} + \sum E^{\mathrm{i}}_{\mathrm{m}}$ and w is the Lagrangian multiplier. The important necessary condition here is represented as follows:

$$(P_{\mathrm{e}} + t_{\mathrm{e}}) = \left(\frac{\partial C(E_{\mathrm{do}})}{\partial E_{\mathrm{do}}}\right) + w\theta. \tag{10.25}$$

The impacts of a blending mandate on the supply of domestically produced ethanol can be evaluated as follows:

$$\frac{\partial\left(\dfrac{\partial C(E_{\mathrm{do}})}{\partial E_{\mathrm{do}}}\right)}{\partial\theta} = -w < 0, \tag{10.26}$$

which implies that the marginal costs of producing ethanol decline as the rate of the blending mandate increases so that the ethanol supply curve S_E in Fig. 10.3 shifts to the right toward S'_E.

Current energy data illustrate these points by showing that as ethanol production has increased, use of crude oil as an input at U.S.-based refineries has declined since 2004. This is illustrated in Fig. 10.4. These same data show that domestic ethanol production has increased by 2.56 billion gallons during the 2004–2007 period, while conventional gasoline production has declined by 2.64 billion gallons during the same period.[7] Therefore, there is no evidence that a blended gasoline price would be lower with mandated ethanol production.

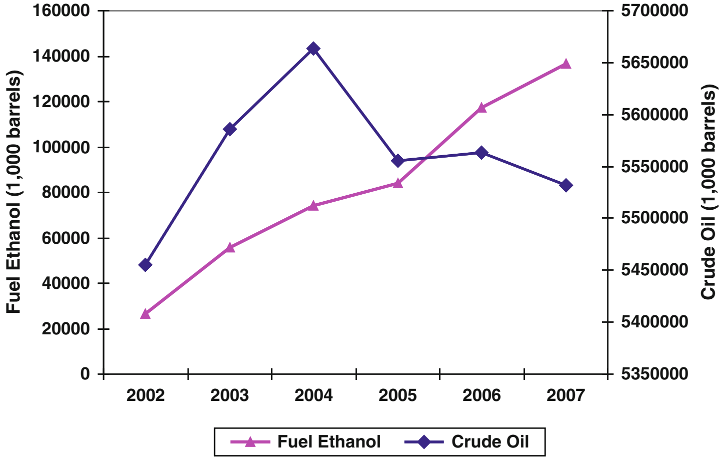

Fig. 10.4 Refinery and blender net inputs of crude oil and fuel ethanol. *Source*: Energy Information Agency, U.S. Department of Energy, 7/28/08 http://tonto.eia.doe.gov/dnav/pet/pet_pnp_inpt_a_epc0_yir_mbbl_m.htm

So, these results tell us that the impact of a blending mandate on the equilibrium price and quantity of blended fuel depends on the relative magnitudes between (1) the reduced conventional gasoline production as a result of the blending mandate, (2) the increase in ethanol production, (3) the level of blenders' market power, and (4) the price elasticity of consumer demand for motor fuel. An equilibrium price of blended gasoline could be higher when the reduction in the conventional gasoline supply resulting from the blending mandate is greater than the increase in ethanol production.

10.5 Effects of Reducing the Biofuel Tax Credit on Commodity and Energy Markets

As a result of lowering the ethanol tax credit, distillers would reduce ethanol production and, therefore, corn demand for ethanol production would also decline (see Fig. 10.1). Using equation (10.12), the reduced ethanol production resulting from a lower tax credit can be measured as follows:

$$dE_{\mathrm{do}} = \left[\left(\frac{\partial E_{\mathrm{do}}}{\partial t_{\mathrm{e}}}\right) + \left(\frac{\partial E_{\mathrm{do}}}{\partial P_{\mathrm{e}}}\right)\left(\frac{\partial P_{\mathrm{e}}}{\partial t_{\mathrm{e}}}\right)\right] dt_{\mathrm{e}}$$

$$= \left\{ \begin{array}{l} \left[u_0 - u_1\left(\frac{N_0}{N_1}\right)\right]\left[\frac{(u_0 v_1 - u_1 v_0)P_{\mathrm{m}}}{N_1^2}\right]\left(1 + \frac{\partial P_{\mathrm{e}}}{\partial t_{\mathrm{e}}}\right) \\ -\dfrac{u_0\left[N_1\left(\frac{\partial M}{\partial t_{\mathrm{e}}}\right)\left(1 + \frac{\partial P_{\mathrm{e}}}{\partial t_{\mathrm{e}}}\right) - u_1 M\left(1 + \frac{\partial P_{\mathrm{e}}}{\partial t_{\mathrm{e}}}\right)\right]}{N_1^2} \\ +\left(\frac{u_1}{N_1^4}\right)\left\{ \begin{array}{l} N_1^2\left[u_0 M\left(1 + \frac{\partial P_{\mathrm{e}}}{\partial t_{\mathrm{e}}}\right) + N_0\left(\frac{\partial M}{\partial t_{\mathrm{e}}}\right)\left(1 + \frac{\partial P_{\mathrm{e}}}{\partial t_{\mathrm{e}}}\right)\right] - 2u_1 N_0 N_1 M\left(1 + \frac{\partial P_{\mathrm{e}}}{\partial t_{\mathrm{e}}}\right) \\ -MN_1^2\left(\frac{\partial M}{\partial t_{\mathrm{e}}}\right)\left(1 + \frac{\partial P_{\mathrm{e}}}{\partial t_{\mathrm{e}}}\right) + u_1 N_1 M^2\left(1 + \frac{\partial P_{\mathrm{e}}}{\partial t_{\mathrm{e}}}\right) \end{array} \right\} \end{array} \right\} dt_{\mathrm{e}} \tag{10.27}$$

where $M = \left[\frac{(1+B_{\mathrm{h}}H_1)(N_0+A_{\mathrm{c}}N_1)+k_{\mathrm{s}}N_1(H_0+A_{\mathrm{h}}H_1)}{(1+B_{\mathrm{h}}H_1)(1+B_{\mathrm{c}}N_1)-k_{\mathrm{s}}\gamma_{\mathrm{c}}N_1H_1}\right]$ and

$$\frac{\partial M}{\partial t_{\mathrm{e}}} = \frac{\begin{array}{c}\{(1+B_{\mathrm{h}}H_1)^2[u_0(1+B_{\mathrm{c}}N_1) + u_1(A_{\mathrm{c}} - B_{\mathrm{c}}N_0)] + k_{\mathrm{s}}^2\gamma_{\mathrm{c}}H_1N_1(H_0 + A_{\mathrm{h}}H_1)(1-u_1) \\ +k_{\mathrm{s}}\gamma_{\mathrm{c}}H_1(1+B_{\mathrm{h}}H_1)[(N_0 - u_0N_1) + (1-u_1)A_{\mathrm{c}}N_1] + k_{\mathrm{s}}u_1(1+B_{\mathrm{h}}H_1)(H_0 + A_{\mathrm{h}}H_1)\}\end{array}}{[(1+B_{\mathrm{h}}H_1)(1+B_{\mathrm{c}}N_1) - k_{\mathrm{s}}\gamma_{\mathrm{c}}H_1N_1]^2}.$$

The reduction in corn demand for ethanol production is estimated by inserting equation (10.27) into equation (10.28), which is derived from the ethanol production function in equation (10.1), as follows:

$$dQ_{\mathrm{e}} = \frac{dE_{\mathrm{do}}}{u_0 - u_1 Q_{\mathrm{e}}}, \tag{10.28}$$

where the numerator dE_{do} measures the total effect on domestic ethanol production of lowering the tax credit, as derived in equation (10.27), while the equilibrium corn demand for ethanol production Q_{e} is as derived in equation (10.11). The initial impacts of lowering the ethanol tax credit to \$0.45 per gallon (from \$0.51 per gallon) on ethanol production and corn demand for ethanol production are estimated using equations (10.27) and (10.28), respectively. However, this impact requires further explanation as illustrated using Fig. 10.5. The curve E_{s} represents the ethanol supply curve and the curve F_0 represents the mandated ethanol production. When distillers are paid $[P_{\mathrm{e}} + t_{\mathrm{e}}]$ for domestically produced ethanol, blenders use domestically produced ethanol up to E_{do}, while the remaining mandate, (F_0–E_{do}), is met through imports of ethanol. Consistent with the equilibrium condition in equation (10.19). However, as the ethanol tax credit is lowered to \$0.45 from \$0.51 per gallon, distillers would receive $P_{\mathrm{e}} + t'_{\mathrm{e}}$ per gallon of ethanol and domestic ethanol production would decline to E'_{do}. Since $[P_{\mathrm{e}} + t'_{\mathrm{e}}]$ is now less than $[P^{\mathrm{i}}_{\mathrm{m}}(1+\delta) + T^{i}_{\mathrm{m}}]$ from equation (10.19), ethanol imports would also decline, but the demand for domestically produced ethanol would subsequently increase, allowing blenders to meet the blending mandate, which would also increase the ethanol price P_{e} to P'_{e}.[8] However, the increase in the ethanol price would be less than the reduction of the tax credit to t'_{e}, due to the market power effects and, therefore, $(P'_{\mathrm{e}} + t'_{\mathrm{e}}) \leq (P_{\mathrm{e}} + t_{\mathrm{e}})$, where the equality holds under perfect competition in the domestic ethanol market. Domestic

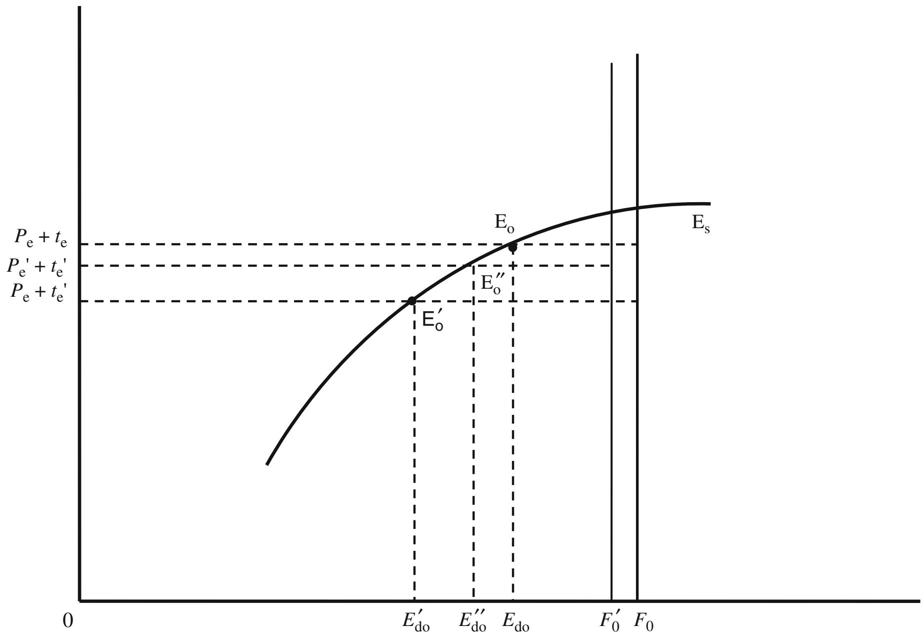

Fig. 10.5 The effects of lowering the tax credit on the ethanol market

distillers would receive the total price for a gallon of ethanol, $[P'_e + t'_e]$, and produce ethanol E''_{do}, which is less than E_{do}, which is the level they were at before the lowering of the ethanol tax credit.

While lowering the ethanol tax credit would affect somewhat both distillers and corn farmers, gasoline consumers would suffer the most from a lowering of the tax credit. Since blenders utilize domestically produced ethanol up to the point where the marginal value product of ethanol equals the sum of the marginal factor costs of ethanol and the shadow value of the blending mandate (weighted by its blending rate) as shown in equation (10.16), the increase in the marginal factor costs to $P'_e(1+\varepsilon)$ from $P_e(1+\varepsilon)$ would then result in an increase in the blended gasoline price P_F. An increase in the blended gasoline price would also lead to a higher conventional gasoline price (see equation (10.15)). Since renewable volume obligation (RVO) is based on annual conventional gasoline volume, the blending requirement F_0 shifts to the left toward F'_0 in Fig. 10.5, as both conventional gasoline demand and supply decline. As the blended gasoline price rises, consumer demand for blended gasoline would decline, so domestic ethanol production, ethanol import, and corn demand for ethanol production would be somewhat less than what they were before the lowering of the tax credit.

10.6 Conclusions

Commodity programs have been the traditional policy tool used to support commodity prices and, consequently, influence producers' land allocation decisions among competing crops. However, newly enacted biofuel-related programs, especially as defined in the American Jobs Creation Act (AJCA) of 2004 and the Energy Independence and Security Act (EISA) of 2007, are, arguably, now much more influential policies affecting relative and absolute commodity prices. From an economic analysis perspective, the introduction of these programs has created numerous complexities in modeling the commodity price adjustment process for both corn and soybeans and energy prices. Therefore, we present an economic simulation model that incorporates ethanol production from corn and bio-diesel production from soybeans to simultaneously evaluate the impacts of various U.S. biofuel policies on agricultural commodity and energy markets. We also incorporate a refiners' profit function associated with conventional gasoline production and a blenders' profit function associated with blended gasoline production to evaluate the effects of tax credits, blending mandates, and tariffs on equilibrium prices of commodity and energy markets.

First, we investigate how the current tax credit of $0.51 per gallon of ethanol under the AJCA and the ethanol blending requirement under the EISA affect commodity market equilibriums. Results indicate that commodity price and production rise, but at a diminishing rate of a tax credit, due to the assumption of quadratic biofuel production functions. Second, we demonstrate that conventional gasoline supply declines as a result of a blending requirement under the EISA. As the rate of the blending requirement increases, the marginal costs of producing conventional gasoline increases by shifting the conventional gasoline supply curve to the left. Previous studies implicitly assumed that conventional gasoline and ethanol are independent goods in production so that blended gasoline supply would increase and its price per gallon would decline as a result of a blending mandate. However, we demonstrate theoretically that refiners reduce conventional gasoline production due to the shadow value associated with the blending mandate. The Energy Information Administration (2008) data lend support to our claim by showing that refinery net input of crude oil (for conventional gasoline production) has been declining since 2004. These data illustrate that conventional gasoline declined by 2.64 billion gallons between 2004 and 2007, while ethanol production increased by 2.58 billion gallons during the same period. These results suggest that there is no evidence that conventional gasoline price would be lower by 15% with mandated ethanol production as reported by the Merrill Lynch study (Blanch, 2008).

Finally, we show that blender' decisions between using domestically produced and/or imported ethanol to blend with conventional gasoline depends on the level and use of biofuel-specific tax credits, ad valorem taxes, import duties, as well as domestic and imported ethanol prices (c.i.f). The recently passed 2008 Farm Bill lowers the tax credit for ethanol to $0.45 per gallon, beginning in January 2009, while the import duty for sugar-based ethanol remains at $0.54 per gallon. Due to the blending mandates, however, the ethanol price would rise until the equilibrium condition in equation (10.19) holds. Consequently, our results tell us that ethanol production, and therefore, corn demand for ethanol production, would decline as a result of a lowering of the ethanol tax credit. However, these same results tell us that the unit price of blended gasoline would likely increase so that consumer demand for blended gasoline would likely decline.

Notes

1. Import tariffs were established by the Omnibus Reconciliation Act of 1980 and amended by the Tax Reform Act of 1986 (Yacobucci, 2006).
2. The recently passed 2008 Farm Bill lowered the tax credit for ethanol to $0.45 per gallon, beginning in January 2009.
3. Technically, the bio-diesel mandate expires after 2008.
4. Due to the lack of facilities in ethanol transportation, we assume that oil companies/blenders have market power in the ethanol market as described by Hartwig (2006).
5. Blenders produce blended gasoline (B) with conventional gasoline (G) and ethanol (E) such that $B = (1-\theta)G + \theta E$, where θ is the rate of a blending mandate and B equals the consumer demand for gasoline at equilibrium. As the rate of a blending mandate increases, blenders use more ethanol and less conventional gasoline.
6. Meanwhile, Blanch (2008) and Lieberman (2008) discuss the effect of a reduction in capital investment on refinery facilities and how this will contribute to a reduction in gasoline production in the future.
7. Approximately 19.6 gallons of motor gasoline are produced from one barrel of crude oil (EIA, 2008).
8. The term $\left(\frac{\partial P_{\mathrm{e}}}{\partial t_{\mathrm{e}}}\right)$ in equation (10.27) can be estimated by setting $dE_{\mathrm{do}} = 0$.

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Chapter 11
Biofuels Versus Food Competition for Agricultural Resources: Impacts on the EU Farming Systems

Massimo Canali and Maurizio Aragrande

Abstract This chapter investigates the impacts of the biofuel policies on European agriculture. The analysis starts by evaluating the cropland area required to supply the potential production capacity of the European biofuel industry in 2010, the problems related to the technical adaptation of farms to feedstock production, and the approach to biofuels in the European Commission's proposals for the last review of the Common Agricultural Policy (CAP). Then the chapter examines the availability of land for biofuel crops within the European Union and worldwide, the impacts on the environment, the biodiversity and the water resources, including the issue of sustainable biofuel production. The conclusions focus on some possible adjustments in the current policy framework.

11.1 An Evaluation of the Land Needed to Supply the Potential Production Capacity of EU Biofuel Industry

In the year 2003, the European Parliament and the Council established that the Member States (MSs) of the European Union (EU) have to place a minimum amount of biofuels on their markets, on the basis of national indicative targets. The reference values for these targets – calculated on the energy content of all petrol and diesel sold in the MSs for transport purposes – were set at 2% for the year 2005 and at 5.75% for the year 2010 (Directive 2003/30/EC).

According to the European Commission's *Bio-fuel Progress Report* (COM, 2006, 845 final), in the year 2005, the biofuel share in the European fuel market was 1% and the sum of the national targets set by the MSs covered just 1.4% of the total fuel market: hence, the EU 2005 target was not fulfilled. Regarding the prospects for the year 2010, the most optimistic estimates of the European Commission indicated a

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biofuel share of 3.9%, which means that also the second target of 5.75% in 2010 is unlikely to be achieved. Nonetheless, in the same report and in the *Renewable Energy Roadmap* (COM, 2006, 848 final), the European Commission proposed to confirm the 2010 target and to set a new and more ambitious target of 10% of biofuels in the EU road transport for the year 2020: the European Council of 8–9 March 2007 agreed on these proposals.

The EU final energy consumption of liquid fuels for road transport in the year 2010 will be 309.88 million tons of oil equivalent (Mtoe). To comply with the 5.75% target, this consumption will require that 17.82 Mtoe are obtained from biofuels (estimations based on data from European Commission - DG Energy and Transport 2008a, and 2008b, and from Eurostat, 2007). In the year 2007, the total energy content of the EU biofuel production, in terms of net calorific value (NCV), could be estimated between 5.60 and 5.80 Mtoe, about 85% from bio-diesel and 15% from bio-ethanol: this is less than one third of the 2010 target.

The expected EU biofuel production capacity for the year 2010 is shown in Table 11.1. The figures include the processing plants that were on line as well as those that were under construction or were planned in the year 2007 (DEIAGRA, 2007, pp. 25–30). Only the plants processing feedstock from crops cultivable in the MSs have been taken into account. The plants designed to process imported feedstock -like palm oil- and animal fats have been excluded. In the bio-diesel sector, these plants could give an additional production capacity of 3.32 million tons in 2010 (DEIAGRA, 2007, p. 27).

The types of feedstock used for bio-ethanol are wheat, barley, rye, and sugar beet, while rapeseeds, sunflower, and soybeans are for bio-diesel. The EU hypothetical production capacity in 2010 results in 9.13 million tons of bio-ethanol, mainly from wheat (40%) and maize (22%), and 13.93 million tons of bio-diesel (73% from rapeseeds). The entire quantity of biofuel has a total NCV of 18.20 Mtoe, two thirds of which come from bio-diesel, and so it complies with the 5.75% target.

The bio-ethanol production capacity appears to be widely distributed among the MSs. France is first among equals with 14% of total EU capacity, followed by Hungary with 13%, Spain with 12%, Germany with 10%, and Belgium with 8% of total capacity. Production of bio-diesel seems more concentrated: Spain accounts for 29% of the total, followed by Germany (26%), Italy (7%), France (7%), and Belgium (6%). However, according to the available data, it should be noticed that, if all the planned processing plants are constructed, the 2010 EU production capacity would grow by 5.4 times in the bio-ethanol sector and by 2.3 times in the bio-diesel sector with respect to the year 2007 (DEIAGRA, 2007, pp. 25–30).

In Table 11.2, we propose an estimate of the total land area needed to supply the EU biofuel industry operating at the hypothetical full capacity in the year 2010. Note that the estimates assume that all the feedstock is produced within the EU territory[1]. The results displayed in Table 11.2. Indicate that a total amount of 26.74 million hectares of biofuel crops, corresponding to 24% of the EU-27 arable land area, would be needed. This value includes 19.73 million hectares of oilseed crops for bio-diesel, 6.61 million hectares of cereals and 0.40 million hectares of sugar beets for bio-ethanol. With respect to the year 2006, the land area devoted to oilseed

Table 11.1 Biofuel production capacity of the EU in 2010

Country	Million tons of bio-ethanol from:						Million tons of bio-diesel from:			
	Wheat	Barley	Rye	Maize	Sugar beet	Total	Rapeseeds	Sunflower	Soybeans	Total
Austria	0.14	–	–	–	0.02	0.16	0.21	0.15	–	0.36
Belgium	0.25	0.25	–	–	0.21	0.71	0.78	–	–	0.78
Bulgaria	0.02	0.02	–	–	–	0.03	0.17	0.18	0.06	0.41
Cyprus	–	–	–	–	–	–	–	–	–	–
Czech Rep.	0.17	0.11	–	0.06	0.11	0.45	0.31	–	–	0.31
Denmark	0.35	–	–	–	0.07	0.42	–	–	–	–
Estonia	–	–	–	–	–	–	–	–	–	–
Finland	–	0.29	–	–	0.05	0.34	0.15	–	–	0.15
France	0.62	–	–	–	0.70	1.32	0.98	–	–	0.98
Germany	0.28	0.14	0.16	–	0.32	0.90	3.60	–	–	3.60
Greece	0.07	–	–	–	0.07	0.14		0.06	–	0.06
Hungary	–	–	–	1.23	–	1.23	0.01	0.01	–	0.02
Ireland	–	–	–	–	–	–	–	–	–	–
Italy	0.06	0.06	–	0.44	0.03	0.59	0.63	0.11	0.30	1.04
Latvia	0.05	–	0.05	–	–	0.10	0.16	–	–	0.16
Lithuania	0.17	–	0.19	–	–	0.36	0.21	–	–	0.21
Luxemburg	–	–	–	–	–	–	–	–	–	–
Malta	–	–	–	–	–	–	–	–	–	–
Netherlands	0.35	–	–	–	0.01	0.36	0.51	–	–	0.51
Poland	0.06	0.06	–	–	–	0.12	0.23	0.01	–	0.24
Portugal	0.08	0.08	–	–	–	0.16		0.15	–	0.15
Romania	–	–	–	0.16	–	0.16	0.09	0.09	0.03	0.21
Slovakia	–	–	–	0.10	–	0.10	–	–	–	–
Slovenia	0.02	–	–	0.02	–	0.04	–	–	–	–
Spain	0.62	0.50	–	–	–	1.12	1.48	1.09	1.51	4.08
Sweden	0.16	–	–	–	–	0.16	0.04	–	–	0.04
United Kingdom	0.29	–	–	–	0.05	0.34	0.62	–	–	0.62
EU-27	**3.76**	**1.51**	**0.40**	**2.01**	**1.64**	**9.31**	**10.18**	**1.85**	**1.90**	**13.93**

Source: Own elaboration from DEIAGRA (2007, pp. 25–30)

Table 11.2 Estimated land requirements to supply the EU biofuel production capacity in 2010

	Bio-ethanol crops (Mio ha)						Bio-diesel crops (Mio ha)					As % of the total arable land area		
Country	Wheat	Barley	Rye	Maize	Sugar beet	Total	Rapeseeds	Sunflower	Soybeans	Total	Total (Mio ha)	Bio-eth. crops	Bio-dies. crops	Total
Austria	0.09	–	–	–	0.00	0.10	0.21	0.13	–	0.34	0.43	7	24	31
Belgium	0.10	0.17	–	–	0.05	0.32	0.57	–	–	0.57	0.89	38	69	106
Bulgaria	0.02	0.03	–	–	–	0.05	0.29	0.26	0.20	0.75	0.80	1	23	24
Cyprus	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Czech Rep.	0.12	0.13	–	0.03	0.03	0.31	0.32	–	–	0.32	0.63	10	1	21
Denmark	0.16	–	–	–	0.02	0.18	–	–	–	–	0.18	8	0	8
Estonia	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Finland	–	0.44	–	–	0.02	0.46	0.28	–	–	0.28	0.74	21	13	34
France	0.29	–	–	–	0.14	0.43	0.84	–	–	0.84	1.28	2	5	7
Germany	0.13	0.12	0.16	–	0.01	0.48	2.84	–	–	2.84	3.32	4	24	28
Greece	0.08	–	–	–	0.02	0.10	–	0.11	–	0.11	0.21	4	4	8
Hungary	–	–	–	0.65	–	0.65	0.01	0.01	–	0.02	0.67	14	0	15
Ireland	–	–	–	–	–	–	–	–	–	–	–	0	0	0
Italy	0.04	0.08	–	0.17	0.01	0.30	1.09	0.12	0.52	1.74	2.04	4	22	25
Latvia	0.05	–	0.11	–	–	0.17	0.27	–	–	0.27	0.43	16	27	43
Lithuania	0.17	–	0.43	–	–	0.59	0.35	–	–	0.35	0.95	35	21	57

Table 11.2 (continued)

Country	Bio-ethanol crops (Mio ha)						Bio-diesel crops (Mio ha)					As % of the total arable land area		
	Wheat	Barley	Rye	Maize	Sugar beet	Total	Rapeseeds	Sunflower	Soybeans	Total	Total (Mio ha)	Bio-eth. crops	Bio-dies. crops	Total
Luxemburg	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Malta	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Netherlands	0.13	–	–	–	0.00	0.14	0.38	–	–	0.38	0.52	15	42	57
Poland	0.05	0.10	–	–	–	0.15	0.26	0.01	–	0.27	0.43	1	2	3
Portugal	0.18	0.27	–	–	–	0.45		0.72		0.72	1.17	31	50	81
Romania	–	–	–	0.14	–	0.14	0.18	0.14	0.09	0.40	0.54	1	4	6
Slovakia	–	–	–	0.06	–	0.06	–	–	–	–	0.06	4	0	4
Slovenia	0.02	–	–	0.01	–	0.03	–	–	–	–	0.03	15	0	15
Spain	0.70	0.99	–	–	–	1.68	3.00	2.61	3.31	8.92	10.60	12	66	79
Sweden	0.09	–	–	–	–	0.09	0.04	–	–	0.04	0.14	3	2	5
UK	0.12	–	–	–	0.01	0.13	0.55	–	–	0.55	0.68	2	10	12
EU-27	**2.54**	**2.32**	**0.69**	**1.05**	**0.40**	**7.01**	**11.51**	**4.11**	**4.12**	**19.73**	**26.74**	**6**	**18**	**24**

Source: Own elaboration

production would double, the cereal crop area would expand by 11%, and the sugar beet area by 23%.

The estimates suggest that the EU 5.75% biofuel target will not be achieved within the year 2010: it could be achieved later than 2010 only if a major part of the feedstock or the biofuels are imported. In any case, the achievement of the target will have a considerable impact on the European agriculture and food markets, with an intensification of the farming systems, including conversion of grassland, meadows, and idle land into crop production.

The following sections investigate the technical adaptation of the European farms to the production of biofuel feedstock, and the approach to biofuels of the recent revision of the Common Agricultural Policy. Then we examine: the availability of land for biofuel crops in Europe and in the rest of the world; the impacts on the environment, biodiversity and water resources; and the issue of sustainable biofuel production.

11.2 Technical and Structural Adaptations of the Agricultural Holdings

The diversion of farm resources from food to biofuel production can take place either through a shift in the commercial destination of agricultural commodities (e.g., oilseeds and cereals from the food industry to the biofuel processors) or through a change in the farms' cropping patterns and use of land (e.g., conversion of land from fruit and vegetable production, fodder crops, and grassland into cereal and oilseed crops for biofuels; and clearing of woodland for crop production).

In the first case, the production practices for cereals, sugar beet, and oilseeds produced in the EU do not change significantly when the harvest is for the biofuel industry. A technical proximity between food and biofuel crops gives flexibility to farms, as it was observed, for example, in Austria, where producers supplied maize alternatively to the feed industry or to the biofuel industry, depending on prices (DEIAGRA, 2006). In this case, the technical adaptation is mainly related to price variations. Rising prices, for instance, stimulate a more-intensive use of inputs and, in the long term, encourage farm investments that bring technical and structural improvements, while an income effect may delay the abandonment of marginal farms.

Regarding the changes in the cropping patterns and in the use of land, the most relevant farm adaptation costs are related, on the one side, to the conversion of non-arable land, such as woodland, grassland, and tree crops into arable land and, on the other side, to the acquisition of the necessary technology. Biofuel crops require machinery for sowing, fertilisation, weeding, pest control, harvesting, and storage. There is a minimum scale of production that makes these investments affordable, and, in general, the big holdings are more favoured than the small- and the medium-sized holdings.

The competitive advantages of the biggest holdings can be reduced by improving the organisation of the supply chain. The outsourcing of services requiring high investments (e.g., rent of machinery, cooperative garners, and dryers) allows small- and medium-sized farms to use advanced technologies through organisational innovation. These forms of horizontal and vertical integration are widely used by farmers, especially in the EU-15, but the level of integration in the single agricultural supply chains is very different from one country to another and from one region to another. Thus, the current levels of integration existing in each region, in particular in the cereal and oilseed production, also determine a competitive advantage for biofuel crops.

Several case studies (see DEIAGRA, 2006) have shown that, in some regions, integration and cooperation among producers have spurred the development of small bio-diesel processors and oilseed mills directly managed by associations of producers, who utilise the biofuel in their own holdings or sell it in the local markets.

The organisation of the supply chain influences the location strategies of the biofuel processors, which, because of the high transportation and logistic costs, are mostly positioned near seaports (when they are conceived to process imported feedstock) or in the feedstock-producing regions. Mixed options, such as the biofuel plant located near the Livorno port in Italy to process both the imported and the locally produced feedstock, have also been observed. From this perspective, the existence of farms specialised in cereal or oilseed cropping systems are a prerequisite for the development of biofuel districts. On the other side, the biofuel processors may implement strategies of vertical integration by providing finance and other services in order to facilitate the adaptation of the farm sector to the specific requirements of this industry.

Supply contracts between farmers and processors are a widespread tool for vertical integration in the biofuel industry. The contracts guarantee the delivery of supply over periods varying from 1 to 3 years and regulate the feedstock prices, for example, on the basis of specific quotations in the energy market (DEIAGRA, 2006).

In the French regions of Champagne–Ardenne and Normandy, bio-ethanol production has been developed on the existing agro-industrial districts by making large use of inter-professional agreements (*accords interprofessionnels*). Farmers, organised in cooperative companies, are the owners of bio-ethanol–processing factories that supply oil refineries producing ETBE through contracts involving other stakeholders, such as transport firms, owners of fuelling stations, and local authorities (Aragrande et al., 2007). The same actors are involved in long-term agreements to implement common strategies and projects.

11.3 Biofuels and the CAP "Health Check"

In 2007, the Common Agricultural Policy (CAP) was under a review process - called the "CAP Health Check" - aimed to define the necessary policy adjustments for the 2009–2013 period. The European Commission's proposals issued from the "Health Check" addressed three key policy areas: (1) the efficiency of the single payment scheme (SPS); (2) the Common Market Organization (CMO) and the functioning of the safety net for producers, and (3) the emerging topics of climate change, biofuels, and biodiversity, which should be addressed by strengthening the CAP's second pillar – rural development. The European Commission proposed to reduce the level of commodity support, reinforce "decoupling" within the SPS, and provide additional funding for rural development initiatives by redirecting a portion of the direct payments (COM, 2007, 722 final).

As regards biofuels, after stating that food and feed production remain the "primary vocation" of the European agriculture, the European Commission introduced two new initiatives: (1) provide incentives for developing second-generation biofuels within the second pillar; and (2) revise the energy crop aid scheme, since this sector now benefits from the incentives and the compulsory targets of the EU policies on energy and the environment, and takes also advantage from the increasing price of energy products. Among the changes in the SPS, the European Commission proposed the abolition of the set-aside measure, which implied the abolition of the set-aside exemption for non-food crops.

Traditionally, the CAP encouraged non-food uses of crop products as a way of reducing the EU agricultural oversupply, but the European Commission's proposals have brought to new and more neutral approach on this matter. The aids to the crops for the first-generation biofuels have been reduced, while the emphasis is now on the second-generation biofuels, which are considered as not competing with food crops for the use of agricultural land. In fact, they can be obtained from generic lignocellulosic biomasses, rather than from traditional food crops like cereals, oilseeds, and sugar crops. However, it is also worth to notice that, at the present time, the second-generation biofuels are only produced by pilot plants and not on a commercial scale.

The other CAP adjustments envisaged by the European Commission include moving away from the SPS historic model in favour of a new regional model, reducing support for the largest producers through "modulation", the simplification of cross compliance, the abolition of market intervention for all non-bread cereals, and, finally, the phasing out of milk quotas. These measures will make the European farmers more responsive to changing market conditions and also more reactive to increasing price of biofuel crops, as it took place in the US corn market during the last years.

From this perspective, it is surprising that, despite its statement on the priority of food, the European Commission did not advance any concrete proposal to address the growing competition between food and non-food uses of agricultural resources.

11.4 The Big Issue of Land Requirements

In recent years, many developed and developing countries have set ambitious biofuel targets, and several governmental and international organisations operating for environment and conservation have already expressed their concern for the very large extension of agricultural land required to implement these policies (e.g., see: JNCC, 2007; UNEP/CBD/SPSTTA/13/2, 2007; UNEP/CBD/SPSTTA/ 12/9, 2007).

Actually, the land factor poses the greatest risks for the environment and food security.

In paragraph 1, we estimated that, at current crop yields, more than 26 million hectares of arable land – nearly one fourth of the total EU arable land area would be needed to make the European biofuel processors work at full capacity and comply with the EU 2010 target. Differently from our estimations, the European Commission-DG AGRI evaluates that 17.5 million hectares (see Table 11.3) could satisfy the target of 10% of biofuels in the European fuel market for the year 2020 under several and very favourable assumptions: (i) the second-generation biofuels will cover 30% of the EU biofuel demand, either by processing the by-products of ordinary cereal crops – which will increase the bio-ethanol yields of cereals by 30–40% – or by exploiting lignocellulosic biomasses from 1.7 million hectares of uncultivated land in order to produce biomass-to-liquid (BTL) diesel; (ii) the yields of crops will rise in general by 1–2% per year thanks to technological improvements; and (iii) 20% of the total EU biofuel production, 10% of which will be biofuels of first generation and 10% of second generation, will be obtained from imported feedstock. In the case that all the feedstock needed for the second-generation biofuels is

Table 11.3 European Commission's estimates on the land requirements within the EU-27 to achieve the EU biofuel target of 2020

Description	2006 (Mio ha)	2020 (Mio ha)	Variation in the cropped area (Mio ha)
Bio-ethanol crops area			
– from cereals (1st generation)	0,90	7,10	+ 6,20
– from cereals (2nd generation)	n.a.	5,20	+ 5,20
– from sugar beet	0,10	0,60	+ 0,50
(a) Subtotal	1,00	12,90	+ 11,90
Bio-diesel crops area			
– from oilseeds (1st generation)	2,10	2,90	+ 0,80
– BTL (2nd generation)[a]	n.a.	1,70	Not cropped
(b) Subtotal	2,10	4,60	+ 0,80[b]
Total area utilised for biofuels	**3,10**	**17,50**	**+ 12,70[b]**
Food and feed crops area			
– cereals	58,10	50,20	– 7,90
– oilseeds	6,70	5,60	– 1,10
– sugar beet	1,80	0,83	– 0,97
– other	36,90	36,60	– 0,30
(c) **Total food and feed crops area**	**103,50**	**93,23**	**– 10,27**
(d) Idle land and compulsory set-aside land	7,20	4,70	– 2,50
Total arable land area (a + b + c + d)	**113,80**	**113,73[b]**	**– 0,07**

[a]The BTL bio-diesel is supposed to be obtained from lignocellulosic raw materials taken from 1.7 Millions hectares of land, which are not devoted to crops, such as forests, woods, and shrub-land
[b]The figure does not include the 1.7 Mio hectares used for BTL bio-diesel.
Source: Own elaboration from European Commission-DG AGRI (2007, p. 8)

produced in Europe, the DG AGRI estimates that the land required for the EU 2020 target would be 19.5 million hectares (European Commission-DG AGRI, 2007).

In the United States (US), the production of bio-ethanol increased from 4.87 million tons in 2000 to 14.52 million tons in 2006 and 19.38 million tons in 2007 (estimation from data published in RFA, 2008), when the land area devoted to the production of corn reached 37.9 million hectares (USDA-NASS, 2008), an increase of 6.2 million hectares over the previous year. Taking into account the US corn grains average yields of 9.6 tons per hectare in 2007 (USDA-NASS, 2007) and an ethanol/grain conversion rate of 0.3, it results that the production of 6.7 million hectares of corn crop was for bio-ethanol. The Renewable Fuel Standard (RFS) established by the Energy Independence and Security Act (EISA) of 2007 mandates that the biofuel consumption in the United States has to attain 15 billion gallons (i.e., 44.8 million tons) by the year 2015 and 36 billion gallons (or 107.5 million tons) by the year 2022.

The 2015 mandate may be reached with corn-starch ethanol. Under the optimistic hypothesis of Searchinger et al. (2008b, p. 5), who assume that in 2015 the US average yields of ethanol from corn will have grown to 4,375.4 litres per hectare, this target would require about 13 million hectares of corn. But the EISA also requires that an additional bio-fuel consumption of 21 billion gallons (or 62.72 million tons) between 2015 and 2022 may not be supplied with corn-starch ethanol. As the second-generation biofuels probably will not be available on a commercial scale in that period, the alternatives are bio-ethanol derived from sorghum or sugar beet, bio-diesel, or the importation of Brazilian ethanol from sugar cane (Yacobucci and Schnepf, 2007, pp. 7–9). At current crop yields, 21 billion gallons of ethanol need about 46 million hectares of sorghum or 15.4 million hectares of sugar beets in the United States, or 13.2 million hectares of sugar cane in Brazil. It should be noticed that, in the year 2006, the total sugar cane crop area harvested in Brazil (ethanol + sugar) was of 5.8 million hectares, and the total ethanol production was of 4.5 billion gallons (Filho, 2007). The hypothesis to use bio-diesel from feedstock produced in the United States is even more unrealistic, since with the current yields only 180.5 gallons per hectare are in average obtainable from rapeseeds and 167.7 gallons per hectare from soybeans.

11.4.1 The Agricultural Land Usable for Biofuels in Europe

The new arable land available within the EU territory to achieve the biofuel targets is quite limited. Most of the biofuel feedstock must be obtained either by diverting land from food production and from other uses (grasslands, shrub lands, woods, and forests), or through import. There is also the possibility of importing biofuels. The importation of feedstock and biofuels implies that land-use changes take place outside Europe, in the rest of the world.

The European Commission, basing on the arguable assumptions mentioned in the previous section, evaluates that the EU-27 biofuel crop area will expand by 12.7 million hectares in order to meet the 10% target by the year 2020 (see Table 11.3).

However, according to the European Commission's estimates, the total arable land area would remain almost unchanged at about 113.8 million hectares. Hence, the land area devoted to food and feed crops would decrease by 10.27 million hectares, while 2.5 million hectares of set-aside land would be planted with biofuel crops. The cultivation of cereal crops for food and feed would be reduced of 7.9 million hectares, or 13.6%, with respect to the year 2006 (own calculations from European Commission-DG AGRI, 2007, pp. 7–8). But all this would imply a quite illogical policy scenario where, on the one side, the processing of agricultural commodities into biofuels is encouraged and, on the other side, European farmers are prevented from converting grassland and other non-cultivated land into crops, despite the increasing demand for both biofuels and food.

The European Commission's assumptions regarding the production of food crops would also imply an increase of the EU food imports and a decrease of the EU food exports. The additional food import is an indirect consequence of the biofuel policy, which should be added to the direct importation of feedstock. According to a JRC study (De Santi, 2008, p. 27), the indirect imports would bring the total import of feedstock to 32–39% of the EU biofuel industry needs in 2020. By way of comparison, the European Commission's assumption is that 20% of the feedstock would be imported, with second-generation biofuels supplying 30% of the EU demand. But, if the second-generation biofuels are not available, imports of feedstock (both direct and indirect) would account for 56–64% of total EU demand in 2020. The land needed to produce this feedstock would be found outside the EU, in addition to that needed to offset the reduction of the EU food exports.

The European Environment Agency (EEA) estimates that the land area available for environmentally sustainable bio-energy production is expected to be of 13 million hectares in 2010, 16.2 million hectares in 2020, and 19.3 million hectares in 2030. These estimates are based on the following assumptions: (i) the production of biofuel crops will not compete directly with the production of food crops; (ii) a reform of the CAP will liberalise the trade of agricultural goods, by allowing massive imports of livestock products into the EU and the release of large areas of European arable land now used for production of feed crops; and (iii) the second-generation biofuels will satisfy the EU demand for biofuels (EEA, 2006, pp. 14–30). As regards the EU biofuel targets, the EEA's scientific committee concluded that while the achievement of the 5.75% target in 2010 seems unlikely, the land area required to meet the 10% target exceeds the available land area – despite the very favourable assumptions made – and recommended the suspension of the measure by defining it "overambitious" (EEA, 2008).

11.4.2 The Land Availability Outside Europe

The Earth's emerged lands have a total area of 13.3 billion hectares, out of which 32% (4.2 billion hectares) is unusable for agriculture because of climate, altitude or slopes, 11% (1.5 billion hectares) is under crops, 26% (3.5 billion hectares) is grassland for livestock feeding and pasture, 30% (3.9 billion hectares) is covered by forests and woods, and the remaining 2% (0.2 billion hectares) is occupied by human settlements and infrastructure. On this premise, in the coming decades, only the conversion of grassland could provide new arable land for crops (Doornbosch and Steenblik, 2007, p. 13).

The OECD estimates that by the year 2050 some 440 million hectares will be globally available for bio-energy production, with much of the land area coming from the conversion of grasslands. The study assumes: (i) a global population of 9 billion people; (ii) no significant changes in the nutritional habits of the people; and (iii) that the additional food needs due to population growth will be met by increased yields of crops and livestock. Roughly 80% of the new land potentially available is distributed between South America and Africa, and about half is located in just seven countries: Argentina, Bolivia, Brazil, Colombia, Angola, Democratic Republic of Congo, and Sudan. However, even if all the 440 million hectares of the OECD estimations were used for bio-energies – which also depends on the creation of infrastructures, on the competition with food crops, and on the constraints related to environmental concerns – in the year 2050 the biofuels could account only for less than one fourth to the world total consumption of liquid fuels for transportation (Doornbosch and Steenblik, 2007, pp. 12–17).

11.5 Some Issues on the Impact of Biofuel Policies on the Environment and on the Sustainability of Biofuel Production

11.5.1 The Effects on Biodiversity and Ecosystems

A large-scale conversion of natural grassland and forests into biofuel crops will severely degrade the Earth's ecosystems. A significant portion of the land area for biofuel crops will be located in the tropical and subtropical regions of Central and South America, in Africa, and in Southern and South-Eastern Asia, regions that are already affected by intensive exploitation.

These regions lost nearly 170 million hectares of forests and woodlands over the 1990–2005 period; between 2000 and 2005, the rate of deforestation reached 11 million hectares per year. In Europe, where the forest area increased by 12 million hectares between 1990 and 2005, the fulfilment of the biofuel targets would probably entail the conversion of woods and natural meadows that are critical to the current revitalization process (data from FAO-Forestry Department, 2005).

An expansion of the biofuel crops would have an adverse affect on biodiversity worldwide. For example, in South East Asia, a large extension of tropical rainforest, including valuable protected areas, has been cleared to cultivate oil palm plantations for bio-diesel. In the United States, the expansion of the corn acreage threatens land enrolled in the Conservation Reserve Program. In Brazil, there is insistent pressure to expand the coastal fields of sugar cane and convert additional cerrado habitats to soybean or sugar cane plantations (Groom et al., 2008, p. 5; Kepler, 2007; Rodrigues and Ortiz, 2006, pp. 18–21).

The degradation of the natural habitat is a direct effect of crop area enlargement, which influences the viability of wild species, including species threatened with extinction. The wild fauna underwent a considerable decline in Europe between the late 1970s and early 1980s due to the intensification of agricultural practices. A revitalization has taken place since the year 2000 (Secretariat of the CBD, 2006, pp. 25–27), but the expansion of biofuel crop production on grassland and forests could bring an important regression: for example one third of all permanent grassland habitats listed in Annex I of the Directive for the European Habitats are considered to be threatened by the intensification of farming (EEA, 2007, p. 13).

In the developing countries, the degradation of the natural habitats destroys resources for the livelihood of indigenous communities by favouring their dissolution. This threatens the survival of traditional farming systems and environmental practices of native populations, which are considered critical to sustaining biodiversity by the UN Convention on Biological Diversity (Secretariat of the CBD, 2006, pp. 38–39).

11.5.2 Monoculture and GM Crops

Maize and other cereals, sugar beet, sugar cane, palm oil, rapeseed, soybean, and sunflower are the most widespread biofuel crops, and they are also widespread food crops, generally grown in large plantations, with intensive use of chemicals, energy, machinery, and genetic improvements. The expansion and intensification of these crop systems to supply transport fuels could have an impact on many aspects of biodiversity, including a reduction of crop rotations at the advantage of monocultures dominated by intensive biofuel crops.

In the United States, much of the growth in the corn acreage that took place in 2007 (an increase of 6.2 million hectares) was achieved by reducing the soybean plantings (diminishing by 4.5 million hectares). This has affected the traditional Corn Belt's 2-year crop rotation between corn and soybeans, and there is concern that the rotation may evolve towards a 3-year scheme, with corn for two consecutive years and soybean production in the 3rd year. In several US regions, other crops that compete with biofuel crops are expected to decline. For example, the area planted to cotton declined by 1.8 million hectares in 2007 (Westcott, 2007, p. 13–14).

Biofuels and genetically modified (GM) crops are strictly related. In 2007, the plantings of GM crops represented 64% of the world soybean area, 24% of the world corn area, and 20% of the world rapeseed area. In that order, they are the first, second, and fourth most widespread GM crops. The enlargement of the US corn-ethanol area has been associated with a considerable increase of the GM corn plantings, from about 17 million hectares in 2005 to 21 million hectares in 2006 and 29 million hectares in 2007, accounting for 77% of the total US corn plantings (data from the From GMO-Compass database). Monoculture schemes and GM crops accentuate the dependence of men's well-being on an increasingly reduced number of crops and crop cultivars. This trend is one of the risks associated with the spread of modern farming technologies and is considered a negative indicator of biological diversity (CBD Secretariat, 2006, p. 27).

11.5.3 Intensification of Farming and Impact on Soil and Water Resources

The expansion of biofuel crops is related to more intensive use of pesticides, fertilizers, and tillage. Pesticides directly contaminate terrestrial and water habitats. Many GM cultivars of maize, sugar beet, rapeseed, and soybean are resistant to specific herbicides and favour an increased use of these chemicals. Fertilizers affect the natural nutrient cycling. In particular, nitrogen and phosphorus leach into ground water, while run-off contaminates surface water, resulting in eutrophication. Tillage intensifies mineralization of organic matter, and it reduces the soil's nutrient retention capacity. This has implications for the release of greenhouse gases (GHG) from the soil (MEA, 2005, pp. 331–353) and direct impacts on biodiversity due to nitrogen deposition and deterioration of water quality in aquatic ecosystems (CBD Secretariat, 2006, pp. 31–34). The intensification in the use of soil – for example, by clearing additional land or converting pastures and grassland into cereal and oilseed corps – can make the biofuels' GHG balance negative (Fargione et al., 2008; MNP, 2008, pp. 43–49; Searchinger et al., 2008a).

The most widespread European biofuel crops, such as rapeseed and winter cereals, are generally cultivated as rain-fed crops. Corn is usually irrigated and sugar beets need irrigation in the Mediterranean area. Production of sunflowers can also be limited by water scarcity. Since corn needs irrigation in most of the EU production area (Kenny and Harrison, 1992, pp. 119–120), its expansion could represent the main factor of competition between biofuel and food crops for water resources; the water requirements of soybeans are comparable to corn, but the area under this crop in Europe is relatively small. In the Mediterranean Europe, irrigation is mainly used in fruit and vegetable production, which are more suitable than biofuel crops for most of the Mediterranean holdings. But competition cannot be excluded in the future, especially in the larger holdings, if prices of oil and biofuel feedstock increase.

11.5.4 Efficacy on GHG Reduction and Sustainability Criteria

A reduction in the emissions of greenhouse gases (GHG) is one of the main environmental aims of the biofuel policies, but the real efficacy of biofuels for this purpose must be questioned. The substitution of currently available biofuels (i.e., first-generation biofuels) reduces GHG emissions only if the feedstock is produced on lands already under cultivation. If grasslands or forests are converted to production of feedstock, the release of important amounts of carbon and nitrous oxide stored in the soil could result in a net increase of GHG emissions. And diverting land currently under food crop production would imply a shortfall that can only be addressed by clearing new land for food crops. Thus, there is always some indirect effect that leaves the final GHG balance in doubt (De Santi, 2008, p. 7).

The extent of these indirect effects on GHG emissions depends on the type of new land converted to the production of feedstock. The impact is smaller if this newly converted land was formerly agricultural and abandoned recently, and it is higher if the land has been obtained by clearing forests (Fargione et al., 2008; MNP, 2008, pp. 43–49; Searchinger et al., 2008a). For example, the annual carbon dioxide emissions caused by deforestation, fire, and drainage of peat land in South East Asia are equivalent to almost 8% of the global emissions from the use of fossil fuel. The release from peat-land drainage and degradation of forests, also due to expanding plantations of oil palm for bio-diesel, places Indonesia in third position for carbon dioxide emissions, behind the United States and China. Without computing the emissions from converted peat land, Indonesia is ranked in 21st position (Hooijer et al., 2006, p. 29).

Sustainability criteria can be applied to avoid that land with a high potential release of GHG and great biodiversity value be involved in biofuel production, but it is necessary that the criteria be adopted and the control systems be homogeneous at a global level, which is extremely difficult to achieve. The European Commission's directive proposal on the promotion of renewable energies (COM, 2008, 19 final) issued in January of 2008 set up sustainability criteria for biofuels marketed within the EU. A minimum GHG reduction of 35% is required for the life cycle of biofuels, but the computation of the GHG savings through the default values proposed by the European Commission does not guarantee that all the indirect effects of biofuel production are taken into account. Thus, the compliance with the 35% threshold is in doubt (MNP, 2008, pp. 35–41).

The directive proposal states that biofuel crops are subject to the CAP's cross-compliance requirements, and it introduces criteria aimed at preventing changes in the land use that may result in higher GHG emissions or threaten biodiversity. But, the terms used by the European Commission to define the natural grassland are open to wide interpretations, which do not assure the exclusion of land-use changes generating negative net balances, in terms of both GHG and biodiversity (MNP, 2008, pp. 43–49).

A further critical point of the proposal is that the social impact of biofuels and, in particular, the consequences for the global food supply are only subject to a generic "monitoring" by part of the European Commission, but any measure has been provided to activate a system for the prevention and the management of food crisis.

Finally, about the efficacy of biofuels, it has been remarked that the use of biomass in activities such as heating and small-scale production of electricity may prove to be a cheaper and more effective way of reducing GHG emissions (De Santi, 2008, pp. 21–22; EEA, 2008).

11.6 Conclusions

The EU biofuel policy aims to increase the consumption of biofuels by setting targets for their use in road transport, with the main objectives of reducing the GHG emissions and promoting the renewable energies. But the contribution of the European agriculture to the achievements of the targets has not been clearly defined. If the primary role of EU agriculture is the sustainable production of food, the approach should be inverted. The potential contribution of the EU agriculture to biofuel production has to be evaluated prior to establishing targets. This should be accomplished through a detailed assessment of the available resources and the possible environmental impacts on the EU MSs and globally.

Non-food crops can be an important opportunity for the European farmers. But this opportunity has to be exploited within the framework of the next CAP reform, especially for the EU regions where agro-energies may really improve marginal rural economies without harming the environment and the other farm resources. The European Commission's proposal for the CAP Health Check envisages that partially decoupled payments be maintained for specific regions to be identified on a case-by-case basis. This type of aid could be adequate for that goal. The biofuel incentives should not become a destabilising factor in food markets. The incentives should serve to reduce the impact on the environment and on EU agricultural production, while making the EU biofuel industry more adaptable to fluctuations in the prices of food and energy.

More comprehensive sustainability criteria for the European biofuel industry should be introduced, especially as regards the GHG emissions and the land-use changes. The aspects relating to food security should receive much more attention. Measures aimed at preventing food crises should be introduced.

A significant part of the biofuels used in road transport within the EU will be imported or produced from imported feedstock. About this aspect, a certification that imported biofuel and feedstock are obtained with sustainable practices will be effective only to check the incoming shipments, but it will not be enough to tackle all the implications of biofuel production at the global level, especially as regards the indirect effects referred in the previous section. For example, according to the European Commission's directive proposal, if feedstock is obtained from land already used for food crops, this would be a sustainable practice, since it does not imply the clearing of new land with additional emissions of GHG stocked into the soil and threats to biodiversity. But, in order to maintain the current level of food consumption, it will be however necessary to clear new land for the food crops that have been converted into biofuel crops. This indirect effect is not taken into account.

To address these environmental concerns, quantitative regulations are also necessary. The traders who will supply the European market of biofuels and feedstock should be selected by monitoring regularly the actual sustainability of the imported commodities. Import quotas should be established and distributed on that basis.

The real contribution of biofuels to the reduction of GHG emissions and to the development of renewable energies is under discussion. In the years to come, the technological progress could bring significant improvements from second-generation biofuels, but so far the opponents to biofuel policies have very sound arguments. A precautionary principle suggests to revise the current targets, examine the effectiveness of alternative transportation policies, and explore different ways of exploiting the agricultural biomass, which could offer surer balances in terms of energy and emissions of GHG. Finally, the EU 5.75% target should be delayed, the 2020 target should be suspended, and it should be recognised that the implementation of standards for the sustainable production of biofuels requires a worldwide coordination of the national policies, with an intergovernmental cooperation based on specific global agreements.

Note

1. The land requirements have been calculated on the basis of the MSs' average crop yields of the 2003–2006 period (European Commission – DG AGRI, 2008), and by using the following conversion rates: bio-diesel/grains = 0.35 for rapeseeds, 0.45 for sunflower, and 0.18 for soybeans; bio-ethanol/grains = 0.3 for wheat and maize, 0.2 for barley and rye; bio-ethanol/refined sugar = 0.42.

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Part IV
International Trade and Domestic Agricultural Policy

Chapter 12
WTO Compliance and Domestic Farm Policy Change

Tim Josling

Abstract The establishment of the WTO in 1995 posed a challenge for the conduct of domestic farm policies. Both the levels of support and the instruments used were constrained by the Agreement on Agriculture and other parts of the Uruguay Round Agreement. This chapter explores the experience of the period since 1995 to see to what extent the WTO commitments have shaped domestic farm policies, particularly in the United States and the European Union. This influence can come about either through the negotiated constraints on policy outcomes or through the litigation of complaints by other countries. Notifications of domestic support levels show little direct impact on US farm policy but the outcome of litigation has had some influence on policy choices. In the European Union, the reform of the CAP has been much more influenced by WTO subsidy constraints but somewhat less by litigation.

12.1 Introduction

One major objective of the WTO Agreement on Agriculture was to influence domestic agricultural policies, particularly in the developed countries. The idea was to promote less trade-distorting means of support so as to work toward a more open trade system for agricultural products. The United States was a strong supporter of this aim, and maintained the pressure during the Uruguay Round to bring domestic support under the disciplines of trade rules. The disciplines that were developed influenced both instrument choice and the levels of support. Though domestic politicians have had a natural tendency to downplay the significance of these constraints, there is abundant evidence of the growing influence of WTO rules on farm policies. Completion of the Doha Round would make the link between trade rules and domestic policy even more apparent. In the absence of a Doha Round agreement

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one might expect to see the more vigorous enforcement of existing restraints on domestic policies through the litigation process of the WTO.

Twenty-four years after the Punta del Este Declaration that launched to Uruguay Round, and which for the first time incorporated the mandate to include domestic policy in the negotiations, it is appropriate to pull together the evidence to see what impact the Agreement on Agriculture (URAA) and other aspects of the Uruguay Round agreement has had on farm policy. For convenience, the focus is on the United States and the European Union as the two trading partners that have the most extensive domestic farm support systems and the strongest interest (both offensive and defensive) in the disciplines of the WTO in this area. But the picture is not complete without some mention of other countries, such as Australia, Canada, and Brazil, that have been major players in the game.

The chapter starts with a brief review of what restraints the URAA was designed to impose on developed country farm policies and continues with a discussion of the significance of these restraints over the period since 1995. The importance of these constraints was enhanced by the expanded use of litigation by other countries in order to challenge perceived violations. Section 12.2 discusses the cases that have had a noticeable impact on the development of domestic policy. Section 12.3 poses the question of what further impact the WTO rules would have if the currently proposed provisions of the Doha Round were to be adopted. By implication, the failure to adopt these provisions would reopen the question of whether existing rules are being applied correctly. A final paragraph attempts to summarize the arguments and conclusions of the chapter.

12.2 The URAA

The Uruguay Round of trade negotiations under the General Agreement on Tariffs and Trade (GATT) marked a transition of the multilateral trade system from a limited intergovernmental agreement on rules of conduct for trade in goods to a more comprehensive treaty covering trade in services and trade-related aspects of intellectual property protection as well as goods trade. It set up a secretariat to assist members in their application of the rules and established a dispute settlement system that could ensure that the broader rules were respected and interpreted in an agreed manner. All members undertook the full set of obligations (the "single undertaking") though the rules themselves allow for limited differentiation by development status ("special and differential treatment" for developing countries).

One key part of the Uruguay Round was the Agreement on Agriculture. The Uruguay Round Agreement on Agriculture (URAA) was a new departure in the treatment of agricultural goods in the multilateral trade system.[1] It devised agriculture-specific rules that obliged the conversion of non-tariff border measures to tariffs as well as placing restrictions on border policies including, for the first time, restraints on export subsidies. And, in particular, it addressed the question of the impact of domestic farm policies on trade flows. The URAA imposed restraints on the level of support provided by domestic programs and introduced incentives to shift to less trade-distorting measures. Moreover, it introduced institutional monitoring of compliance with the rules and schedules, temporarily sheltered some types of agricultural subsidy from challenge under a new subsidy agreement, and committed member governments to further talks on agricultural policy reform.

Though the URAA specifically relates to agricultural programs and trade policies, other aspects of the WTO are of actual or potential importance. One of the most significant aspects is the Agreement on Subsidies and Countervailing Measures (SCM), which governs all subsidies. The clause in the URAA that sheltered agricultural subsidies from challenge under the SCM expired in 2003, and since that time the provisions have applied to a range of agricultural programs. Another aspect is the Sanitary and Phytosanitary (SPS) Agreement, which obliges WTO members to base health and safety standards on scientific risk assessment. For certain sectors of agriculture, particularly livestock and fruits and vegetables, rules that ensure science-based import regulations in other countries are of considerable importance (Josling et al., 2004). These agreements came into effect in 1995 as a part of the Marrakesh Agreement that established the World Trade Organization. As a part of the set of WTO agreements, they are subject to litigation under the Dispute Settlement Understanding that also emerged from the Uruguay Round.[2]

The central elements of the URAA are often referred to as the three "pillars": market access, domestic support, and export competition. In all three areas, new rules were added and reductions in trade distortions were agreed. Together they form a comprehensive framework for the regulation of measures that restrict trade in agricultural products. US and EU farm policy must comply with these rules if they are not to risk challenge by other countries. On the other hand, competing agricultural exporters and those countries that are markets for US and EU farm goods also have to adhere to the rules. The full impact of the URAA includes the benefits that the developed countries might get from the restraint on other country's policies as well as the restraints that are accepted for themselves.

Market access rules include the conversion of all non-tariff import barriers (quotas and restrictive licenses) to tariffs. Moreover, it was agreed that tariff levels were to be bound and that tariff-rate quotas (TRQs – quantities that can be imported at a zero or low tariff) were to be established to maintain market access as "tariffication" took place. These TRQs were to represent "current access" in cases of existing trade or a "minimum access" of 3% of domestic consumption (rising to 5% over the implementation period) in cases where there were no imports in the base period. Tariffs were to be reduced from the base period (1986–1990) by an (unweighted) average of 36%, with a minimum cut of 15% for each tariff line, over a 6-year period (1995–2000).[3] In addition, the agreement established a special safeguard regime (SSG) that countries could use to counter import surges or price drops in markets where they had newly established tariffs.

Domestic support was defined to include payments to farmers in addition to the transfers from consumers through border policies. These included deficiency payments, direct payments, administrative price systems, public research and extension programs subsidies based on compliance with environmental regulations, and other programs that benefited farmers directly.[4] These elements of domestic support were put into three categories, which have become known as the Amber Box (those tied to output or input prices or to current output levels), the Blue Box (those that were tied to supply control programs), and the Green Box (those unrelated to price and output). The Amber Box payments were subject to a reduction of 20% over the transition period as indicated in individual country schedules: neither the Blue Box nor the Green Box payments were subject to reduction.

The rules regarding export competition included a prohibition on new export subsidies and a reduction of existing subsidies by both volume and expenditure. A list of export subsidy practices that are covered is given in Article 9.1. Following the agreed modalities, country schedules were drawn up that provided for reductions relative to the base period of 36% by expenditure and 21% by quantity subsidized. In addition, rules were made more explicit with regard to food aid and countries agreed to negotiate limits on export credit guarantees (government underwriting of sales to purchasers that might lack creditworthiness).

Though the new rules offer the possibility of more open markets, market access for agricultural products did not greatly improve as a result of the tariff reduction schedules. Many of the tariff cuts merely reduced the "water" in the tariff schedules (the superfluous protection given by a tariff that is higher than that which would close off any imports). Ceiling bindings were often set at high levels even though applied tariffs were much lower. The introduction of TRQs, though arguably an improvement on the quantitative restrictions that they replaced, still restricted trade in the more sensitive products. So the task of reducing tariffs to a level more in keeping with non-farm tariffs was left to subsequent rounds of negotiations. The Doha Round shows how difficult it is to take this next step.

12.3 The Impact of the URAA on Policy

The impact of the introduction of the URAA on farm policies has been profound but subtle. Few farm support policies that existed in 1995 had to be abandoned. But the development of policies since that time has been within the framework of the URAA. The URAA was designed to be permissive of the major types of policy in use, but to set up incentives for changes over time. The changes have generally been along the lines that have been favored by "reformers" in domestic policy discussions, but that does not mean that they have been ineffective. The process of domestic and trade policy reform have gone hand in hand. Domestic policy change has allowed the introduction of more discipline in international trade: the trade rules have steered countries in general along the path chosen for domestic policies. The common theme is the use of tariffs as the sole means of border protection and of direct supports as the approved vehicle for farm income supplements. The removal of non-tariff trade barriers changes the nature of domestic policy as it makes supply control difficult to administer at the market level (though resource retirement at the producer level is still possible). Direct payments break in large part the link between farm support and output decisions, and enables a link to be made to the provision of public goods by the farm sector.

How has this played out in practice? The most significant changes that have come along with the implementation of the Uruguay Round in the United States have been in market access. The United States finally abandoned the use of quotas as required by Section 22 of the Agricultural Adjustment Act (as amended) as a result of tariffication of all non-tariff import measures. This also meant that the 1955 waiver that had been renewed annually since that date was no longer needed. The action may not have caused much comment at home, but the implications were not lost on trade partners. The US trade policy for agricultural products was no longer in (waivered) violation of the GATT rules. Also significant was the abolition of "voluntary" export restrictions (VERs) that exporters chose to impose under the implicit threat that there would be mandatory import restrictions if they did not do so. This policy had been used extensively to protect the meat market in the United States from imports of beef and sheep meat from Australia and New Zealand at times when US prices were low. The legal status of VERs in the GATT had never been established, but they were seen as an intrusion into the desirable working of the market.[5] The European Union also saw a major change in its domestic agricultural policy, the CAP, as a result of the application to agricultural goods of the "tariffs only" principle. The "variable levies" that had been used since the inception of the CAP to keep domestic prices stable when world prices fluctuated were always challenged by exporters as not being consistent with the GATT. But, like VERs, they were considered "gray area" measures that fell into no category defined in the GATT. Variable levies were not straightforward tariffs that could be put in a schedule, but they were not quotas as the quantities imported were not constrained. The URAA specifically banned their use, along with other dubious import restrictions. The European Union complied and changed its variable levies into tariffs (tariffication) and bound the resulting tariffs.

A more subtle change came about as a result of the introduction of TRQs in cases where non-tariff import measures were converted into tariffs. Caution by the exporters that the new bound tariffs may still be too high for some significant market access opportunities to open up led to the introduction of TRQs: the importers then used these to favor countries to which they had offered preferential access. So the TRQ emerged as a way of squaring the need to offer some market access to partners in regional and bilateral trade agreement with the imposition of the URAA.

Even the binding of tariffs has implications for domestic policy. The fact that it is difficult to renegotiate a bound tariff, in that one has to satisfy principal suppliers, means that it is not an appropriate tool for managing domestic markets. So in effect the tariff is locked up in a schedule in the WTO and cannot be used by agricultural ministers or congressional committees as they make regular policy decisions.

The limits on export subsidies and the prohibition on new such subsidies have also had a restricting impact on farm policy in the United States and the European Union. In the United States, the use of (overt) export subsidies has virtually been abandoned in the period since 1995: some small programs remain for dairy products. This could of course have happened even without the URAA, but the trade rules reinforce and lock in these changes even if made for domestic reasons. The European Union still uses export subsidies, but has moderated its reliance on such subsidies for clearing domestic markets. Export subsidies are expensive and tend to benefit foreign consumers and to penalize domestic consumers. It may be that no new subsidies would have been introduced in the past 15 years, but it has been important to competing exporters to know that such subsidies would not have been allowed by the URAA.

The new rules for food aid that were incorporated in the URAA had as their intent the avoidance of commercial displacement by concessional sales. Food aid quantities have trended downward in the past decade, and so it is difficult to see the impact of the URAA. And the talks that were suggested in the URAA to negotiate limits on export credits were not successful No advance was made on the contentious issue of the activities of single-desk export agencies, once used extensively by Canada, Australia, New Zealand and a few other exporters to organize and expand export markets: these state trading activities have been somewhat curtailed in the past decade, but not as a result of the introduction of the URAA.

The most difficult question to answer is whether the URAA has made any significant impacts on domestic policies. The discussion between the United States and the European Union at Blair House in November 1992 was a key turning point in the Uruguay Round negotiations. The outcome was to frame the constraints on domestic policy that were to be included in the URAA in such a way that current legislation would not be in gross violation of the agreement and that the option of forcing change through litigation was circumscribed. Thus the Blue Box was introduced to relieve the US direct payments for program crops under the 1990 Farm Bill from reduction (though increases over and above the 1992 level were prohibited), and to ensure that the EU compensatory payments for grains and oilseeds that were introduced in the 1992 reform of the CAP were not going to be challenged by other countries. To ensure the lack of legal challenges, a Peace Clause was agreed for the URAA (Article 13) that sheltered many, but not all, domestic policies from the Subsidies and Countervailing Measures (SCM) Agreement (Steinberg and Josling, 2003).

The first year of US notifications covered the last year of the 1990 Farm Act. The United States still had deficiency payments with acreage idling provisions and this is reflected in the Blue Box component of the notification. Crop prices were relatively high and so the notified total AMS and *de minimis* were both small. With the passage of the 1996 Farm Act, direct income support payments were introduced to replace the deficiency payments: the direct payments were notified in the Green Box. AMS support remained low until crop prices started to deteriorate in 1998 (Fig. 12.1). From that time until the passage of the 2002 Act, production-linked "emergency" payments were authorized that increased AMS support and its share of total support. During the life of the 2002 Act AMS support has generally remained high and variable. More recently, strengthening commodity prices have led to a significant estimated reduction in the total AMS (in 2006, for example) – a condition that has continued into 2008.[6] Weaker prices would increase the expenditure on trade-distorting policies. As discussed below, this could pose some significant

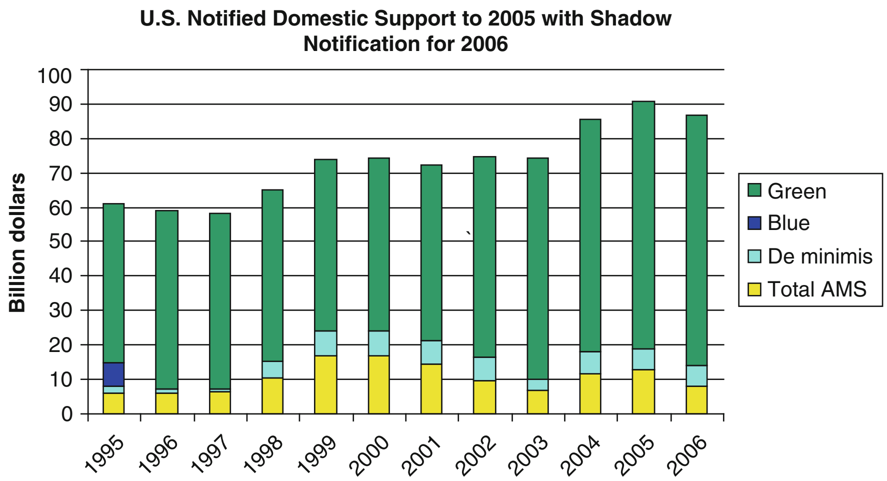

Fig. 12.1 US notifications of domestic support, 1995–2005, with shadow notification for 2006. *Source*: Blandford and Josling, 2008

challenges for the United States in meeting future commitments under a DDA Agreement.

The Uruguay Round Agreement included bindings on the level of the most trade-distorting domestic support, as included in the Total AMS. The Current Total AMS was not to exceed the Final Bound AMS level after the transition period. Figure 12.2 shows the Current Total AMS and the Final Bound AMS for the United States. Support was comfortably within the bindings, although the pronounced variability of notified support by the United States is apparent. As discussed in Blandford and josling (2008) support would probably have exceeded the binding if direct payments

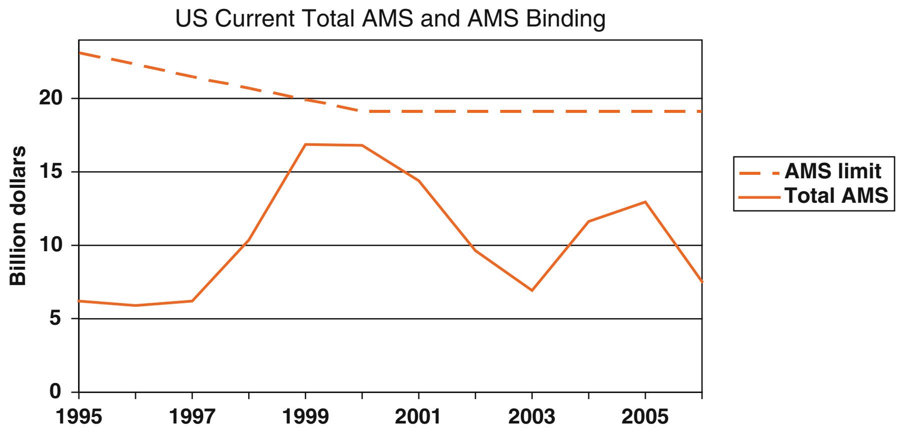

Fig. 12.2 Current total AMS in the United States relative to WTO AMS binding. *Source*: Blandford and Josling, 2008

(notified as Green Box) and counter-cyclical payments (notified as non-product-specific AMS) had been included in the PS AMS. The possibility that this may be required in the future has been raised in an ongoing WTO dispute-settlement case brought by Brazil and others (see below).

The first notification of domestic support by the European Union, in 1995–1996, coincided with the final years of the implementation of the MacSharry reforms.[7] Direct payments (the area payments on cereals and oilseeds, and the headage payments on beef and sheep) were placed in the Blue Box, as they were associated with limits on production. As a result, the original notifications, from the 1995–1996 marketing year, included a large AMS component (48 billion euro) and smaller but sizable Blue Box element (21 billion euro), and a relatively modest amount of Green Box payments (19 billion euro).[8]

The European Union further notified its level of domestic support in December 2006. The period covered support up to the 2003–2004 marketing year. The nature of the CAP reforms since 1995 is reflected in the notifications of domestic support to the WTO. The changes in policy show up as a major shift in the pattern of the notification among the different categories of domestic support. Support prices have been reduced for most of the major products, to close somewhat the gap between EU prices and those in world markets. Export subsidies have also been reduced, in part, as a result of the WTO constraints.

The "new" CAP, starting with the MacSharry reforms, places heavy reliance on direct payments to farmers based on past production patterns and broadly unrelated to current prices and output decisions. Thus the nine notifications from 1995–1996 to 2003–2004 show a marked reduction in price supports compensated by an increase in direct payments. Current Total AMS payments fell from around 50 billion euro in 1995–1996 to 30 billion euro in 2003–2004 – a 40% decline. Blue Box payments rose over the period, from 20 to 25 billion euro, and Green Box payments from 18 to 22 billion euro.[9]

The mix of policies in the European Union changed relatively little from 1995 to 2000, as the reforms in the cereal and oilseed sectors were being assimilated. But budget pressures and the prospect of ten new members from eastern and central Europe led the European Union to consider further reforms. These were incorporated in a decision known as the Agenda 2000 reforms that were agreed in 1999. These reforms had a noticeable impact on the EU domestic support notifications, maintaining the direction of the 1992 reforms but pushing somewhat further. Intervention prices were reduced by 29% for cereals (including a more substantial cut for rice) and, from 2005, they were to be reduced by 15% for butter and skimmed milk powder, reducing the gap between these "administered" prices and the fixed reference prices.[10] The AMS fell from 48 billion euro in 1999–2000 to 29 billion euro in 2002–2003. Changes in the beef regime also modified the notifications somewhat: to the existing subsidies for suckler cows and the special beef premium was added a slaughter premium and some supplementary payments, notified as Blue Box payments as they were limited to base levels of livestock numbers. Blue Box payments increased by 5 billion euros over this period.

Even more significant in their impact on the European Union's domestic support notification have been the reforms enacted since that time, notably the 2003 Fischler Reforms, the changes in the regime for the Mediterranean crops in 2004, the reform of the sugar policy in 2005, and the reform of the fresh and processed fruit and vegetable policies in 2007. The introduction of a Single Farm Payment, the key ingredient of the 2003 Reform, further separates payments from current production. An estimate of the notifications for the years 2004–2005 and 2006–2007 are included in Fig. 12.3.[11] The 2004–2005 notification of domestic support will include some of these decoupled payments under the Fischler reforms, those that were made in 2004, but the main impact will be on the notifications from 2005–2006 and 2006–2007, by which time many of the policy changes will have been implemented.

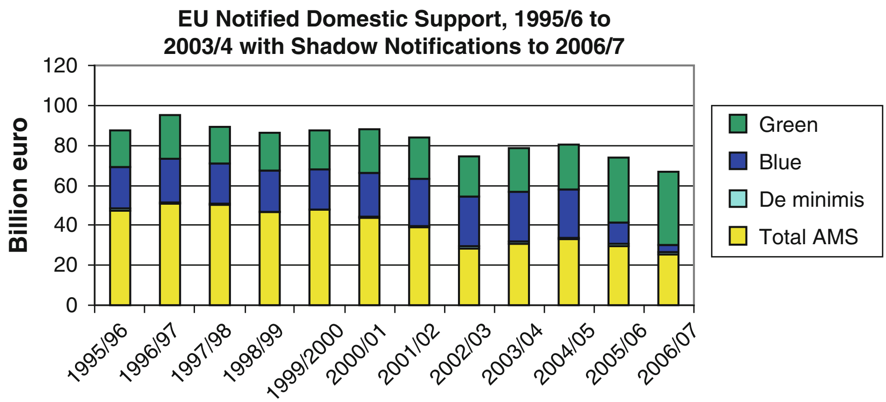

Fig. 12.3 EU notifications of domestic support, 1995–1996 to 2003–2004 with estimates to 2006–2007. *Source*: Blandford and Josling, 2008

The result of these reforms is that a significant shift from Blue Box to Green Box is likely to occur in the next few notifications, as the Blue Box could be reduced to about 4 billion euro in 2006–2007 from about 25 billion euro in the most recent notification, and the Green Box could expand from 22 billion euro to 38 billion over the same period. A significant further reduction could occur in the AMS, from 31 billion to 21 billion euros between 2003 and 2006, reflecting the changes in policy, as many payments that were previously linked to production are shifted to the Green Box. By 2006–2007 the transformation of the CAP into a predominantly Green Box policy will be well underway, with a further increase in decoupled direct payments and a reduction of those in the Blue Box and the Product-Specific AMS (Blandford and Josling, 2008; Josling and Swinbank, 2008).

Under the URAA limits on trade-distorting measures the Current Total AMS as calculated by the European Union (and agreed by other countries) was to be reduced by the year 2000 to 67.2 billion euro.[12] These commitments continue until a revised set of limits is agreed, as would be the case if the Doha Round arrived at a conclusion. The European Union is well within the limits set by the Agreement on

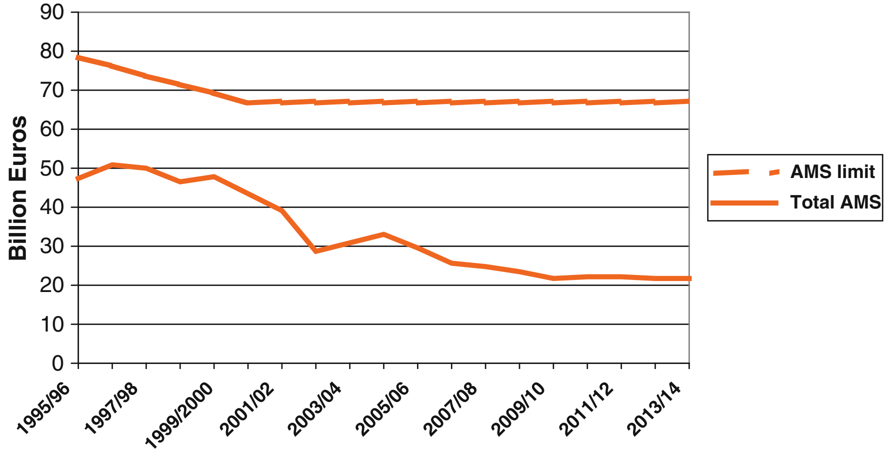

Fig. 12.4 Current total AMS in the European Union relative to WTO AMS binding. *Source*: Blandford and Josling, 2008

Agriculture, in part because of the high AMS recorded in the base period and in part as a result of the steady progress of reform, moving away from price support toward direct payments. Figure 12.4 shows the Current Total AMS in relation to the negotiated AMS limit. In the latest official notification, the AMS stood at 30.9 billion euro, and the estimated notification for the year 2006–2007 shows the level at 21.2 billion euro. Projected notifications for the years beyond 2006–2007 indicate that one can expect the level of AMS payments to drop to about 20 billion euro with the full impact of the CAP reform, and to be stable after 2009 (Josling and Swinbank, 2008). This situation gives the European Union considerable scope for agreeing to reductions in the ceiling for the AMS as a part of a Doha Round agreement.

12.4 WTO Litigation and Agricultural Policies

The Peace Clause did not, of course, stifle all disputes in the area of agriculture. There have been about 100 disputes over agricultural trade notified to the DSB over the lifetime of the WTO.[13] On average there have been about eight disputes every year that can be classified as agricultural.[14] In the first couple of years of the WTO fifteen agricultural disputes were notified to the DSB. Four of these agricultural disputes focused on issues of implementation by the European Union of the Uruguay Round commitments. Over this period, the United States initiated three disputes with Korea about the treatment of imported agricultural products, reflecting a long-running concern by US exporters. And two of the most prominent of the agricultural disputes were litigated in 1996, both with their origin in the GATT and each involving the United States and the European Union (as was typical of many of the trade disputes at that time). These "legacy" disputes were over the European Union's

(1992) import regime for bananas and the (1988) EU regulations over the use of hormones in beef.[15] At least in the United States, the justification for the strengthening of the GATT dispute settlement process through the DSU was, in part, based on the prospect of finally resolving these conflicts.

As these disputes were being adjudicated, a burst of new litigation occurred in 1997, with 13 disputes that year, perhaps reflecting the lag from commercial concern to formal request for consultations. Most of the 1997 cases were concerned with the operation of tariff rate quotas (TRQs) and other import regulations, representing the tensions that accompanied the process of "tariffication" and the removal of non-tariff import barriers. Typical of the disputes at this time were the challenges to the operation of TRQs by the European Union by Brazil on poultry and by New Zealand on butter, and to the operation of TRQs by the Philippines on pork and by the United States on poultry. One exception was the challenge by the United States and New Zealand to the Canadian dairy policy (discussed in more detail below).

Disputes in 1998 also focused on market access issues, and the number of cases fell to more "normal" levels. Among these complaints was a challenge by Canada to transport restrictions on cattle, hogs, and grain by the United States that also reflected an attempt to settle an older dispute using the new-found legal structure of the WTO. A renewed burst of activity in 1999 was followed by a less contentious year in 2000, with the focus again on import regulations in both years.[16] The year 2001 saw a number of safeguard complaints, in part due to the weakening of world prices at the turn of the century.

A significant shift in the type of agricultural disputes is noticeable in 2002, with the challenge by Australia, Brazil, and (later) Thailand to the EU sugar regime. The conflict was over the extent to which that regime in effect provided export subsidies about the scheduled limits. This was followed by a challenge from Brazil to the US policy toward upland cotton, on this occasion questioning the subsidies given to US producers. Thus the emphasis had shifted from disputes over import regulations and contingent protection to the farm policies that were becoming exposed to legal scrutiny. Litigation began to be discussed as a complement to the slow-moving Doha Round in the effort to curb subsidies notably in the United States and the European Union. The cat was out of the bag.

The year 2003 saw another ten disputes on agricultural issues reported to the DSB. Two cases reflected the changed nature of food trade: the resurrection of an earlier challenge by the United States to the European Union's system of protecting geographical indications (GIs), and a challenge by three countries to the slow process of authorizing the release of biotech products on the EU market.[17] At the end of 2003 the Peace Clause expired, widening the net of subsidies that could be appealed under the SCM.[18] There was no immediate rush to litigation, though a number of countries actively explored the possibility for successful challenges. The panel report on the US-cotton dispute emerged in September 2004 and that on EU-sugar was circulated in October 2004. The reports and their broad confirmation by the Appellate Body gave renewed hope to those who saw the DSU as an effective way of forcing policy change in the European Union and the United States. But in fact the number of new cases initiated since 2004 has been markedly less than before, perhaps reflecting the influence of continued negotiations in the Doha Round. Nevertheless the most significant cases in the past 3 years have been those that have challenged US domestic support notification, again reflecting the emphasis since 2002 on using current agreements to rein in farm support policies.

To see the impact of these opinions it is necessary to consider the details of several of the most important cases. Four such cases are discussed here, including the banana case, with a rich history of market discrimination by the European Union in favor of its own former dependencies and colonies; the landmark Canada-dairy case that addressed the question of whether export subsidies could result from domestic price setting; the US-cotton case that explored the application of the SCM Agreement to agricultural subsidies; and the EU-sugar case that extended the Canadian dairy ruling.

12.4.1 The EU Banana Case

The common agricultural policy of the European Union contains a common market organization for bananas. Indeed this commodity achieved some notoriety in the early discussions of the European Economic Community. The French overseas departments were major producers, as were the Cameroons and other African colonies. Germany, with no colonies left opted for "dollar" bananas from Central and South America. Trade in bananas has elicited a series of disputes over the years, pitting the post-colonial regimes of the EU countries against the US-based multinational companies that had a foothold in those parts of Europe that did not have tropical colonies.

The banana controversy in the GATT was stimulated initially by the changes in the European import rules implied in the European Union's policy of "Completing the Single Market" which were introduced at the start of 1993. Moving from the varied import systems run by individual countries to an EU-wide policy that could be operated without internal trade barriers proved to be a challenge. "Dollar" bananas appeared to lose some of their market access to those coming from the former colonies of France and the United Kingdom. Some countries in Latin America settled on a market sharing deal with the European Union but others complained to no avail. The Uruguay Round, with its strengthening of the dispute settlement process, came along at an opportune time for the disaffected group. Two panel reports under the GATT, in 1993 and 1994, had failed to improve the market position for "dollar" bananas.[19] The third panel, reporting on May 22, 1997, proved to be more effective. "Bananas III", as the report became known, found the European Union in multiple violation of trade rules. The various steps taken to resolve this conflict continued for a decade.[20]

The United States had originally intended to stay on the sidelines: it would not have been consistent with the attempt to build up relations with the Caribbean to be seen to challenge the European Union's preferences in that region. But 1996 was an election year. Having sold the WTO to the US Congress partly on the basis of the strengthened DSU, it was vulnerable to the argument that holding the European Union to the trade rules was an important aspect of US trade policy. Direct pressure from the US-based multinational corporations, in particular the Chiquita corporation, swung the Clinton administration behind the complaint. At a stroke this raised the stakes and turned a thorny issue of preference systems into a matter of high principle and policy.[21] Along with the beef-hormone dispute the banana case focused attention on the willingness of the European Union to subjugate its policy preferences to the judgment of a WTO panel. If it proved unwilling, this would not be lost on those whose support for the extension of multilateral trade rules was tenuous at best.

The substantive issues covered by the GATT that were considered by the panel were of three types: tariff questions, quota allocation questions, and the legality of the import licensing regime. Several of these issues had also to be considered in the light of agreements that came out of the Uruguay Round, including the Licensing Agreement as well as the Agreement on Agriculture and the Trade-Related Investment Measures (TRIMS) Agreement. In addition, the panel considered the compatibility of the licensing regime with the European Union's obligations under the GATS.

The tariff issue was perhaps the easiest of the three. The complainants charged that the differential tariff rates that applied between third country bananas and non-traditional ACP imports was a violation of MFN: no objection was lodged against the duty-free imports from the ACP where these were necessary to conform to the requirements of the Lomé Convention. The WTO had been granted the European Union a waiver from its Article I obligations in December 1994 (extended in October 1996): the European Union argued that this was adequate to cover the whole import regime, and not just the traditional ACP imports. The panel decided that as the waiver was not specifically limited to the traditional trade quantities, it must be assumed that "the preferential tariff for the non-traditional ACP bananas is clearly a tariff preference of the sort that the Lomé waiver was designed to cover." (WTO, 1997, p. 333) As a consequence the European Union "won" the tariff argument and defined in part the relationship between the Lomé Convention and the WTO.

The European Union was less fortunate in the case of quota allocation. The argument over the allocation of quotas went to the heart of the complaints over the EU banana regime. At its simplest, the argument revolved around whether the quotas under which banana imports are allowed were allocated in a way consistent with Article XIII of the GATT, which stipulates that they should be allocated in a non-discriminatory way and one that disturbs trade as little as possible. The complaining parties charged that the European Union had allocated the banana import quotas in a way that was inconsistent with this Article. Some countries (the ACP and those that had signed the BFA) had country-specific quotas, while other countries had no such quotas but had to compete for the "other" category of imports. Moreover they argued that the quotas given to those countries were too large and did not reflect market developments. The allocation method also gave the BFA countries exclusive right to fill any shortfall in supplies under the BFA quotas.

If the quota allocation system ran afoul of Article XIII, the licensing system that gave expression to the quotas came in for the most severe condemnation by the panel. This system was judged with respect to its transparency and its tendency to discriminate. The system itself was complex, which in itself made for a lack of transparency. But the complaining parties charged that the intention of the license system was to favor firms that had historically imported bananas from the Windward Isles and French overseas territories. This discrimination was contrary to Articles I (non-discrimination) and III (national treatment) of the GATT. It was also claimed that the CMOB violated Article X of the GATT that requires that countries administer trade measures, including licenses, "in a uniform, impartial and reasonable manner". Moreover, it was argued that the European Union's licensing system contravened the Agreement on Import Licensing Procedures (Licensing Agreement) that had been incorporated into the basic rules of the WTO at the conclusion of the Uruguay Round.[22] In addition it was charged that the arrangement violated the TRIMS agreement, which contains a list of trade-related investment measures such as purchasing requirements that are deemed to be inconsistent with national treatment in the GATT. The requirement that firms have to purchase bananas from the ACP in order to apply for "B" Licenses was therefore a violation of this provision.

In the case of bananas the European Union changed somewhat drastically a commodity market regime in the CAP on the basis of a WTO ruling. Though perhaps not as visible as the cereal and livestock regimes to other temperate zone producers, the banana regime was very sensitive within the European Union. In fact, one could say that the exporters of dollar bananas bet that the German view of the single market regime for bananas would prevail over that favored by the French and the British. When they were proved wrong, they successfully mounted a legal challenge through the US administration. This seems a very clear-cut example of the way in which domestic policy can be influenced by trade rules.

12.4.2 The Canadian Dairy Case

If the banana case was about market access into the European Union, the first major case on export subsidies involved Canadian dairy policy – a somewhat improbable situation given that country's high-cost dairy sector. In the aftermath of the Uruguay Round, the Government of Canada instituted a new policy designed to assist exporters of dairy products (mainly cheese) made with expensive domestic milk. A separate "export" class of milk was defined which could be sold at a price lower than that for domestic use. The architects of the policy no doubt assumed that, as no government funds were involved, such a scheme would not be seen by trading partners as an export subsidy.

New Zealand, supported by the United States, took issue with the policy and, after the requisite consultations, it became the subject of a WTO dispute.[23] The panel ruled that the program did indeed constitute a subsidy to exports as it resulted from government action even though no funds were involved. The Canadian policy was changed to reduce the role of the government, leaving it up to the private sector to negotiate sales of the milk for processing and sale to export destinations.[24] New Zealand and the United States were not convinced that this had solved the problem. The panel was asked to rule on the new policy, and again found it to be in violation of Canada's export subsidy commitments on the grounds that the price of domestic milk was controlled by the government and that this in itself could be enough to subsidize exports (WTO, 1999).[25] Importantly, the Appellate Body in ruling on the second case directed the panel to use the test of whether the cost of the milk to the export processors was less than the cost of production incurred by the farmers. The panel reconvened and decided that as most farmers produced for both the domestic and the foreign market they in effect sold the milk surplus to their domestic allotment at a "subsidized" price (WTO, 2001).

The case was settled when the Canadian provinces abolished their CEM programs. This was a further case of a policy that was popular at home – as the cheese sector in Ontario and Quebec had taken full advantage of the export opportunity – but terminated as a result of an unfavorable WTO ruling. New Zealand and the United States withdrew their request for sanctions, and argued that the outcome vindicated the working of the dispute settlement machinery. But the significance of the outcome of the challenge by New Zealand and the United States to the Canadian dairy policy was soon obvious to export interests in other countries. If selling farm products for exporting (or processing for export) at a price less than the cost of production was indeed regarded as an export subsidy then any situation where high, administered domestic prices coexisted with exports might be shown to be contrary to the WTO – or at least would need to be counted against the export subsidy commitments. Sugar policies in the European Union were an obvious target but other cases could subsequently emerge.

In the present context this outcome has another implication. The WTO rules and commitments are based on the notional separation of domestic support from market access and export competition. These aspects are clearly linked economically and politically, but it was assumed that they were at least possible to separate in administrative terms. But if an administered price can grant a subsidy on exports, the link between domestic support and export competition is exposed. In other words, the legal avenue has made obvious what the pillars of the URAA had attempted to conceal: that the root cause of trade problems is high domestic prices set by farm policy and supported by high tariffs. The levels of support have not been effectively reduced by the constraints imposed on export subsidies or on domestic subsidies.

12.4.3 The US Cotton Case

The case against US Cotton subsidies appears also to question the distinction between different types of subsidies. The issue on this occasion was the inclusion of upland cotton as a commodity eligible for the full range of domestic policies covering grains and oilseeds. The rulings of the panel are best summarized by considering the nine elements of the US programs that were the subject of the challenge by Brazil.[26] Five of these elements (direct payments, production flexibility contract payments, market loss assistance payments, counter-cyclical payments, and marketing loan payments) relate to the major instruments of farm policy adopted for the "program crops" in the Farm Bills that cover the period 1999–2003.[27] Two more are specific to cotton (Step 2 subsidies and cottonseed payments), and the other two are of more general application (crop insurance and export credit guarantees). The panel ruled basically on two issues: whether these subsidies were allowed or prohibited and whether they caused "serious prejudice" (even if allowed) to Brazil (WTO, 2004b; WTO, 2005b).

The two subsidies that were not price related (and which had therefore been notified by the United States as being in the Green Box) were found not to be the cause of "price suppression" in world markets. They were, however, found to contain provisions that made them ineligible for the Green Box: specifically the restrictions on the alternative crops that farmers could grow on cotton land. These, the panel decided, could keep more acres in that crop than would totally "decoupled" payments have done. The three subsidies that were price-related were found to have caused price suppression through their impact on keeping cotton production high in the United States at a time of low world prices.[28]

The panel ruled that the Step 2 subsidies paid to domestic users were prohibited under the Subsidies and Countervailing Measures Agreement (SCM) and the Step 2 subsidies available to export users were prohibited because they were not included in the US schedule of subsidies. Moreover, the Step 2 subsidies also caused significant price suppression in world markets. Cottonseed subsidies and crop insurance payments were deemed not to have caused price suppression, and were not prohibited subsidies.

The final aspect of the US programs on which the panel ruled was the set of export credit guarantees that are available to US firms when they sell into overseas markets where credit risks are a factor. The finding in this case was that the export credit guarantees given to cotton producers constituted an export subsidy, and since no such subsidy had been included in the US schedule it was in effect prohibited.[29]

The panel ruling required the United States to end the prohibited subsidies within six months of the adoption of the report or by July 1, 2005, at the latest. This ruling applied to the Step 2 payments, to both domestic and export users, and to the export credit guarantees for cotton. The United States decided that it could make these changes in legislation without having to await the next Farm Bill expected in 2007. The Administration urged Congress to scrap the Step 2 payments, and these ceased at the end of the crop year, in August 2006. The USDA has also proposed changes to the export credit arrangements by eliminating the 1% cap on the fees that are charged for borrowing through the GSM-102 program, and by terminating the GSM-103 program that provides for longer repayment periods.

More problematic for the United States is how to adjust the programs that the panel found to cause significant price suppression. Withdrawing the marketing loan and counter-cyclical payments would require major changes in the US legislation and could not easily be done outside the context of the next Farm Bill. Taking other steps to remove the adverse impacts on Brazil might seem easier to achieve, but any attempt to restrict US cotton exports could prove difficult. Compensation to Brazil for lost exports would also seem politically implausible, and a deal to boost Brazilian exports of other commodities would be similarly unpopular. So the prospect is for no change in these aspects of US policy at least until the 2012 Farm Bill, at which time the policies may in any case need to be modified as a result of the Doha Round.

An interesting side issue raised by the panel report is the conclusion that the direct payments and production flexibility contract payments are not eligible for the Green Box. This would seem to indicate that countries might eventually ask the United States to resubmit notifications of domestic support for the years in question. This would almost certainly put the United States in excess of its amber box limits, and raise serious problems with trading partners. This issue has been taken up in the TAMS (Total AMS) case (see below) brought by Canada and Brazil.

12.4.4 The EU Sugar Case

The impact of the Canadian dairy case on the approach taken by exporters toward farm policies in other countries can be seen in the challenge brought by Brazil, Australia, and Thailand against the EU sugar subsidies.[30] Complaints about EU sugar policy are not new. Australia had challenged the EU sugar regime in 1979 in the GATT and Brazil followed in 1980, but these were complicated by the fact that there was an international sugar agreement (ISA) (to which the European Union was not a signatory) that restricted exports. Under such circumstances the panels were unable to determine the extent of injury that the plaintiffs had suffered and the policies continued unchecked (Tangermann and Josling, 2003). The United States also challenged the CAP sugar policy in the GATT in 1982, but no panel was established. The European Union indicated its willingness to join the ISA, and proceeded in turn to challenge the US sugar regime.

One of the contentions of these sugar exporters in the recent WTO case was that the EU grants *de facto* export subsidies by means of the high price paid for sugar used on the domestic market. The domestic market price is maintained for sugar produced under two quotas (the “A” and “B” quotas): production over those quotas (usually called “C” sugar) cannot be sold on the domestic market and receives no direct subsidy. At issue is whether the “C” sugar benefits indirectly as farmers can cover their fixed costs from returns from the high-price quotas. The analogy with the exported milk products from Canada is close, if not exact. The complainants maintain that if such subsidies were included, the European Union would be in breach of its export subsidy commitments under the URAA.

A second contention was that the European Union exports the equivalent of the 1.4 million tons of sugar that are imported under preferential agreements enshrined in the Cotonou Agreement with former colonies. This sugar is sold to the European Union at the internal price but re-exported at the world price. This was not notified as a part of the European Union’s schedule of exports that benefit from subsidies: it was explicitly excluded in a footnote.

The panel found, and the Appellate Body agreed, that the European Union was in breech in both respects (WTO, 2004a; WTO, 2005a). The exports of C sugar did benefit from the high price of A and B quotas awarded to the same farms. As the C sugar was solely destined for exports, the effect was to cross-subsidize.[31] By implication, if C sugar were sold on the internal market to any extent, the argument would have required a further stage of showing that the exports were harming other exporters. But as the implicit financial benefits to producers of C sugar were not notified as export subsidies they were *de facto* prohibited regardless of their market impact. Similarly, the panel found that the re-export of the ACP (and Indian) sugar was prohibited as it did not appear in the EU schedule. Thus the EU-sugar case differs from that of US cotton in that it centers primarily on the notification of export subsidies. The fact that these notifications were not challenged at the time raises questions about how the activities of the Agriculture Committee might be linked more usefully to the issue of the nature of these policies.

The sugar case is complicated by an additional element. If the European Union cannot either re-export the ACP imports or sell C sugar on the world market, the domestic price has to be reduced and/or the quotas have to be reduced. The EU Commission realized this link with reform of the EU sugar regime, and used the argument effectively to persuade member states of the need for policy change. The political decision was made by the European Union's Council of Ministers on November 22, 2005, to undertake a reform that cut the sugar price support level by 36% and compensated farmers with "decoupled" payments. Though the support price will stay significantly above the world price level, the incentive to produce for export (over and above the quota volume) will be significantly reduced. As the output falls, the European Union will come into compliance with the panel ruling: cross-subsidized production will not find its way into export markets, and the ACP sugar will be absorbed largely in the domestic market.

12.4.5 The TAMS Case

Cases brought against countries for the way they have notified policies that come under domestic support have been infrequent. With inconclusive debates in the Committee for Agriculture and without the guidance of panel reports, countries were able, largely, to decide for themselves whether particular policies were consistent with the definitions of the Green and Blue Boxes, and hence not subject to reductions. So long as countries were way below their limits on domestic support it was not a priority to challenge the notifications themselves. But the jump in funding for the 2002 US Farm Bill caused a re-think of this situation, with the possibility that the limits may have been breached if notifications had been erroneous. The statement of the US-Cotton panel that some of the expenditures that the United States had claimed as "green" may have been mis-labeled turned this possibility into a contestable proposition.

The recent cases by Canada and Brazil raise the broader question of whether the United States has violated its total AMS commitment under the URAA during certain years.[32] A primary issue is again whether direct payments to farmers have been correctly notified as meeting the criteria of the Green Box or should be included in the AMS. A second issue concerns whether US counter-cyclical payments under the 2002 Farm Bill (and the similar prior emergency payments) are non-product-specific (NPS) AMS as notified by the United States or should be considered product specific (PS), because they are inherently linked to specific commodity prices and like direct payments are paid without regard to the type of farm production but with exception for certain restrictions on base acreage land use. Canada also has questioned whether certain disaster relief programs reported in the Green Box meet its criteria. Brazil has raised questions on whether certain other policies provide subsidies that have not been counted in notified support. The outcomes of these dispute settlement cases, in conjunction with any negotiated outcome of the Doha Round, will have implications both for the United States and other countries in terms of the manner in which certain policies are notified, whether domestic support is judged consistent with WTO obligations, and policy reforms that might be undertaken in the future.[33]

The TAMS case illustrates that ambiguity still exists. On the one hand, it is a remarkable case, which when decided by a panel would clarify the somewhat fuzzy nature of the "boxes". On the other hand, it refers to past notifications that were alleged to wrongly classify certain subsidies. So the remedy in the event of a successful challenge is presumably to oblige a re-notification by the United States of its domestic support for several historical years. But the United States could well argue that in the current period of high prices, support levels are already well below the limits set in the schedules even with re-notification. So it would not be clear what the United States could do to make amends: changing current policies would not be an appropriate remedy, and compensation for past violations is not contemplated in the DSU.

This does not drain the interest away from the case. The reclassification of direct payments in the United States away from the Green Box in a revised notification would indeed be a small prize for competing exporters. But add the possibility of a new set of limits in the Doha Round, and the case becomes critical. If the Doha Round succeeds in reducing allowable AMS expenditure, the allocation of subsidies to these boxes becomes much more sensitive. The prospect exists that the major driver of change in US farm policy could indeed be the WTO dispute settlement process, and the decisions on the classification of subsidies. That could also set up some controversy over the role of WTO rules when they clash with powerful political interests. Agricultural trade will continue to provide vexing issues for the multilateral trade system and its judicial processes.

12.5 The Significance of the Doha Round

The agreement to include agriculture as a key part of the Doha Development Agenda in 2001 has led to further changes in the nature of the relationship between domestic farm policy and trade rules. The United States pushed for the elevation of agriculture from the "built in agenda" that was mandated by the Uruguay Round to a pivotal aspect of the Doha Round. But the game has changed considerably since that decision was taken. The United States is now under pressure in the Round to make "real" cuts in its farm programs.

The European Union has been playing a more active role in setting the agenda for the agricultural component of the Doha Round than it did in the Uruguay Round and in earlier GATT rounds.[34] The Commission, negotiating on behalf of member states, has tried to avoid the defensive position that gave it little room to suggest changes in the rules that it would favor. In particular it wanted to avoid being isolated as the main defender of protectionist agricultural programs, and risk being blamed for resisting further progress in bringing agricultural trade rules closer to those in the non-agricultural sector.

This new position has indeed had a major impact on the conduct of the negotiations. Although transatlantic tensions still exist, often over issues such as regulations regarding biotech food and the use of place names for trademarks, the past 5 years have seen a noticeable convergence of EU and US positions on agricultural trade rules. The conflicts that are prolonging the Doha Round agricultural talks are more often between the United States and the European Union on the one hand and developing countries on the other. Both the United States and the European Union have agreed that there will be significant cuts in tariffs, subject to partial exclusions for sensitive products, and major reductions in the allowable level of trade-distorting domestic support. The elimination of export subsidies is no longer a significant point of contention, although there are still differences in the area of food aid.

The main reason why the European Union can be so much less defensive in its approach to trade talks is in the progress it has made with domestic reform of agricultural policy. The MacSharry reforms of 1992 allowed the European Union to agree to disciplines on domestic and export subsidies in the Uruguay Round Agreement on Agriculture (URAA), as well as resolving the oilseed controversy. Cereal prices were cut to bring them closer to world prices and oilseed hectarage was restrained. Payments that were made in compensation for price cuts were placed in the Blue Box, and thus avoided mandated reductions. Support given through administered prices also declined, in part as a result of the use of the difference between these prices and fixed reference prices for the calculation of the subsidy element. So the partially-reformed CAP had no difficulty staying within the bounds of the European Union's schedule of subsidy reductions in the first few years.

Further reforms have had a similar impact, lowering the level of trade-distorting subsidies and making it easier for the European Union to contemplate and accept further restrictions on agricultural policies in the WTO. In this connection, the changes in 1999 (the Agenda 2000 reforms) and the subsequent significant changes in 2003 and 2004, under the leadership of Commissioner Fischler, have continued and developed the approach taken by MacSharry. Price support has been removed or weakened for many commodities, and payments are now made to farmers on the basis of historical production of a wide range of products with no obligation to produce any particular product to claim payment. This "Single Farm Payment" has made the CAP significantly more consistent with the “tariffs and decoupled payments” model that underlies the URAA.

To what extent would a successful conclusion of the Doha Development Agenda (DDA), along the lines of the modalities in the Revised Draft Modalities paper of July 10, 2008, require further changes in the Farm Bill and the common agricultural policy? Will those changes be made easier by corresponding disciplines on the domestic programs of other countries? How much increased market access is likely to be generated as a result of cuts in tariffs that would be required of the European Union and the United States? Will the termination of the European Union’s use of export subsidies to balance its internal market have any significant impact on price levels and on world market conditions? What other issues will the European Union insist on as it moves toward a package that is acceptable to member states?

12.6 The Revised Draft Modalities for Domestic Support

WTO members are at present considering a number of changes to the URAA that would have an impact on the constraints on EU policy from WTO obligations. In July 2008, Ambassador Crawford Falconer, the chair of the special session of the WTO Committee on Agriculture, released a revised set of draft modalities for agriculture that included detailed proposals for future disciplines on domestic support (TN/AG/W/4/Rev.3). The Falconer revised draft modalities paper was an attempt to frame the parameters of such increased restraint so as to enable countries to converge on a single document, and formed the basis for the July Mini-Ministerial.

There has recently been an attempt to project the levels of AMS, OTDS, and other components of domestic support under assumptions about the outcome of the negotiation on modalities. The discussion in this section is based on the report of that study (Blandford and Josling, 2008). The United States is projected to stay comfortably within its total bindings for the duration of the projection period (see Fig. 12.5).

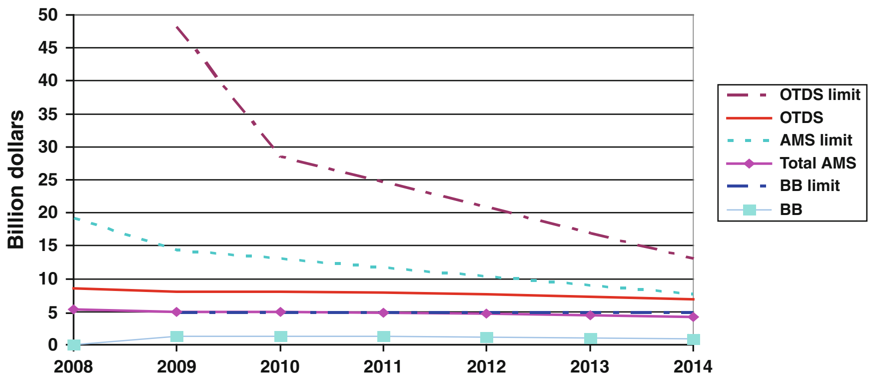

Fig. 12.5 Projected notifications of domestic support, the United States, 2008–2014, and proposed limits to OTDS, AMS and Blue Box. *Source*: Blandford and Josling, 2008

In addition to the relatively high crop prices projected by USDA an important contributing factor to this result is a change in dairy policy included in the 2008 Farm Act. Prior to this Act, the US dairy support program was defined with respect to a support price for milk. That structure was reflected in US notifications in that the per unit market price support calculation was applied total milk production. The 2008 Act redefines the support program with respect to support for three dairy products – butter, cheddar cheese, and non-fat dry milk.[35] Those support prices are defined to be consistent with the previous support price for milk ($9.90 per hundred weight). The effect of this change is to allow the United States to notify market price support for dairy on the basis of the volume of the three dairy products concerned, rather than the total volume of milk production. We build this change in notifications into the projections beginning in 2008. There remain some technical questions associated with how the calculation would be made, but the estimate is that the change in methodology would reduce notified market price support for dairy by roughly 65%. The application of the revised approach results in a projected notification of $1.9 billion in 2014, compared to $5.5 billion under the previous method. If it were not for this change, we project that the United States would exceed its Total AMS binding in 2014 by roughly $0.2 billion, rather than being $3.4 billion below the binding.

Although the overall bindings relative to aggregate support would seem to suggest few problems for the United States, there are issues with some commodities. The projections suggest that the draft modalities would result in product-specific AMS and Blue Box bindings being exceeded for cotton throughout the implementation period of an agreement, with an excess for peanut Blue Box payments (CCPs) and for AMS support for sugar. As noted above the change in the dairy program removes a potential problem of exceeding the PS AMS binding for dairy. These results indicate that there are likely to be significant issues to be faced for a limited number of commodities, two of which (cotton and sugar) have proved to be highly politically sensitive in the United States.

In terms of other possibilities for box-shifting the projections for US notified support suggest that the greatest potential for the United States lies in an expansion of the non-product-specific support category. With a projected payments equal to $6.9 billion of the “available” $13 billion OTDS, the United States would still have $6.1 billion in non-product-specific support that could be used, while still staying within WTO commitments. The exact amount could change depending on what happens to PS AMS and Blue Box payments under the ACRE program in the 2008 Farm Bill, but some shifting of support into the non-product-specific category would appear to be a possibility for the United States. Given the considerable pressure that was exerted for a reduction in direct payments (Green Box), in the debate on the 2008 Farm Bill, the popularity of such payments among farmers might well decline in the future with less support for box-shifting in that direction.

The Falconer proposals, as they would apply to the European Union, would place a limit on overall trade-distorting support (OTDS). This OTDS limit would be subject to reductions over the implementation period of the agreement. There would also be reductions in the limits for the total AMS from the final values applying under the Uruguay Round Agreement as well as in the *de minimis* percentages. The Blue Box would have limits imposed based on the percentage of the value of production. Limits would also be imposed on the product-specific AMS and on product-specific Blue Box support, as described in the table.

The implications for the European Union of these proposals are striking. The Base OTDS, from which reductions would be measured, would be 110.3 billion euro. Thus the range for the Final Bound OTDS would be from 16.5 to 27.6 billion euro. This corresponds to an estimate of 24 billion euro for the Current Total OTDS in the year 2013–2014.[36] Thus the more restrictive limit would appear to bind and impose further policy changes of a nature consistent with developments since 2003. The overall picture is shown in Fig. 12.6, which shows the projected notifications relative to the more ambitious limits in the range indicated in the Draft Modalities paper. The AMS limit would be reduced from the current level of 67.2 billion to 20.1 billion euro (augmented minimally by allowance for the enlargement of the European Union).[37] The estimated Current Total AMS for the year 2013–2014 is 24.0 billion euro, indicating a significant restraint on EU policies in the final year of the transition period if they continue on their current course. The year 2013–2014 is the year when a new budgetary cycle starts in the European Union at which time the funding for the CAP could well be trimmed for internal reasons.

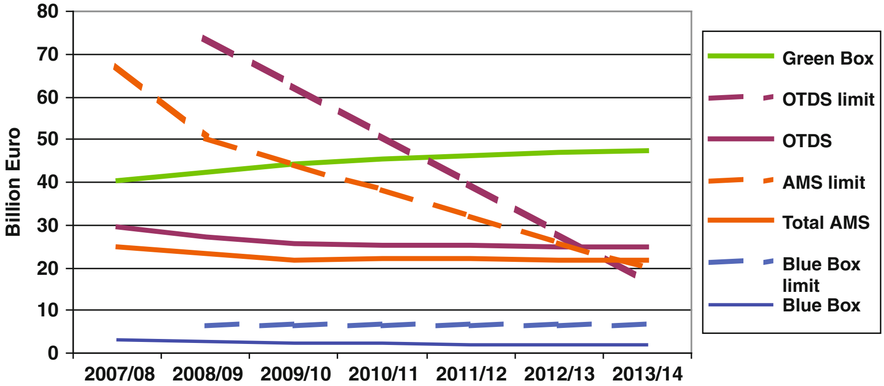

Fig. 12.6 Projected notifications of domestic support, European Union, 2007–2008 and 2013–2014, and proposed limits to OTDS, AMS, and Blue Box. *Source*: Blandford and Josling, 2008

In addition to the constraints on total AMS and Blue Box support, the Revised Modalities draft also proposes restrictions on product-specific AMS and Blue Box amounts. These constraints might well be binding in specific instances. The Revised Draft suggests caps on product-specific AMS payments at the 1995–2000 levels. Increases in administered prices are effectively restricted by this constraint. Changes in fixed reference prices are not envisaged in the URAA, and would presumably have to be negotiated. But variations in the level of "eligible production" for both the products where the market price support is calculated and for those where an equivalent measure of support is used could well lead to AMS limits being violated.

Blue Box limits at a product-specific level are also likely to have some impact. Though the total Blue Box spending may be decreasing, as payments move to the Green Box, those for individual products cannot increase to make use of that "slack". Although these payments are currently tied to fixed yield, areas and head of livestock, the restriction implies no possibility of any re-basing of such payments that would violate the limits.

Although it would appear that the European Union can continue to run the CAP for some years in the face of cuts of 70% for the AMS limit and the introduction of a cut of 85% in overall trade-distorting support, these results should not be interpreted as an indication that the WTO constraints introduced by the Doha Round will not ultimately affect EU policy. In order to stay within the new limits, changes would have to be made to ensure that direct payments can continue to be notified as Green Box without being challenged by other countries. And further transfers of subsidies from the blue to the Green Box will be necessary.

The extent to which the Single Farm Payments are truly compatible with the Green Box has been raised by some commentators (McMahon, 2007; Swinbank, 2007; Swinbank and Tranter, 2005). Were they to be notified in the AMS or Blue Box, under current WTO constraints, the impact would not be great. The limit of 67.2 billion euro for the AMS would not be approached, and the Blue Box is not limited.[38] However, the situation would be drastically changed if the Doha Round were to be completed along the lines of the Revised Modalities. In all cases except where the direct payments are notified in the Green Box (where no limit exists) the new WTO constraints would be violated by the year 2013–2014. If direct payments were to be notified in the Blue Box, the total would far exceed the limit of 5.6 billion euro suggested in the Revised Draft. Up to 28 billion euro would have to be notified in the AMS and this would well exceed the limit of 20.1 billion euro suggested in the same draft. *A fortiori*, if all the direct payments were to be notified in the AMS, the limit of 20.1 billion euro would again be violated. Perhaps more relevant is the effect on the OTDS of any decision to place direct payments outside the Green Box. The OTDS limit of 16.5 billion euro suggested by the Draft would be less than the level of direct payments alone, leaving all other support to be cut or changed to Green Box compatible payments.[39]

12.7 Conclusions

In the United States, domestic farm policy has largely been separated from trade policy. Domestic policy is under the watch of the agricultural committees of Congress and the USDA: other Congressional committees have oversight of trade issues and the USTR is the agency within the administration that negotiates and watches trade matters. Coordination is through interagency contact and through the interests of individual senators and representatives. Thus it is common to assert that the WTO has little impact on domestic policy on the basis of the fact that the debates about domestic policy appear remarkably unconstrained by and unaware of trade rules and obligations. But this does not mean that trade issues are not important to domestic policy in the United States: it has much more to do with the division of labor in the Congress and in the administration. This chapter has attempted to trace some of these linkages and show that it is quite possible to have a domestic policy process that is apparently unaware of trade issues but in practice passes legislation that is linked with the trade policy of the country.

The division of labor is different in the European Union. The Commission is an executive body but also with the sole power of initiation of (EU) legislation. Moreover it has competence by virtue of the EU Treaty over trade negotiations, subject to a mandate from the ministers of trade. So the European Union can coordinate the domestic and trade policy functions somewhat easier by virtue of the function of the Commission. The mandate and the interpretation of that mandate are the effective controls that the member states have over trade policy. The Commission can, and has, premised its domestic policy initiatives on the constraints, objectives, and opportunities in the realm of trade policy. The contention of this chapter is that the conflicts between trade and domestic policy are likely to be internalized within the decision process so that a more cohesive policy set emerges. Therefore it should not come as a surprise that the impacts of the WTO constraints on the CAP are less than in the case of the United States.

In the United States it has taken litigation to bring home the implications of the WTO URAA. The major challenge to the US farm programs was Brazil’s complaint about the upland cotton subsidies: though the focus was on the cotton program, it raised issues that went beyond that commodity to include soybeans and corn and other “program crops”. The fact that the panel found broadly in favor of Brazil was a clear indication that the attempt to enforce existing rules could succeed and that litigation could in certain circumstances lead to policy change. First, Canada and then, the European Union also have had to change policies as the result of unfavorable rulings of WTO panels. On the other hand, the judgments that have led to policy change have been those that dealt with export subsidies, direct or indirect. The Canadian responses to the panel reports on its dairy policy have not weakened the main distortive instruments of high domestic milk prices held up by supply control and steep tariffs. But from the viewpoint of dairy exporters the most egregious aspects of the policy, the promotion of cheese exports by means of allowing manufacturers to buy milk at a much lower price has been curbed. The European Union changed its banana policy to bring it in line with the instruments suggested by the WTO panel, those of a simple tariff and duty-free access for the ACP exporters. The European Union also reformed its sugar policy to avoid the subsidy granted on the re-export of ACP sugar and the cross-subsidy implied by the high price for quota sugar relative to the sugar above quotas that had to be exported outside the European Union.

Quantitative constraints on the level of domestic support have not so obviously been influential in policy change. But that is in part because of the somewhat lax process of examining the conformity of domestic support policies with the URAA. So when the panel examining the US-cotton case ruled that the direct payments were not eligible for the Green Box if they restricted the choice of crops that could be grown on base acres, the door was left open for challenges that would focus on whether the maximum levels of support agreed in the URAA had in fact been violated. The ongoing TAMS case brought by Brazil and Canada will clarify the issue, but could indeed lead to the conclusion that the URAA did in fact impose a limit on domestic support (in the United States) even though it was not recognized at the time. The European Union, by contrast, has not been challenged on its Green Box notifications, though this could conceivably change.

The importance of the Doha Round is thus magnified by the legal challenges. The removal of most of the "slack" between AMS limits and actual AMS spending will make it much more likely that countries get close to their maximum allowable trade-distorting subsidy levels. This increases the possibility of challenges against such countries that feel their export interests have been harmed. By contrast, if the Doha Round is not completed then the challenges on domestic support are likely to be more restrained.

Notes

1. The scope of the URAA covers products in HS Chapters 1–24, excluding fish and fish products but including cotton, wool, hides, flax, hemp, and a few other products.
2. Other aspects of the WTO, not discussed in this chapter, include the Agreement on Trade-Related Intellectual Property (TRIPS), which covers patents for agricultural biotech and geographical indications for foods and wines, and the Technical Barriers to Trade Agreement (TBT), which attempts to prevent the use of standards and labels from being used as a disguised trade barrier. In addition, the WTO Anti-Dumping Agreement is sometimes invoked in agricultural disputes.
3. The levels of tariff reduction and the requirements for market opening were included in the "Modalities" document that formed the basis for offers (draft schedules). This document ceased to be relevant after the schedules themselves had been agreed.
4. Deficiency payments are subsidies that make up the difference between the market returns and a predefined target price. Direct payments are paid in ways that do not depend on current output: the usual basis is acreage and yield in some base year. Administrative prices can also give a subsidy if the price level is kept above that which obtains in the market.
5. Of course, from the point of view of the exporting country the collection of a tax on exports is better than the imposition of a tax on imports by the importer. But export sectors will argue for the removal of either tax.
6. Note also the significant increase in Green Box support in the United States, due primarily to a major expansion in expenditures on domestic food assistance programs.
7. The compensation payments were introduced progressively in the marketing years 1993–1994 and 1995–1996.
8. No estimate exists of what would have been the AMS notifications before 1995, had they been required. But it is likely that, in the 8 years between the 1986–1988 base and the first year of the URAA, trade-distorting support (as measured by the AMS) fell from about 80 billion to 50 billion euro. This was due, in large part, to the introduction of the MacSharry reforms and the placing of these payments in the Blue Box. Green Box eligible policies probably rose modestly over the same period.
9. Though this might appear to suggest that about 10 billion euro in less trade-distorting support has replaced 20 billion euro of more trade-disruptive payments, it should be remembered that the much of the AMS is a calculation based on the difference between an administered price

and a fixed reference price. So a drop in this support can be unrelated to either government payments or farm income.

10. The Agenda 2000 package also agreed a new dairy premium from 2005, to compensate dairy farmers for the scheduled reductions in butter and skim milk powder intervention prices. In G/AG/N/EEC/17 the European Union said it intended declaring these payments in the Blue Box.
11. For the details behind these forecasts see Josling and Swinbank (2008).
12. The European Union (at that time the EU12) declared a base period AMS of 73.53 billion euro, which with a 20% reduction would have given an AMS commitment in 2000 equal to 58.82 billion euro. However, a "credit" of 2.38 billion euro was negotiated, and this led to a Final Bound Total AMS of 61.20 billion euro being agreed (see Supporting table 9a in the EU notification). Enlargement to the EU15 necessitated some changes. The initial AMS figure of 78.7 billion euro mentioned in the text was the EU15 limit in the first year of implementation. The revised Final Bound Total AMS was fixed at 67.2 billion euro for the EU15. No limit has been agreed for the EU of 25 or of 27: for the purposes of this chapter we will assume that the EU15 limit is continued.
13. Not all disputes that are notified to the DSB result in the establishment of a panel.
14. The average number of requests for consultation notified to the DSB has been 28 per year since 1995.
15. Another dispute that had been prominent in the GATT era was over the EU subsidies to oilseeds. The final agreement that ended this dispute was negotiated at the same time that the modalities for agriculture in the Uruguay Round were agreed between the United States and the European Union, at Blair House in November 1992.
16. An interesting issue was raised by Brazil on the preferential treatment for coffee imported by the European Union from competitor countries under regional trade agreements.
17. The original US GI case had been held in abeyance, and was revived following a new policy initiative by the European Union. Australia took out a case in 2003 that then was joined with the earlier case.
18. For more detail on the effect of the Peace Clause on agricultural disputes see Steinberg and Josling, 2003.
19. The panel reports had no impact. The EU effectively prevented their adoption by the General Council, following a long GATT tradition of blocking unfavorable reports.
20. As an agricultural policy case the banana issue would have been interesting enough. But the case tackled much more than the conflicts over post-colonial discrimination. It was the first panel to consider an argument that a country had contravened the General Agreement on Trade in Services (GATS). By allocating import licenses to domestic firms based on past shipments the banana import regime gave valuable trading permits to the competitors of the US-based multinationals. The European Union had agreed to end discrimination in "wholesale trade services" in the Uruguay Round. This aspect of the case increased its importance and provided a potentially useful clarification of the relationship between rules for goods trade and those for trade in services.
21. Mexico followed the lead of the United States in part because of the Mexican ownership at that time of one of the firms (del Monte) and in part as an expression of North American solidarity on a matter of WTO principle.
22. The Licensing Agreement provided more detail on the way in which licensing measures were to be administered, and is included as an Annex 1A agreement in the Marrakesh Agreement which established the WTO.
23. The dispute also included a complaint about the administration of Canadian dairy import regulations, but that raised different issues and will not be discussed here.
24. Canada abolished the Special Milk Class 9(e) and restricted sales under Class 5(d) to conform to its export subsidy commitments. A new milk category of Commercial Export Milk (CEM) was established.
25. The challenge to Canadian dairy policy was not covered by the Peace Clause as it charged that the export subsidy commitments had been violated.

26. Brazil requested consultations with the United States on September 27, 2002. After three abortive discussions, a panel was established on May 19, 2003, and issued a report on June 18, 2004. This ruling was appealed by the United States, and the Appellate Body issued its report on March 3, 2005. The report as amended was adopted on March 21, 2005.
27. The two Farm Bills in question are the 1996 FAIR Act and 2002 FSRI Act. Production flexibility contract payments were authorized under the FAIR Act, and marketing loss assistance payments were added as emergency measures in 1998–2001. The FSRI Act replaced these with direct payments and counter-cyclical payments. Marketing loans for cotton have been in place since 1986 and Step 2 subsidies since 1990. The cottonseed payments are emergency payments authorized by the ARP Act in 2000. Crop insurance is authorized by separate legislation, the Federal Crop Insurance Act.
28. The panel rejected the US argument that the low world prices were from other causes and that the high US exports were an exception rather than the rule.
29. The ruling also declared the export credit guarantees for rice exceeded its allowed export subsidy limit, but did not find fault with other aspects of the program
30. The Australian and Brazilian challenges were initiated in September 2002 and Thailand joined the complaint in March 2003. The dispute numbers are DS265, DS266, and DS283, respectively. The panel report was presented on October 15, 2004, and was appealed. The Appellate Body gave their opinion on April 28, 2005, and the DSB accepted the report as modified.
31. Investigations of subsidies in non-agricultural markets often explore the possibility of cross-subsidization within firms. The economics of cross-subsidization is not as well accepted as the accounting conventions.
32. The two cases brought by Canada and Brazil (DS 357, 365, respectively) have been merged. The complaint is that United States exceeded its Total AMS limits in several recent years.
33. Were direct and countercyclical payments and their antecedents to be ruled product-specific support that should have been included in the US Current Total AMS, then the United States would indeed have exceeded its AMS commitment in 1999, 2000, 2002, 2004, and 2005, as suggested in the Brazil and Canada cases (see Blandford and Josling, 2008).
34. The use of the term European Union for the collective position and interest of the European Union rather than the technically correct term EC (European Community), preferred in WTO documents.
35. Economists would argue that a price support program for a subset of dairy products is likely to affect the prices of all dairy products; that is, that the original formulation of the notifications is still appropriate in an economic, if not a legal sense.
36. In order to examine the impact of these changes on future notifications we assume that new WTO support commitments are implemented over the period from 2010–2014, so that all new reductions and bindings apply fully in 2014. Our assumptions about the evolution of agricultural policy in the European Union are that progressively more of the direct payments can be notified as Green Box, as the "health check" consolidates the changes in the 2003 Reforms.
37. The limit for the OTDS at the end of the transition period appears to be less than the AMS limit (a function of the higher percentage cut), implying that the AMS will have to be reduced by even more than indicated here to avoid violation of the OTDS limit. There will in effect be no room for Blue Box and *de minimis* payments by the end of the transition.
38. Inclusion in the Blue Box of new or modified subsidies however could be challenged, but these subsidies could be transferred to the AMS without violating the AMS limit. The AMS limit itself will be somewhat higher that 67.2 billion euro, to take into account the allowable limits of new members.
39. However, another source of uncertainty is less of a problem in the European Union. Unlike the situation in the United States, relatively little of the support provided to farmers in the European Union is subject to increases if market prices fall.

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Chapter 13
Agricultural Competitiveness

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Abstract This study looks at international competitiveness of agriculture in the United States and the European Union. At the outset, it is necessary to define a measure of competitiveness. We define international competitiveness as the price of output in the member states of the European Union relative to that in the United States. We then decompose relative price movements into changes in relative input prices and changes in relative productivity levels. Our price comparisons indicate that the United States was more competitive than its European counterparts throughout the period 1973–2002, except for the years 1973–1974 and 1983–1985. Our results also suggest that the relative productivity level was the most important factor in determining international competitiveness. Over time, however, changes in competitiveness were strongly influenced by variations in exchange rates through their impact on relative input prices. During the periods 1979–1984 and 1996–2001, the strengthening dollar helped the European countries improve their competitive position, even as their relative productivity performance lagged.

13.1 Introduction

The Doha Round of trade negotiations has stagnated, with the European Union and the United States at an impasse over the level of support for agriculture and the need for increased market access. These "trade frictions" accompanied the rapid expansion of agricultural exports to the United States.[1] Explanations for the resulting trade imbalance must include variations in exchange rates, changes in the relative prices

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of factors of production, and the relative growth of productivity in European and US agriculture.[2] We analyze the role of each of these factors in explaining the increased competitiveness of European Union agriculture relative to its US counterpart.

At the outset of this discussion, it is essential to define a measure of international competitiveness. Our measure of international competitiveness is the price of output in the member states of the European Union relative to the price in the United States. This measure of competitiveness is common to the literature on general equilibrium. If production exhibits constant returns to scale, as is assumed in this study, then equilibrium requires that the price of output equals unit cost. Hence, our measure of international competitiveness can be interpreted as a comparison of the relative cost of production. In order to explain changes in international competitiveness, we must account for changes in the determinants of this relative price.

The starting point for our analysis of competitiveness is the exchange rate between each national currency and the dollar. Variations in exchange rates are easy to document and are often used to characterize movements in relative prices among countries. However, movements in these relative prices of goods and services do not coincide with variations in exchange rates. To account for changes in international competitiveness a measure of the relative prices of specific goods and services is required.

Relative prices between European and US agriculture can be summarized by means of purchasing power parities. The purchasing power parity for an industry's output is defined as the number of units of a given currency required to purchase the same amount of goods as a unit of the numeraire currency. The dimensions of the purchasing power parities are the same as the exchange rate. However, the purchasing power parities reflect the relative prices of the goods and services that make up the industry's output in each country.

In this study, we construct purchasing power parities for agriculture in the eleven European countries and the United States for the period 1973–2002. These are relative prices of agricultural output in each country expressed in terms of national currencies per dollar. We divide the relative price of output by the exchange rate to translate the purchasing power parities into relative prices in dollars. We employ relative prices denominated in dollars as our measure of international competitiveness. Variations in exchange rates are reflected in the relative prices of output in all twelve countries.

To account for changes in international competitiveness among the eleven European countries and the United States, we have constructed purchasing power parities for the inputs employed in agriculture. By analogy with output, the purchasing power parities for inputs are based on the relative prices of the goods and services that make up the inputs. We have disaggregated inputs among capital, land, labor, and intermediate goods. We can translate purchasing power parities for inputs into relative prices in dollars by dividing by the exchange rate.

The final step in accounting for changes in international competitiveness is to measure relative levels of productivity for all twelve countries in the comparison. For this purpose, we employ a multilateral model of production. This model enables us to express the price of output in each country as a function of the prices of the inputs and the level of productivity in that country. We can account for the relative prices of output among countries by allowing input prices and levels of productivity to differ among countries. We have compiled data on relative productivity levels in the eleven European countries and the United States for the period 1973–2002. For this purpose, we have revised and extended the estimates for 1973–1993 reported by Ball et al. (2001).

The methodology for our study was developed by Jorgenson and Nishimizu (1978). They provided a theoretical framework for productivity comparisons based on a bilateral production function. They employed this framework in comparing output, input, and productivity at the aggregate level for Japan and the United States. The methodology was extended to the industry level by Jorgenson and Nishimizu (1981). The industry-level approach introduced models of production for individual industries based on bilateral production functions for each industry. This study employs the price function dual to the industry production function. A brief discussion on the theoretical framework for international comparisons is provided in the next section of this chapter.

In subsequent sections, we describe the product and factor accounts for European and US agriculture. These accounts underpin our estimates of relative output and input prices and relative levels of total factor productivity. We employ changes in relative productivity levels and relative prices of inputs in accounting for changes in international competitiveness. The final section provides a summary of results and conclusions.

13.2 Theoretical Framework

Under competitive conditions, we can represent the production technology by a price or unit cost function that is dual to a linearly homogeneous production function for all twelve countries (Samuelson, 1953; Shephard, 1953, 1970):

$$\begin{aligned}\ln P = \alpha_0 &+ \sum_{\mathrm{i}} \alpha_{\mathrm{i}} \ln W_{\mathrm{i}} + \alpha_t T + \sum_{d} \alpha_d D_d + \frac{1}{2} \sum_{\mathrm{i}} \sum_{j} \beta_{\mathrm{i}j} \ln W_{\mathrm{i}} \ln W_j + \sum_{\mathrm{i}} \beta_{\mathrm{i}t} \ln W_{\mathrm{i}} T \\ &+ \sum_{\mathrm{i}} \sum_{d} \beta_{\mathrm{i}d} \ln W_{\mathrm{i}} D_d + \frac{1}{2} \beta_{tt} T^2 + \sum_{d} \beta_{td} T D_d + \frac{1}{2} \sum_{d} \beta_{dd} D_d^2,\end{aligned} \tag{13.1}$$

where P is the price of the output in each country, the W_{i} are input prices, T is time, D_d is a dummy variable equal to one for the corresponding country and zero otherwise, and d is an index of countries, running over Belgium, Denmark, Germany, Greece, Spain, France, Ireland, Italy, the Netherlands, Sweden, and the United Kingdom.[3] Since we express levels of output and input prices and levels of productivity relative to the United States, we omit a dummy variable for the United States from the price function. Since T and D_d interact with input prices, differences in levels of productivity across time and across countries are permitted to be nonneutral.

In examining the differences in production patterns among countries, we combine the price function with the demand functions for inputs. We can express these functions as equalities between the share of each input in the value of output and the elasticity of the output price with respect to the price of that input[4]:

$$v_{X_{\mathrm{i}}} = \frac{\partial \ln P}{\partial \ln W_{\mathrm{i}}} = \alpha_{\mathrm{i}} + \sum_{j} \beta_{\mathrm{i}j} \ln W_j + \beta_{\mathrm{i}t} T + \beta_{\mathrm{i}d} D_d. \tag{13.2}$$

The sum of the elasticities with respect to all inputs equals unity, so that the value shares also sum to unity.[5]

We can define the rate of productivity growth, say v_T, as the negative of the rate of growth of the output price with respect to time, holding input prices and the country dummy variables constant:

$$-v_T = \frac{\partial \ln P}{\partial T} = \alpha_t + \sum_{\mathrm{i}} \beta_{\mathrm{i}t} \ln W_{\mathrm{i}} + \beta_{tt} T + \beta_{td} D_d. \tag{13.3}$$

Similarly, we can define the difference in productivity between any country and the United States, say v_D, as the negative of the logarithmic derivative of the level of the output price with respect to the dummy variable representing differences in productivity between the countries, holding input prices and time constant:

$$-v_D = \frac{\partial \ln P}{\partial D_d} = \alpha_d + \beta_{\mathrm{i}d} \ln W_{\mathrm{i}} + \beta_{td} T + \beta_{dd} D_d. \tag{13.4}$$

Our empirical application does not involve estimating the parameters of the price function; rather, we use index numbers that are exact for the translog specification. This approach was followed by Jorgenson and Nishimizu (1978, 1981) in their bilateral comparisons of output, input, and productivity for the United States and Japan. The average rate of productivity growth between two discrete points of time, say T and $T-1$, can be expressed as the difference between a weighted average of growth rates of input prices and the growth rates of the price of output for each country:

$$-\bar{v}_T = \ln P(T) - \ln P(T-1) - \sum_{\mathrm{i}} \bar{v}_{X_{\mathrm{i}}} [\ln W_{\mathrm{i}}(T) - \ln W_{\mathrm{i}}(T-1)], \tag{13.5}$$

where the average rate of technical change is

$$\bar{v}_T = \frac{1}{2}[v_T(T) + v_T(T-1)],$$

and the weights are given by the average value shares

$$\bar{v}_{X_i} = \frac{1}{2}[v_{X_i}(T) + v_{X_i}(T-1)].$$

The index number defined by (13.5) is the translog price index of productivity change suggested by Jorgenson and Griliches (1967).[6] Diewert (1976) showed that the index is exact for the translog price function.

The difference in productivity between any two countries, say $\hat{v}_D$, can be expressed as weighted averages of the differences between logarithms of the input prices for each country and the geometric mean of input prices over all twelve countries, less the difference between logarithms of the output price. Expressing differences in productivity relative to the United States:

$$\begin{aligned}-\hat{v}_D = \ln P(d) - \ln P(US) - \sum_{\mathrm{i}} \hat{v}_{X_\mathrm{i}}(d)[\ln W_\mathrm{i}(d) - \overline{\ln W_\mathrm{i}}] \\ + \sum_{\mathrm{i}} \hat{v}_{X_\mathrm{i}}(US)[\ln W_\mathrm{i}(US) - \overline{\ln W_\mathrm{i}}],\end{aligned} \tag{13.6}$$

where

$$\hat{v}_{X_\mathrm{i}}(d) = \frac{1}{2}\left[v_{X_\mathrm{i}}(d) + \frac{1}{N}\sum_d v_{X_\mathrm{i}}(d)\right],$$

and a bar indicates the average over all N countries.

The translog index of productivity differences defined by (13.6) was introduced by Caves et al. (1982). Its use for making bilateral comparisons results in transitive multilateral comparisons that retain a high degree of characteristicity.[7]

To complete the methodology for comparing levels of output and input prices and levels of productivity among countries, we require specific forms for the functions defining the price of output and the prices of the inputs. We specify the price of output as a linearly homogeneous translog function of the prices of the components of output for all twelve countries[8]:

$$\ln P = \sum_{\mathrm{i}} \alpha_\mathrm{i} \ln P_\mathrm{i} + \frac{1}{2}\sum_{\mathrm{i}}\sum_j \beta_{\mathrm{i}j} \ln P_\mathrm{i} \ln P_j. \tag{13.7}$$

We can define the shares of these components in the value of total output by

$$v_{Y_\mathrm{i}} = \frac{\partial \ln P}{\partial \ln P_\mathrm{i}} = \alpha_\mathrm{i} + \sum_j \beta_{\mathrm{i}j} \ln P_j. \tag{13.8}$$

Since the price of output is a translog function of the prices of its components, the difference between successive logarithms of the price of output can be expressed as a weighted average of differences between logarithms of component prices with weights given by the average value shares:

$$\ln P(T) - \ln P(T-1) = \sum_{\mathrm{i}} \bar{v}_{Y_\mathrm{i}}[\ln P_\mathrm{i}(T) - \ln P_\mathrm{i}(T-1)], \tag{13.9}$$

where

$$\bar{v}_{Y_i} = \frac{1}{2}[v_{Y_i}(T) + v_{Y_i}(T-1)].$$

Similarly, considering data for all twelve countries at a given point of time, the difference between logarithms of the price of output for any two countries can be expressed as weighted averages of the differences between logarithms of the component prices and the geometric average of component prices for the twelve countries. Expressing the differences in output prices relative to the United States:

$$\ln P(d) - \ln P(US) = \sum_{\mathrm{i}} \hat{v}_{Y_{\mathrm{i}}}(d)[\ln P_{\mathrm{i}}(d) - \overline{\ln P_{\mathrm{i}}}] - \sum_{\mathrm{i}} \hat{v}_{Y_{\mathrm{i}}}(US)[\ln P_{\mathrm{i}}(US) - \overline{\ln P_{\mathrm{i}}}], \tag{13.10}$$

where

$$\hat{v}_{Y_{\mathrm{i}}}(d) = \frac{1}{2}\left[v_{Y_{\mathrm{i}}}(d) + \frac{1}{N}\sum_{d} v_{Y_{\mathrm{i}}}(d)\right],$$

and

$$\overline{\ln P_{\mathrm{i}}} = \frac{1}{N}\sum_{d} \ln P_{\mathrm{i}}(d).$$

The price index in (13.10) represents the purchasing power parity between the currencies of the two countries expressed in terms of agricultural output.

If the input prices are translog functions of their components for all twelve countries, we can express the differences between successive logarithms of input prices for a given country as:

$$\ln W_{\mathrm{i}}(T) - \ln W_{\mathrm{i}}(T-1) = \sum_{j} \bar{v}_{X_{\mathrm{i}j}}[\ln W_{\mathrm{i}j}(T) - \ln W_{\mathrm{i}j}(T-1)], \tag{13.11}$$

where

$$\bar{v}_{X_{\mathrm{i}j}} = \frac{1}{2}[v_{X_{\mathrm{i}j}}(T) + v_{X_{\mathrm{i}j}}(T-1)],$$

and $v_{X_{\mathrm{i}j}}$ are the shares of the components in the value of the input aggregates.

Finally, we can express the differences between logarithms of input prices relative to the United States as:

$$\begin{aligned} \ln W_i(d) - \ln W_{\mathrm{i}}(US) = &\sum_{j} \hat{v}_{X_{\mathrm{i}j}}(d)[\ln W_{\mathrm{i}j}(d) - \overline{\ln W_{\mathrm{i}j}}] \\ &- \sum_{j} \hat{v}_{X_{\mathrm{i}j}}(US)[\ln W_{\mathrm{i}j}(US) - \overline{\ln W_{\mathrm{i}j}}], \end{aligned} \tag{13.12}$$

where

$$\hat{v}_{X_{\mathrm{i}j}}(d) = \frac{1}{2}\left[v_{X_{\mathrm{i}j}}(d) + \frac{1}{N}\sum_{d} v_{X_{\mathrm{i}j}}(d)\right]$$

and

$$\overline{\ln W_{ij}} = \frac{1}{N}\sum_{d}\ln W_{ij}(d).$$

The price indexes in (13.12) represent the purchasing power parities expressed in terms of the inputs employed in agriculture.

13.3 Data

We assume that data on production patterns in the eleven European countries and the United States are generated by a gross output model of production. Output is defined as gross production leaving the farm, as opposed to real value added. Inputs are not limited to labor and capital, but include intermediate inputs as well. The text in this section provides an overview of the sources and methods used to construct the product and factor accounts for the period 1973–2002 for each of the twelve countries.[9] A technical appendix providing a complete, detailed description of the data is available from the authors upon request.

13.3.1 Output and Intermediate Input

Our measure of agricultural output includes deliveries to final demand and intermediate demand in the nonfarm sector. We also include deliveries to intermediate farm demand so long as these deliveries are intended for different production activities (e.g., crop production intended for use in animal feeding).

One unconventional aspect of our measure of output is the inclusion of goods and services from certain nonagricultural or secondary activities. These activities are defined as activities closely linked to agricultural production for which information on output and input use cannot be separately observed. Two types of secondary activities are distinguished. The first represents a continuation of the agricultural activity, such as the processing and packaging of agricultural products on the farm, while services relating to agricultural production, such as machine services for hire, are typical of the second.

The total output of the sector represents the sum of output of agricultural goods and the output of goods and services from secondary activities. We evaluate industry output from the point of view of the producer; that is, subsidies are added and indirect taxes are subtracted from market values.[10] In those countries where a forfeit system prevails, the difference between payments and refunds of the tax on value added (or VAT) is also included in the value of output.

Intermediate input consists of all goods and services consumed during the accounting period, excluding fixed capital. Those goods and services that are produced and consumed within the agricultural sector are included in intermediate input so long as they also enter the farm output accounts. The value of intermediate input includes taxes (other than the deductible VAT) less subsidies, whether paid to suppliers of intermediate goods or to agricultural producers.[11]

13.3.2 Capital Input

The measurement of capital input begins with data on the stock of capital for each component of capital input, based on investments in constant prices.[12] At each point of time the stock of capital, say *K(T)*, is the sum of past investments, say $I(T - \tau)$, weighted by the relative efficiencies of capital goods of each age τ, say $S(\tau)$:

$$K(T) = \sum_{\tau=0}^{\infty} S(\tau)I(T - \tau). \tag{13.13}$$

To estimate capital stock, we must introduce an explicit description of the decline in efficiency. This function, S, may be expressed in terms of two parameters, the service life of the asset L and a curvature or decay parameter β. One possible form of the efficiency function is given by:

$$\begin{aligned} S(\tau) &= (L - \tau)/(L - \beta\tau), & (0 \leq \tau \leq L), \\ S(\tau) &= 0, & (\tau > L). \end{aligned} \tag{13.14}$$

This function is a form of a rectangular hyperbola that provides a general model incorporating several types of depreciation as special cases.

The value of β is restricted only to values less than or equal to one. For values of β greater than zero, the function S approaches zero at an increasing rate. For values less than zero, S approaches zero at a decreasing rate.

Little empirical evidence is available to suggest a precise value for β. However, two studies, by Penson et al. (1977) and Romain et al. (1987), provide evidence that efficiency decay occurs more rapidly in the later years of service, corresponding to a value of β in the zero–one interval. For purposes of this study, it is assumed that the efficiency of a structure declines very slowly over most of its service life. The decay parameter for machinery and transportation equipment assumes that the decline in efficiency is more uniformly distributed over the asset's service life. Given these assumptions, the final β values chosen were 0.75 for structures and 0.5 for machinery and equipment.

The other variable in the efficiency function is the asset lifetime L. For each asset type, there exists some mean service life $\bar{L}$ around which there exists a distribution of actual service lives. In order to determine the amount of capital available for production, the actual service lives and the relative frequency of assets with these lives must be determined. It is assumed that this distribution may be accurately depicted by the normal distribution truncated at points two standard deviations before and after the mean service life.

Once the frequency of a true service life L is known, the decay function for that particular service life is calculated using the assumed value of β. This process is repeated for all other possible values of L. An aggregate efficiency function is then constructed as a weighted sum of individual efficiency functions using as weights the frequency of occurrence. This function not only reflects changes in efficiency but also the discard distribution around the mean service life.

Firms undertaking investment decisions should add to capital stock if the present value of the net revenue generated by an additional unit of capital exceeds the purchase price of the asset. Stated algebraically, this condition is:

$$\sum_{t=1}^{\infty}\left(P\frac{\partial Y}{\partial K} - W_K\frac{\partial R_t}{\partial K}\right)(1+r)^{-t} > W_K, \tag{13.15}$$

where P is the price of output, W_K is the price paid for a new unit of capital, R_t is replacement investment, and r is the real discount rate.

To maximize net worth, firms will add to capital stock until (13.15) holds as an equality:

$$P\frac{\partial Y}{\partial K} = rW_K + r\sum_{t=1}^{\infty} W_K\frac{\partial R_t}{\partial K}(1+r)^{-t} = c, \tag{13.16}$$

where c is the implicit rental price of capital.

The rental price consists of two components. The first term, rW_K, represents the opportunity cost associated with the initial investment. The second term, $r\sum_{t=1}^{\infty} W_K\frac{\partial R_t}{\partial K}(1+r)^{-t}$, is the present value of the cost of all future replacements required to maintain the productive capacity of the capital stock.

We can simplify the expression for the rental price in the following way. Let F denote the present value of the stream of capacity depreciation on one unit of capital according to the mortality distribution m:

$$F = \sum_{\tau=1}^{\infty} m(\tau)(1+r)^{-\tau}, \tag{13.17}$$

where $m(\tau) = -[S(\tau) - S(\tau-1)], (\tau = 1, 2, \ldots, L)$. It can be shown that

$$\sum_{t=1}^{\infty}\frac{\partial R_t}{\partial K}(1+r)^{-t} = \sum_{t=1}^{\infty} F^t = \frac{F}{(1-F)}, \tag{13.18}$$

so that

$$c = \frac{rW_K}{(1-F)}. \tag{13.19}$$

The real rate of return r in expression (13.19)[13] is calculated as the nominal yield on government bonds less the rate of inflation as measured by the implicit deflator for gross domestic product.[14] An ex ante rate is obtained by expressing observed real rates as an ARIMA process.[15] We then calculate F holding the required real rate of return constant for that vintage of capital goods. In this way, implicit rental prices c are calculated for each asset type.

Although we estimate the decline in efficiency of capital goods for each component of capital input separately for all twelve countries, we assume that the relative efficiency of new capital goods is the same in each country. The appropriate purchasing power parity for new capital goods is the purchasing power parity for the corresponding component of investment goods output (OECD, p. 162). To obtain the purchasing power parity for capital input, we multiply the purchasing power parity for investment goods for any country by the ratio of the price of capital input in that country relative to the United States.

13.3.3 Land Input

To estimate the stock of land in each country, we construct translog price indexes of land in farms. The stock of land is then constructed implicitly as the ratio of the value of land in farms to the translog price index. The rental price of land is obtained using equation (13.19), assuming zero replacement.

Spatial differences in land characteristics or quality prevent the direct comparison of observed prices. To account for these differences, indexes of relative prices of land are constructed using hedonic regression methods in which a good is viewed as a bundle of characteristics that contribute to the productivity derived from its use. According to the hedonic framework, the price of a good represents the valuation of the characteristics "that are bundled in it", and each characteristic is valued by its "implicit" price (Rosen, 1974). These prices are not observed directly and must be estimated from the hedonic price function.

A hedonic price function expresses the price of a good or service as a function of the quantities of the characteristics it embodies. Thus, the hedonic price function for land may be expressed as $W_L = W(X, D)$, where W_L represents the price of land, X is a vector of characteristics, and D is a vector of other variables.

The World Soil Resources Office of the US Department of Agriculture's Natural Resource Conservation Service has compiled data on characteristics that capture differences in land quality.[16] These characteristics include soil acidity, salinity, and moisture stress, among others.

In areas with moisture stress, agriculture is not possible without irrigation. Hence irrigation (i.e., the percentage of the cropland that is irrigated) is included as a separate variable. Because irrigation mitigates the negative impact of acidity on plant growth, the interaction between irrigation and soil acidity is included in the vector of characteristics.

In addition to environmental attributes, we also include a "population accessibility" score for each region in each country. These indexes are constructed using a gravity model of urban development, which provides a measure of accessibility to population concentrations (Shi et al., 1997). A gravity index accounts for both population density and distance from that population. The index increases as population increases and/or distance from the population center decreases.

Other variables (denoted by D) are also included in the hedonic equation, and their selection depends not only on the underlying theory but also on the objectives of the study. If the main objective of the study is to obtain price indexes adjusted for quality, as in our case, the only variables that should be included in D are country dummy variables, which will capture all price effects other than quality. After allowing for differences in the levels of the characteristics, the part of the price difference not accounted for by the included characteristics will be reflected in the country dummy coefficients.

Finally, economic theory places few, if any, restrictions on the functional form of the hedonic price function. In this study, we adopt a generalized linear form, where the dependent variable and each of the continuous independent variables is represented by the Box–Cox transformation. This is a mathematical expression that assumes a different functional form depending on the transformation parameter and can assume both linear and logarithmic forms, as well as intermediate nonlinear functional forms.

Thus the general functional form of our model is given by:

$$W_L(\lambda_0) = \sum_n \alpha_n X_n(\lambda_n) + \sum_d \gamma_d D_d + \varepsilon, \tag{13.20}$$

where $W_L(\lambda_0)$ is the Box–Cox transformation of the dependent price variable, $W_L > 0$; that is,

$$W_L\,(\lambda_0) = \begin{cases} \frac{W_L^{\lambda_0}-1}{\lambda_0}, \lambda_0 \neq 0, \\ \ln W_L, \lambda_0 = 0. \end{cases} \tag{13.21}$$

Similarly, $X_n\,(\lambda_n)$ is the Box–Cox transformation of the continuous quality variable X_n where $X_n\,(\lambda_n) = (X_n^{\lambda_n} - 1)/\lambda_n$ if $\lambda_n \neq 0$ and $X_n(\lambda_n) = \ln X_n$ if $\lambda_n = 0$. Variables represented by D are country dummy variables, not subject to transformation; λ, α, and γ are unknown parameter vectors, and ε is a stochastic disturbance.

13.3.4 Labor Input

Data on labor input in agriculture consist of hours worked disaggregated by hired and self-employed and unpaid family workers (Eurostat). Compensation of hired farm workers is defined as the average hourly wage plus the value of perquisites and employer contributions to social insurance.

The compensation of self-employed workers is not directly observable. These data are derived using the accounting identity where the value of total product is equal to total factor outlay.

13.4 Purchasing Power Parities

We estimate purchasing power parities for agricultural output in 1996 for the eleven European countries and the United States using equation (13.10) above. Equation (13.12) yields purchasing power parities for capital, land, labor, and materials inputs. These are relative prices expressed in terms of national currencies per dollar. We translate the purchasing power parities into relative prices in dollars by dividing by the exchange rate. These relative prices are shown in Table 13.1.

According to Table 13.1, the levels of output prices in the eleven European countries in 1996 were well above the US price level. The relative price of output was highest in Sweden at 1.629, or some 60% above the US price. The Netherlands had the lowest output price relative to the United States in 1996 at 1.338.

The European countries also faced higher prices for intermediate inputs in 1996. Relative prices ranged from 1.35 in Denmark to 1.055 in Ireland. The cost of capital input, other than land, exceeded that in the United States in all of the European countries except Germany, Ireland, and Italy. Among the eleven European countries, only Sweden had a lower price of land input in 1996. By contrast, the purchasing power parities for labor input in 1996 represent substantially lower costs of labor input in the European countries relative to the United States. In 1996, hourly earnings in the eleven European countries averaged slightly more than 50% of US hourly earnings. This result is consistent with the observation by Ball et al. (2001) that agriculture in the European countries is relatively labor intensive.

We have estimated purchasing power parities between the eleven European currencies and the dollar in 1996. We have also compiled price indexes for output and inputs in each country for the period 1973–2002. We obtain indexes of output and input prices in each country relative to those in the United States for each year by linking these time-series price indexes with estimates of relative prices for the base period. Table 13.2 presents indexes of relative output prices in the eleven European countries and the United States for the period 1973–2002, with a base equal to one in the United States in 1996.

According to the results presented in Table 13.2, the price index of agricultural output in Ireland in 1973 was 0.574, while that in the United States was 0.637. This implies that the Irish aggregate output price index in 1973 was only 90% of that in

Table 13.1 Output and input prices relative to the United States, 1996

	Belgium	Denmark	Germany	Greece	Spain	France	Ireland	Italy	The Netherlands	Sweden	United Kingdom
Output	1.3551	1.4402	1.4711	1.5046	1.3520	1.4907	1.4273	1.4973	1.3381	1.6300	1.6020
Materials	1.1623	1.3498	1.3087	1.1894	1.1886	1.2846	1.0550	1.3448	1.2356	1.3475	1.1729
Capital	1.2399	1.5483	0.8577	1.0143	1.1585	1.2051	0.8242	0.8577	1.5246	1.1211	1.2432
Land	3.2487	1.0169	2.2333	4.9054	4.6744	1.9533	4.1060	2.9146	8.1226	0.5692	2.2617
Labor	0.7923	0.8452	0.5308	0.3235	0.4221	0.5601	0.2896	0.4217	0.7048	0.4701	0.3971

Table 13.2 Output price relative to the 1996 level for the United States

Year	Belgium	Denmark	Germany	Greece	Spain	France	Ireland	Italy	The Netherlands	Sweden	United Kingdom	United States
1973	0.7189	0.8414	0.8690	0.8749	0.7579	0.7493	0.5742	0.7218	0.7702	1.3616	0.6032	0.6373
1974	0.6849	0.7823	0.8499	0.8619	0.7454	0.7638	0.5920	0.7182	0.6830	1.1678	0.6449	0.7159
1975	0.8470	0.9294	1.0029	0.9108	0.7809	0.9432	0.7229	0.7992	0.7789	1.3487	0.7414	0.6720
1976	0.9550	0.9645	1.0532	0.8432	0.7470	0.9159	0.7220	0.7519	0.8381	1.3768	0.7594	0.6790
1977	0.9108	0.9524	1.0751	0.8848	0.8051	0.9080	0.8317	0.8665	0.9061	1.4044	0.7834	0.6612
1978	1.0226	1.1408	1.1852	0.9902	0.8892	1.0236	1.0159	0.9874	0.9657	1.4626	0.8645	0.7418
1979	1.1408	1.2120	1.3361	1.1751	1.0657	1.1384	1.1499	1.1418	1.0751	1.5833	1.0603	0.8220
1980	1.2443	1.2635	1.3525	1.2180	1.0405	1.2306	1.1435	1.2313	1.0960	1.7706	1.2525	0.8629
1981	1.0567	1.1106	1.1422	1.1143	0.9446	1.0741	1.0503	1.0524	0.9942	1.6078	1.2041	0.8828
1982	0.9471	1.0255	1.0720	1.1078	0.8990	0.9877	0.9912	1.0124	0.9255	1.3877	1.1172	0.8589
1983	0.9305	1.0077	1.0159	1.0179	0.7462	0.9282	0.9440	0.9645	0.8926	1.2011	1.0228	0.9684
1984	0.8343	0.8826	0.8990	0.9505	0.7236	0.8241	0.8360	0.8984	0.8244	1.1364	0.9002	0.9236
1985	0.8083	0.8434	0.8508	0.9226	0.6893	0.8173	0.8104	0.8659	0.7742	1.0898	0.8569	0.8416
1986	0.9995	1.0873	1.0911	1.0122	0.9700	1.0618	1.0391	1.1093	0.9850	1.3683	0.9908	0.8338
1987	1.1779	1.2426	1.2683	1.1486	1.0594	1.1975	1.2007	1.2818	1.1576	1.6381	1.1380	0.8458
1988	1.1893	1.2409	1.2943	1.2242	1.1314	1.2225	1.3346	1.3319	1.1696	1.7758	1.2602	0.9174
1989	1.2298	1.2062	1.2890	1.2039	1.2147	1.2347	1.3560	1.3491	1.1497	1.7435	1.2372	0.9432
1990	1.3653	1.3490	1.4065	1.5071	1.3944	1.4426	1.3259	1.6194	1.2828	1.9501	1.3796	0.9505
1991	1.2883	1.2880	1.3487	1.5173	1.4009	1.3694	1.2575	1.6000	1.2604	1.9202	1.3832	0.9158
1992	1.3016	1.3680	1.4151	1.4773	1.3376	1.3870	1.3570	1.6014	1.3069	1.9932	1.4226	0.9025
1993	1.1619	1.1900	1.3151	1.2884	1.1778	1.2860	1.2654	1.2815	1.1539	1.4620	1.3541	0.9359
1994	1.2436	1.2474	1.3681	1.3371	1.2698	1.3678	1.3055	1.2842	1.2084	1.5008	1.4115	0.9143
1995	1.3525	1.4619	1.5540	1.5204	1.5182	1.5526	1.4647	1.3659	1.3789	1.5905	1.5900	0.9456
1996	1.3551	1.4402	1.4711	1.5046	1.3520	1.4907	1.4273	1.4973	1.3381	1.6300	1.6020	1.0000
1997	1.1990	1.2572	1.2808	1.3574	1.1549	1.3154	1.3066	1.3619	1.1790	1.4150	1.4870	0.9635
1998	1.1010	1.1035	1.1886	1.2530	1.1282	1.2871	1.2223	1.3171	1.1277	1.3959	1.3762	0.9196
1999	0.9919	1.0398	1.0679	1.2069	1.1245	1.1894	1.1436	1.2168	1.0219	1.2833	1.2892	0.8856
2000	0.9161	0.9693	0.9910	1.0503	0.9578	1.0508	1.0393	1.0735	0.9268	1.1717	1.1778	0.8966
2001	0.9698	1.0146	0.9935	1.0594	0.9665	1.0759	1.0173	1.0877	0.9664	1.1038	1.2060	0.9053
2002	0.9459	0.9784	1.0061	1.1319	0.9924	1.0945	1.0406	1.1689	1.0126	1.1560	1.2141	0.8733

the United States. In that same year, the ratio of the output price index in the United Kingdom to the US price index was 95%. These results imply that Ireland and the United Kingdom had a competitive advantage relative to the United States in 1973.

Output prices in the other countries in the comparison were well above the level in the United States. The price index in Belgium in 1973 was 0.719. This was nearly 13% above the US price index. In France, the index of output prices was 0.749, or 18% above the US level. The price gap widens further when the comparison is between Sweden and the United States. The index of output prices in Sweden in 1973 was 1.362, or more than double the US price index.

The levels of output prices in the eleven European countries increased relative to the United States during the 1970s. This was a consequence of more rapid inflation in most European countries and an appreciation of the European currencies relative to the dollar through 1980. The competitiveness of US agriculture reached a temporary peak in that year.

The situation changed in the early 1980s. By then the European countries and the United States were vigorously pursuing policies to combat inflation. The change to restrictive monetary policy initiated by the Federal Reserve pushed up interest rates sharply. The dollar appreciated on foreign exchange markets, and world export prices started to fall. By 1984, the price level in most European countries was well below the US price.[17] This had the short-run effect of restoring the competitiveness of European Union agriculture.[18]

The US inflation rate slowed between 1981 and 1986. This was followed by a rapid depreciation of the dollar. By 1986, the level of prices in the European countries, denominated in dollars, once again exceeded the US price. The continued weakness of the dollar through the early 1990s resulted in a further deterioration of the international competitiveness of European Union agriculture. By 1995, prices in most European countries were at their highest levels relative to the United States. But a strengthening dollar between 1996 and 2001 eroded much of the competitive advantage of the United States.[19]

According to the results reported in Table 13.3, the price of materials in the European countries in 1973 exceeded that in the United States. These relative prices trend higher during the 1970s, but the rapid appreciation of the dollar in the early 1980s reversed this trend. By 1984, the price of materials input in the European countries had fallen below the level in the United States. The price of materials increased relative to the United States after 1984, a consequence of the depreciation of the dollar. Relative materials prices reached a peak in the early 1990s. But the subsequent appreciation of the dollar resulted in a decline in relative prices. By 2001, the relative cost of materials in most European countries was again below that in the United States.

A comparison of capital input prices is provided in Table 13.4. The patterns of change for relative capital input prices are similar to those for relative output and materials input prices. Initially, the cost of capital in a number of the European countries was below that in the United States but rose to well above the US level by 1979. The rapid increase in the cost of capital in the United States during the early 1980s and the appreciation of the dollar resulted in a decline in this relative price.

Table 13.3 Materials price relative to the 1996 level for the United States

Year	Belgium	Denmark	Germany	Greece	Spain	France	Ireland	Italy	The Netherlands	Sweden	United Kingdom	United States
1973	0.7097	0.6968	0.7468	0.7168	0.3821	0.6495	0.4187	0.7122	0.6033	0.6904	0.4491	0.4339
1974	0.6591	0.7687	0.7665	0.6856	0.4237	0.6449	0.4622	0.7191	0.5808	0.6047	0.5590	0.5420
1975	0.7225	0.8348	0.7996	0.6532	0.4608	0.8047	0.5198	0.8217	0.6284	0.6417	0.6040	0.5546
1976	0.7681	0.8504	0.8595	0.5810	0.4476	0.7337	0.5102	0.7651	0.6481	0.6666	0.5731	0.5605
1977	0.8385	0.9106	0.9616	0.5633	0.4845	0.6921	0.5964	0.8139	0.7213	0.7021	0.6324	0.5697
1978	0.9161	0.9724	1.0237	0.5945	0.5869	0.7738	0.6832	0.9032	0.8024	0.7606	0.7163	0.5773
1979	1.0347	1.0737	1.1687	0.7455	0.7035	0.8757	0.7697	1.0162	0.9112	0.8620	0.8832	0.6459
1980	1.1387	1.1530	1.2125	0.8357	0.7897	0.9836	0.8641	1.3044	0.9735	1.0110	1.0931	0.7202
1981	0.9678	1.0565	1.0657	0.7797	0.7341	0.8682	0.7675	1.1205	0.8405	0.9595	1.0376	0.7747
1982	0.8648	0.9949	1.0066	0.7459	0.6998	0.8188	0.7434	1.0531	0.8197	0.8694	0.9502	0.7716
1983	0.8375	0.9696	0.9756	0.6965	0.7247	0.7783	0.7005	1.0369	0.7831	0.7839	0.8882	0.8193
1984	0.8006	0.9005	0.8829	0.6487	0.7215	0.7193	0.6557	0.9597	0.7375	0.7798	0.8031	0.8024
1985	0.7658	0.8404	0.8075	0.6289	0.7143	0.7188	0.6512	0.8972	0.6936	0.7930	0.7723	0.7444
1986	0.9203	1.0461	1.0043	0.7060	0.9489	0.9169	0.7928	1.0959	0.8532	0.9657	0.8580	0.6868
1987	1.0539	1.1800	1.1297	0.8123	1.1190	1.0338	0.8545	1.2567	0.9654	1.0967	0.9561	0.6858
1988	1.0563	1.2483	1.1613	0.8789	1.1703	1.0637	0.9009	1.2457	0.9920	1.2012	1.0390	0.8014
1989	1.0189	1.1764	1.1086	0.8373	1.1203	1.0341	0.8590	1.2168	0.9434	1.2369	1.0175	0.8387
1990	1.1945	1.2899	1.2413	1.0275	1.3025	1.1948	1.0041	1.4141	1.0720	1.4044	1.1439	0.8266
1991	1.0957	1.2521	1.2148	1.0650	1.2986	1.1471	0.9741	1.4297	1.0669	1.4020	1.1569	0.8247
1992	1.1948	1.3232	1.3047	1.1512	1.3232	1.1951	1.0481	1.4349	1.1457	1.4817	1.1598	0.8223
1993	1.0550	1.2194	1.1762	1.0158	1.0663	1.0914	0.9106	1.1811	1.0781	1.0961	1.0220	0.8520
1994	1.0407	1.2166	1.2062	1.0790	1.0774	1.1193	0.9378	1.1448	1.1063	1.0975	1.0438	0.8719
1995	1.1512	1.3693	1.3715	1.1614	1.1721	1.2799	1.0217	1.2211	1.2621	1.2180	1.1261	0.9092
1996	1.1623	1.3498	1.3087	1.1894	1.1886	1.2846	1.0550	1.3448	1.2356	1.3475	1.1729	1.0000
1997	1.0119	1.1987	1.1492	1.0672	1.0524	1.1285	0.9926	1.2104	1.0782	1.1925	1.1666	0.9726
1998	0.9561	1.1574	1.0619	0.9870	1.0462	1.0797	0.9170	1.1632	1.0536	1.1466	1.1160	0.9120
1999	0.9000	1.0997	0.9975	0.9681	0.9539	1.0191	0.8777	1.1263	1.0030	1.1078	1.0782	0.8685
2000	0.8286	0.9652	0.8824	0.8736	0.8413	0.9033	0.8011	1.0084	0.9009	1.0205	1.0338	0.9054
2001	0.8288	0.9869	0.8117	0.8463	0.8435	0.9190	0.8141	1.0309	0.9329	0.9595	1.0154	0.9501
2002	0.8839	1.0452	0.9106	0.9029	0.9963	0.9687	0.8788	1.0874	1.0030	1.0268	1.0574	0.9578

Table 13.4 Capital price relative to the 1996 level for the United States

Year	Belgium	Denmark	Germany	Greece	Spain	France	Ireland	Italy	The Netherlands	Sweden	United Kingdom	United States
1973	0.3716	0.2517	0.2113	0.1734	0.1982	0.2447	0.1597	0.2827	0.3003	0.3556	0.3145	0.2737
1974	0.4216	0.3428	0.2414	0.1998	0.2322	0.2869	0.1948	0.3501	0.3515	0.3986	0.3811	0.2942
1975	0.4362	0.3240	0.2671	0.2091	0.2581	0.3448	0.2109	0.3423	0.3798	0.4784	0.4314	0.3225
1976	0.4415	0.3397	0.2611	0.2111	0.2440	0.3270	0.2044	0.3221	0.3891	0.4927	0.4213	0.3402
1977	0.5138	0.3899	0.2878	0.2349	0.2546	0.3616	0.2357	0.3840	0.4734	0.5090	0.4654	0.3752
1978	0.6248	0.5253	0.3477	0.2753	0.2987	0.4454	0.2897	0.4960	0.5801	0.5361	0.5582	0.4217
1979	0.7146	0.6116	0.4450	0.3268	0.4057	0.5024	0.3118	0.6781	0.6922	0.6096	0.7171	0.4850
1980	0.8420	0.6444	0.4721	0.3738	0.4585	0.5748	0.3545	0.3783	0.8165	0.7717	0.8645	0.5739
1981	0.8121	0.5912	0.4453	0.4091	0.4683	0.5853	0.3443	0.3674	0.7898	0.7476	0.8610	0.7229
1982	0.6985	0.6171	0.4206	0.4323	0.4839	0.6160	0.3342	0.3529	0.7296	0.6687	0.8175	0.7490
1983	0.6174	0.5495	0.3922	0.3926	0.4252	0.5551	0.3465	0.3527	0.6011	0.6123	0.7677	0.8189
1984	0.5699	0.4527	0.3643	0.3363	0.4650	0.4345	0.3291	0.3270	0.5224	0.5774	0.7269	0.9273
1985	0.5502	0.4427	0.3520	0.3035	0.4139	0.4478	0.3910	0.3217	0.5055	0.6113	0.7024	0.8568
1986	0.6818	0.6066	0.4698	0.3815	0.5722	0.6120	0.5160	0.4427	0.6639	0.7607	0.6864	0.7532
1987	0.7887	0.8423	0.5752	0.4302	0.6953	0.7245	0.6126	0.5524	0.8758	0.9020	0.8636	0.8016
1988	0.8574	0.9869	0.6159	0.5179	0.9160	0.8377	0.7574	0.6033	0.9938	1.0233	1.0550	0.8373
1989	0.8779	0.9338	0.6315	0.5855	1.0154	0.8571	0.6956	0.6349	1.0555	1.0330	1.0165	0.8531
1990	1.0603	1.2977	0.8195	0.7719	1.3405	1.1254	0.7369	0.7986	1.4497	1.2844	1.1575	0.8790
1991	1.1189	1.3335	0.7651	0.9180	1.4161	1.1168	0.7082	0.8912	1.4772	1.2882	1.1558	0.8662
1992	1.1981	1.3562	0.8495	0.9803	1.3493	1.1972	0.7972	0.8977	1.5405	1.2877	1.2976	0.8575
1993	1.0386	1.1536	0.7311	0.9631	0.9621	0.9988	0.6791	0.7191	1.3364	0.9620	1.2480	0.8659
1994	1.0875	1.2803	0.7776	0.9179	0.9503	1.1042	0.6326	0.7326	1.4340	0.9413	1.3018	0.9303
1995	1.3093	1.6696	0.9796	1.0049	1.1815	1.2772	0.9090	0.7821	1.6589	1.1103	1.3563	0.9795
1996	1.2399	1.5483	0.8577	1.0143	1.1585	1.2051	0.8242	0.8577	1.5246	1.1211	1.2432	1.0000
1997	1.0855	1.2046	0.7172	0.8291	0.9516	1.0283	0.7563	0.7877	1.3631	0.9471	1.1899	1.0295
1998	1.0289	1.0290	0.7018	0.8810	0.9498	0.9730	0.6125	0.7646	1.2836	0.8922	1.1543	0.9902
1999	0.9809	1.0658	0.6775	0.8359	0.8955	0.9534	0.5603	0.7603	1.2689	0.8702	1.0714	1.0669
2000	0.9091	1.0311	0.6481	0.6449	0.8111	0.8796	0.5424	0.6555	1.1911	0.7709	1.0067	1.0908
2001	0.8786	0.9727	0.6552	0.6860	0.7461	0.8551	0.5512	0.6624	1.1471	0.7055	0.9380	1.0165
2002	0.9138	0.9849	0.6611	0.7411	0.7726	0.8467	0.5572	0.6867	1.1616	0.8341	0.9811	0.9994

By 1984, the price of capital in the European countries had fallen to its lowest level relative to the United States. The subsequent weakness of the dollar and declining capital costs in the United States resulted in an increase in the cost of capital in the European countries relative to the United States. The appreciation of the dollar after 1995 reversed this trend.

As can be seen in Table 13.5, the differences in relative land input prices in 1973 were much larger than differences in relative capital input prices. The price of land input in the Netherlands in 1973 was more than six times the level of prices in the United States. In Sweden, however, this relative price was less than one-half the US price. The differences in relative prices had narrowed substantially by the early 1980s, a result of rapid increases in the price of land input in the United States and the appreciation of the dollar. But the farm debt crisis of the 1980s and the ensuing collapse of land prices in the United States resulted in a sharp divergence of relative prices. By 1992, the price of land input in the Netherlands was twelve times the US price. The recovery of land prices in the United States during mid-1990s and the appreciation of the dollar resulted in some narrowing of the differences in relative land input prices, but price levels in the European countries remained well above the level in the United States.

Finally, a comparison of labor input prices appears in Table 13.6. The patterns of change in relative wage rates bear little resemblance to those for relative materials and capital input prices. Rapid wage increases in the European countries during the 1970s and a declining dollar sent wages rates in the European countries above the US level. But the subsequent appreciation of the dollar resulted in a decline in relative wage rates. By 2002, the wage rate in Belgium had fallen to 67% of the US wage rate. The relative wage in Ireland in 2002 was only 33% of the US level.

Our international comparisons of relative output and input prices show, first, that US agriculture has been more competitive than its European counterparts throughout the period 1973–2002, except for the years 1973–1974 and 1983–1985. Second, lower costs of materials, capital, and land inputs contributed to US international competitiveness for most of this period.

13.5 Relative Productivity Levels

In this section, we estimate relative levels of productivity in agriculture for the eleven European countries and the United States for the period 1973–2002. Ball et al. (2001) have reported relative productivity levels for nine of the eleven European countries and the United States for the period 1973–1993. In 1973, six European countries had higher levels of productivity than the United States. The United States closed the gap with two of these countries during the sample period. However, differences in productivity levels between four of the European countries – Belgium, Denmark, France, and the Netherlands – and the United States remained at the end of the period in 1993.

Table 13.5 Land price relative to the 1996 level for the United States

Year	Belgium	Denmark	Germany	Greece	Spain	France	Ireland	Italy	The Netherlands	Sweden	United Kingdom	United States
1973	0.7476	0.1406	0.7791	1.6116	1.0369	0.5136	0.2370	0.3005	1.7234	0.1077	0.3327	0.2628
1974	0.7331	0.2983	0.8246	1.5700	0.9639	0.7068	0.5083	0.4767	2.6926	0.1038	0.2439	0.2347
1975	0.4299	0.1669	0.6506	1.0085	0.7287	0.7322	0.3427	0.2964	1.3595	0.1309	0.0993	0.1870
1976	0.5564	0.2614	0.3995	0.7937	0.5020	0.4886	0.4899	0.2375	0.9472	0.1038	0.0913	0.1786
1977	0.9868	0.4459	0.3768	0.7386	0.3953	0.3653	0.7561	0.2180	1.9883	0.0691	0.0897	0.2574
1978	1.8310	0.9723	0.5799	0.7027	0.3490	0.3403	0.7729	0.2706	3.1814	0.0433	0.1312	0.3954
1979	2.3771	1.1048	1.8706	0.8153	0.3919	0.3143	0.8262	0.4633	4.0613	0.0383	0.3463	0.5880
1980	4.2142	0.8900	2.3255	1.1903	0.5018	0.4865	0.5640	0.6403	3.9482	0.0875	0.4108	0.8714
1981	4.4137	0.3562	3.6310	2.2548	0.6498	1.0723	0.7781	1.1652	3.0703	0.1548	0.3782	1.4552
1982	2.8306	0.2170	2.9133	3.3564	0.8629	1.2170	0.5838	0.8287	2.3024	0.1694	0.5438	1.3201
1983	2.0442	0.2456	2.5110	3.0519	0.7694	0.8464	0.9452	0.7133	2.0477	0.1612	0.5734	1.5105
1984	2.0379	0.1634	2.5738	2.2900	1.0894	0.5391	0.7308	0.5458	2.4152	0.1629	0.6335	1.8294
1985	1.9121	0.2619	2.2268	1.6729	0.8711	0.5251	1.3317	0.4500	2.9347	0.2295	0.4965	1.3250
1986	2.0398	0.3803	2.5510	1.3360	1.8781	0.8163	1.9531	0.7226	5.4748	0.2913	0.6897	0.7463
1987	2.3424	0.6753	3.0895	1.7515	3.0838	1.4638	2.1547	1.2559	6.6694	0.4063	0.9191	0.8502
1988	3.0165	0.9391	3.2448	2.1800	6.1029	1.9889	2.9627	1.8939	9.5227	0.5723	1.4137	0.8892
1989	3.7179	0.8978	3.7953	3.1121	7.5286	1.9941	3.3163	2.5015	9.7868	0.7143	1.5104	0.8417
1990	4.3123	1.4749	5.7303	4.5986	9.1538	2.9397	3.5645	3.3281	10.4906	1.1580	1.5540	0.8944
1991	4.5418	1.4058	4.1079	4.7887	7.5596	2.6846	2.8606	4.3389	9.3810	1.1142	1.1647	0.8102
1992	4.5395	0.9871	3.7840	6.3217	5.3179	2.5337	2.9251	3.4712	9.0047	0.8318	0.9174	0.7335
1993	2.7524	0.5184	1.8923	5.2007	3.2569	1.7596	2.1784	2.4442	6.6270	0.3426	1.1274	0.7166
1994	2.6834	0.7136	2.2536	5.7715	3.3266	1.9139	1.6486	2.6045	5.7365	0.4976	1.3942	0.8802
1995	3.8427	1.2129	3.9673	6.0218	4.7560	2.3241	4.4059	3.0330	8.8239	0.6479	2.2077	0.9605
1996	3.2487	1.0169	2.2333	4.9054	4.6744	1.9533	4.1060	2.9146	8.1226	0.5692	2.2617	1.0000
1997	2.6307	0.6778	1.7461	4.1281	4.4010	1.4864	4.4092	2.3513	7.6223	0.4543	1.5207	1.0979
1998	2.1162	0.4125	1.5562	3.4279	4.7489	1.2974	2.6765	2.2096	8.0486	0.4867	1.2129	0.9085
1999	2.0724	0.6391	1.4925	4.5035	4.7363	1.3400	2.2223	2.4576	5.4840	0.5377	0.9530	1.1808
2000	2.4700	0.7612	1.8154	3.3819	3.5680	1.4991	3.6493	1.9878	4.8812	0.4952	1.0887	1.2241
2001	2.2189	0.8439	1.9399	2.3662	2.7856	1.4077	4.1153	2.2206	4.4436	0.5818	0.8530	0.8209
2002	2.0984	0.7877	1.6661	2.4435	2.4160	1.2550	2.2444	2.0184	4.9510	0.7267	0.7602	0.6918

Table 13.6 Labor price relative to the 1996 level for the United States

Year	Belgium	Denmark	Germany	Greece	Spain	France	Ireland	Italy	The Netherlands	Sweden	United Kingdom	United States
1973	0.2345	0.2172	0.2029	0.0848	0.0934	0.1477	0.0663	0.1163	0.4627	0.1699	0.1202	0.3125
1974	0.2473	0.2286	0.1966	0.0995	0.0890	0.1421	0.0654	0.0935	0.3809	0.1756	0.1158	0.3079
1975	0.3165	0.2280	0.2287	0.1195	0.1005	0.1670	0.1056	0.1268	0.4378	0.2141	0.1685	0.3103
1976	0.3269	0.1909	0.3071	0.1139	0.1105	0.1798	0.0937	0.0990	0.4777	0.2259	0.1805	0.2972
1977	0.3002	0.1999	0.3416	0.1184	0.1315	0.1873	0.1224	0.1264	0.4638	0.2513	0.2005	0.3133
1978	0.3544	0.2643	0.4092	0.1511	0.1586	0.2443	0.1589	0.1412	0.4228	0.2785	0.2286	0.3585
1979	0.3391	0.1956	0.3894	0.1665	0.2041	0.3092	0.1602	0.1581	0.4226	0.2853	0.2508	0.4162
1980	0.2661	0.1805	0.3366	0.1653	0.2237	0.3060	0.1535	0.1872	0.3138	0.3148	0.3138	0.2562
1981	0.1682	0.2227	0.1646	0.1141	0.1486	0.2207	0.1286	0.1336	0.3919	0.3201	0.3109	0.2361
1982	0.2123	0.2654	0.2580	0.1281	0.1510	0.2299	0.1455	0.1453	0.3782	0.3186	0.2809	0.2633
1983	0.2698	0.2193	0.2508	0.1226	0.1180	0.2137	0.1329	0.1592	0.4420	0.2275	0.2141	0.1159
1984	0.2463	0.3651	0.2226	0.1456	0.1320	0.2200	0.1425	0.1397	0.3836	0.2975	0.2187	0.2382
1985	0.2560	0.3404	0.2083	0.1657	0.1575	0.2279	0.1032	0.1481	0.3108	0.2183	0.1916	0.3756
1986	0.4026	0.5292	0.3295	0.1869	0.1682	0.3092	0.1136	0.2034	0.5099	0.3221	0.2484	0.5781
1987	0.4722	0.4427	0.3371	0.2114	0.2012	0.3438	0.1810	0.2348	0.5707	0.3519	0.2761	0.6276
1988	0.4920	0.4522	0.3284	0.2270	0.1818	0.3142	0.2069	0.2052	0.5382	0.3977	0.2536	0.5579
1989	0.5894	0.6113	0.3381	0.2228	0.1610	0.3447	0.2034	0.2248	0.5857	0.4545	0.2909	0.7505
1990	0.6465	0.6382	0.4304	0.2248	0.1631	0.3908	0.2154	0.2261	0.6436	0.5681	0.3196	0.8216
1991	0.6046	0.5696	0.2467	0.2989	0.1793	0.3154	0.2129	0.2380	0.6410	0.4646	0.3740	0.7644
1992	0.6635	0.5525	0.2907	0.2631	0.1935	0.3851	0.2748	0.2555	0.6508	0.4091	0.4155	0.9477
1993	0.7023	0.5901	0.4037	0.1952	0.2767	0.4065	0.2737	0.2275	0.5543	0.4026	0.3674	0.8883
1994	0.7719	0.6520	0.4405	0.2522	0.3352	0.4621	0.3146	0.2690	0.6758	0.4294	0.3782	0.9697
1995	0.7100	0.7963	0.3904	0.3332	0.3256	0.5366	0.2536	0.3245	0.7173	0.4377	0.3839	0.7872
1996	0.7923	0.8452	0.5308	0.3235	0.4221	0.5601	0.2896	0.4217	0.7048	0.4701	0.3971	1.0000
1997	0.7608	0.8067	0.5017	0.3258	0.4042	0.5438	0.2569	0.4280	0.5424	0.4614	0.3882	0.9153
1998	0.7724	0.6580	0.4957	0.2889	0.3873	0.6046	0.3194	0.4659	0.5993	0.4464	0.3814	0.9392
1999	0.6798	0.5775	0.4562	0.3010	0.3667	0.5491	0.3010	0.4574	0.5694	0.3362	0.4258	0.8095
2000	0.5898	0.6051	0.3489	0.2858	0.3910	0.4348	0.2680	0.3917	0.5261	0.3575	0.3633	0.8753
2001	0.6424	0.7454	0.3349	0.2967	0.4698	0.4326	0.2298	0.3827	0.5585	0.3290	0.4047	0.9379
2002	0.5940	0.5604	0.3481	0.3199	0.5249	0.4884	0.2883	0.4177	0.5366	0.3176	0.5153	0.8838

In order to extend the observations through 2002 we must take note of the following revisions of the data. First, the measure of output in the present study includes the value of services, such as machine hire. While accounting for a relatively small share of total output, this series exhibits very rapid growth. Second, our measure of capital input reflects subsidies on purchases of new capital goods (see Note 16). We used this information to improve our estimates of the user cost of capital. Finally, we have compiled regionally disaggregated data on land values and characteristics that reflect land quality. These data allow us to estimate hedonic price indexes for land that reflect differences in land quality across countries.

The revisions of the data have resulted in substantial changes in the rank ordering of countries from that presented in Ball et al. (2001). As can be seen in Table 13.7, only two countries – Belgium and the Netherlands – had higher levels of productivity than the United States in 1973. Moreover, the United States had closed the gaps in productivity by the early 1990s.

Sweden and Spain were the only European countries to achieve faster rates of productivity growth in agriculture than did the United States. Most remarkable was the performance of Spain. Spain began the period in 1973 with the second lowest relative level of total factor productivity of any European country but had overtaken Greece by 1977, Ireland by 1978, Italy by 1979, France by 1984, Germany and the United Kingdom by 1985, and Belgium and Denmark by 2002.

There are several likely explanations for Spain's rapid productivity growth. The first is technological "catch-up" by initially backward countries. The idea is that imitation is less costly than innovation, so that countries initially lagging behind the technology leaders experience faster improvements in technology than do the leaders. Furthermore, the rate of catch-up should accelerate as these countries become more integrated with the rest of Europe.

A second factor is capital deepening. Of the eleven European countries, only Denmark, France, and Ireland had faster rates of growth of capital per unit of labor than did Spain. Ball et al. (2001) find this to be an important factor in determining the speed of convergence of productivity. Thirdly, it can be argued that integration in the European Union has led to increased specialization in production of goods that are competitive in export markets. Mora and San Juan (2004) find that those regions initially specializing in production for export have increased their share of total output since Spain's joining of the European Union.[20]

Finally, we turn to international competitiveness of European and US agriculture. We can account for movements in relative prices of output in the twelve countries by changes in relative input prices and changes in relative productivity levels. Figure 13.1shows the relative price of output in the eleven European countries expressed in dollars. We have expressed these prices in logarithmic form so that a positive difference implies that the output price in the comparison country is above the US price, while a negative difference implies a higher price in the United States. In Figs. 13.2 and 13.3, we show, respectively, indexes of relative input prices and relative levels of productivity.

In the 1970s, output prices in the European countries were above the US price level, due primarily to lower levels of productivity. Although lower labor costs in

Table 13.7 Total factor productivity relative to the 1996 level for the United States

Year	Belgium	Denmark	Germany	Greece	Spain	France	Ireland	Italy	The Netherlands	Sweden	United Kingdom	United States
1973	0.6802	0.5343	0.4609	0.3469	0.3259	0.4806	0.3609	0.4712	0.7476	0.2916	0.4710	0.5730
1974	0.7018	0.6380	0.4865	0.3643	0.3323	0.4759	0.3900	0.4539	0.7850	0.3235	0.5014	0.5601
1975	0.6461	0.5558	0.4437	0.3769	0.3447	0.4664	0.4053	0.4740	0.7433	0.3162	0.4864	0.6047
1976	0.6037	0.5212	0.4730	0.3779	0.3707	0.4609	0.3835	0.4287	0.7243	0.3222	0.4673	0.5944
1977	0.6662	0.5696	0.5136	0.3655	0.3889	0.4583	0.4113	0.4340	0.7285	0.3363	0.4959	0.6434
1978	0.6837	0.5525	0.5306	0.3939	0.4190	0.4846	0.4091	0.4336	0.7312	0.3499	0.5161	0.6275
1979	0.6705	0.5391	0.5496	0.3873	0.4422	0.5139	0.3825	0.4393	0.7361	0.3556	0.5189	0.6569
1980	0.6707	0.5407	0.5456	0.4294	0.5063	0.5127	0.4015	0.4519	0.7297	0.3722	0.5444	0.6232
1981	0.6838	0.5818	0.5524	0.4284	0.4516	0.5144	0.3937	0.4386	0.7653	0.3996	0.5485	0.6974
1982	0.6916	0.6236	0.5920	0.4457	0.4857	0.5598	0.4229	0.4478	0.7851	0.4304	0.5617	0.7203
1983	0.6865	0.5935	0.5868	0.4222	0.5170	0.5462	0.4310	0.4805	0.7915	0.4229	0.5507	0.6200
1984	0.7202	0.6954	0.6036	0.4411	0.5759	0.5654	0.4743	0.4618	0.7891	0.4725	0.5954	0.7389
1985	0.7169	0.6834	0.5845	0.4552	0.6087	0.5760	0.4671	0.4716	0.7776	0.4655	0.5731	0.7894
1986	0.7332	0.7071	0.5951	0.4667	0.5462	0.5834	0.4424	0.4833	0.8181	0.4731	0.5720	0.7864
1987	0.7138	0.6720	0.5758	0.4716	0.6066	0.5961	0.4673	0.4925	0.8041	0.4483	0.5714	0.8132
1988	0.7313	0.7219	0.5836	0.4944	0.6422	0.5991	0.4777	0.4613	0.8302	0.4600	0.5631	0.7832
1989	0.7394	0.7571	0.5921	0.5112	0.6057	0.6040	0.4505	0.4794	0.8502	0.4939	0.5780	0.8535
1990	0.7704	0.7722	0.6718	0.4516	0.6331	0.6206	0.5079	0.4504	0.8858	0.5244	0.5795	0.8769
1991	0.7748	0.7801	0.5960	0.5503	0.6320	0.6059	0.5160	0.4886	0.8961	0.5079	0.5873	0.8774
1992	0.8339	0.7520	0.6202	0.5378	0.6412	0.6468	0.5485	0.4944	0.9061	0.4895	0.5951	0.9550
1993	0.8408	0.8017	0.6204	0.5157	0.6453	0.6378	0.5254	0.5154	0.9142	0.5225	0.5792	0.9126
1994	0.8025	0.7998	0.6337	0.5593	0.6418	0.6444	0.5239	0.5467	0.9349	0.5181	0.5810	0.9969
1995	0.8010	0.8124	0.6460	0.5750	0.5966	0.6569	0.5258	0.5788	0.9395	0.5394	0.5681	0.9276
1996	0.8135	0.8135	0.6570	0.5704	0.7310	0.6799	0.5483	0.6139	0.9312	0.5676	0.5637	1.0000
1997	0.8176	0.8168	0.6660	0.5903	0.7734	0.6874	0.5548	0.6358	0.9029	0.5865	0.5679	1.0048
1998	0.8481	0.8407	0.6804	0.6134	0.7744	0.6984	0.5543	0.6659	0.9417	0.5710	0.5791	1.0085
1999	0.8712	0.8512	0.7140	0.6294	0.7245	0.7127	0.5498	0.7146	0.9688	0.5731	0.5962	1.0061
2000	0.8733	0.8504	0.6936	0.6348	0.7885	0.7085	0.5719	0.7013	0.9736	0.5898	0.6160	1.0449
2001	0.8331	0.8536	0.6664	0.6361	0.8163	0.6908	0.5729	0.6991	0.9537	0.5859	0.5920	1.0392
2002	0.8720	0.8624	0.6945	0.6351	0.8783	0.7138	0.5924	0.6836	0.9489	0.5989	0.6328	1.0476

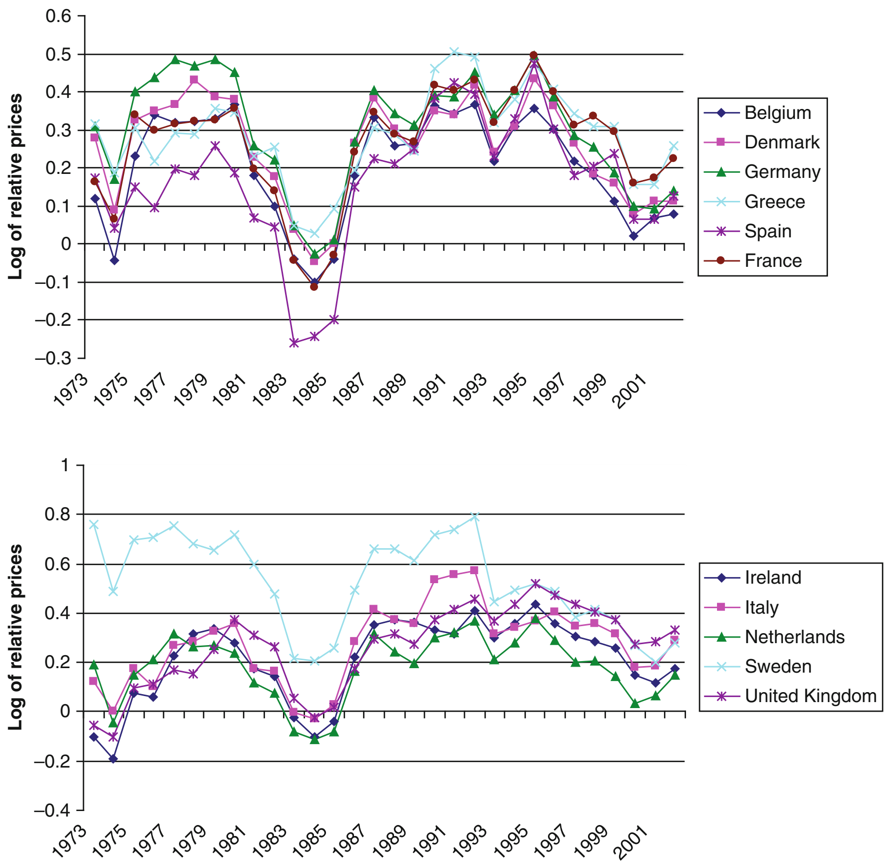

Fig. 13.1 Trends of differences in relative output prices denominated in dollars

the European countries helped to reduce relative prices of output, they were totally offset by lower levels of productivity in all the European countries except Belgium and the Netherlands. These two countries had higher levels of productivity than the United States in the 1970s, but they faced substantially higher prices for capital and land inputs.

The international competitiveness of European agriculture improved during the early 1980s in spite of productivity gains in the United States. This was because of more rapid increases in the costs of capital and land inputs in the United States and the appreciation of the dollar since 1980.

Output prices in the European countries increased relative to the United States after 1984. A weaker dollar resulted in higher prices of materials, capital, and land inputs in the European countries. Slower growth of productivity in the European countries further eroded their international competitiveness.

The upward trend in relative output prices was reversed after 1995, notwithstanding the increasing US productivity advantage. More rapid increases in the prices of

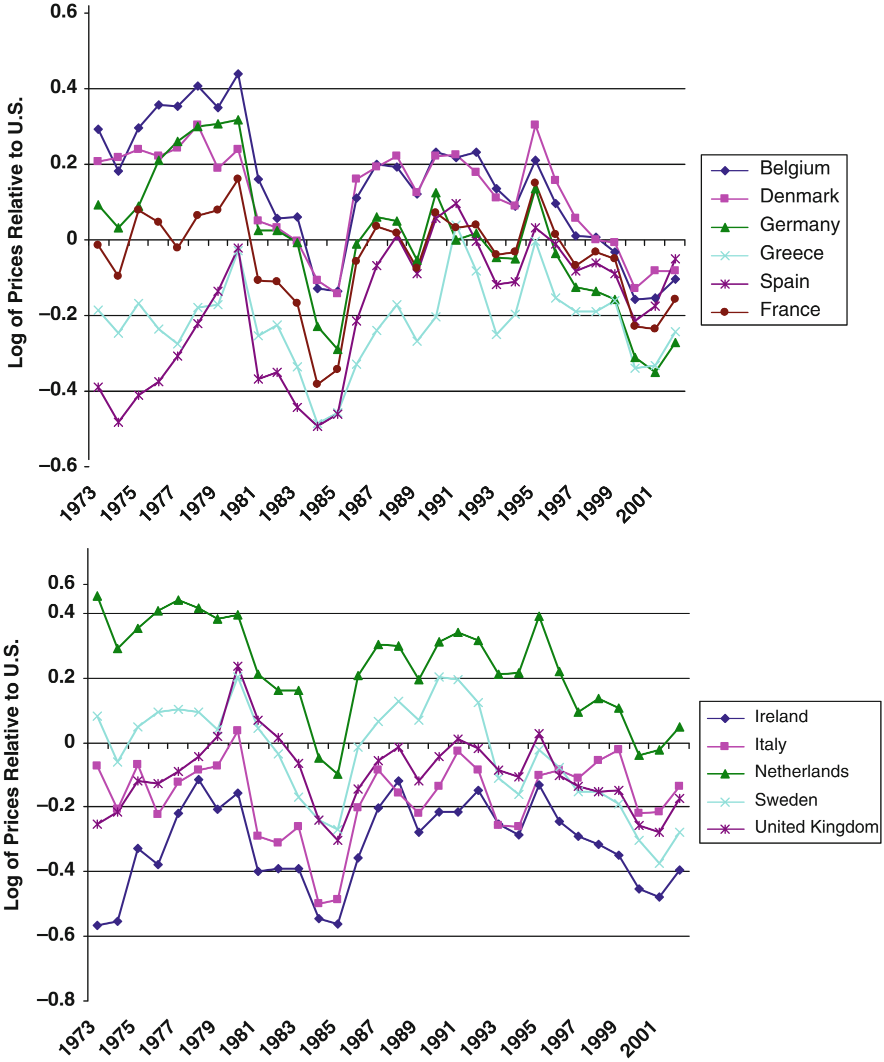

Fig. 13.2 Trends of differences in relative input prices denominated in dollars

capital and materials inputs and the appreciation of the dollar pushed output prices in the United States higher.

13.6 Summary and Conclusions

This study looks at international competitiveness of agriculture in the European Union and the United States. Our measure of international competitiveness is the

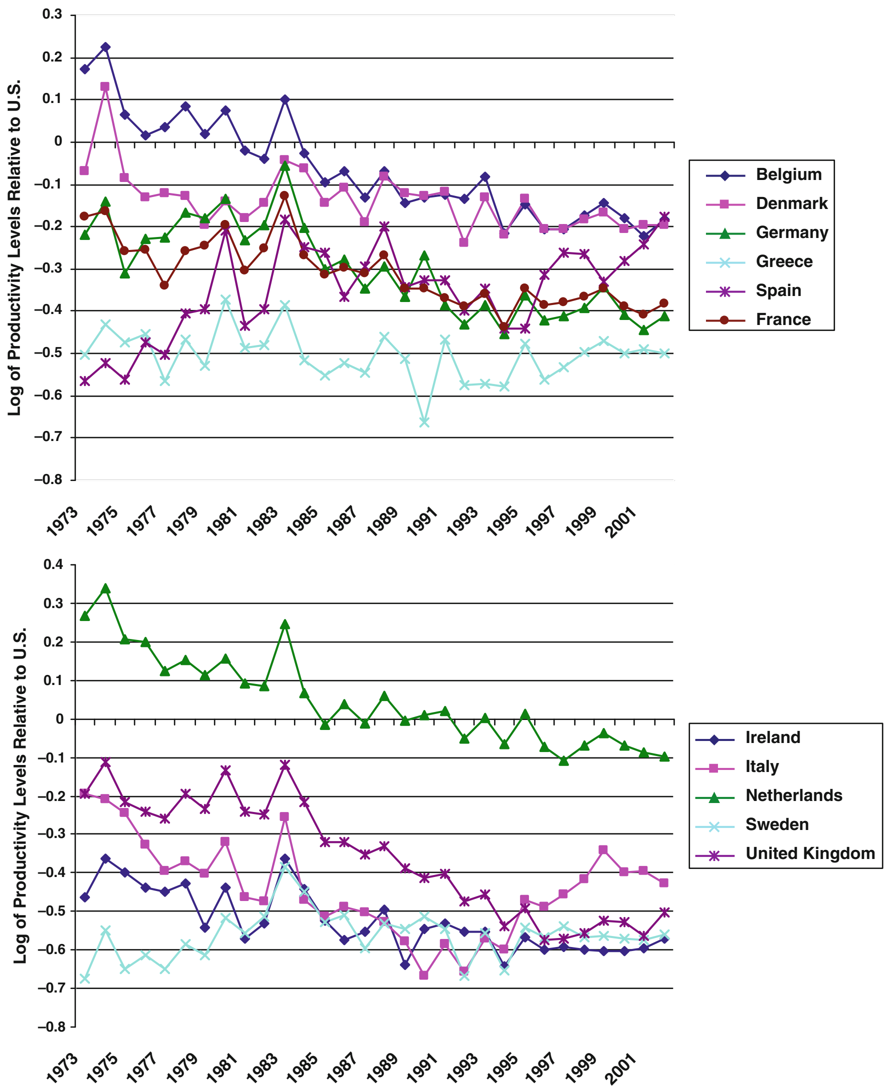

Fig. 13.3 Trends of differences in relative levels of productivity

price of output in the member states relative to that in the United States. We assume that markets are perfectly competitive and in long-run equilibrium, so that the observed price always equals average total cost. This result is used in our decomposition of relative price movements into changes in relative input prices and changes in relative productivity levels.

In international comparisons, growth rates of productivity are typically calculated on the basis of output and input quantities measured in constant prices. The international comparison of output or productivity levels, however, requires conversion of the output and input measures to a common currency unit. This may be done using either exchange rates or purchasing power parities. The two methods would be equivalent if exchange rates always adjusted to offset changes in relative price levels in national currencies. However, exchange rates mainly reflect purchasing power over tradable goods and services and are subject to a good deal of fluctuation as a result of capital movements.

In this study, we calculate purchasing power parities for agricultural output, together with the associated purchasing power parities for the relevant inputs, as data for our analysis of trends in price competitiveness and productivity gaps between the European Union and the United States.

Our price comparisons indicate that the United States was more competitive than its European counterparts throughout the study period, except for the years 1973–1974 and 1983–1985. Our results also suggest that the relative productivity level was the most important factor in determining international competitiveness. Over time, however, changes in competitiveness were strongly influenced by variations in exchange rates through their impact on relative input prices. During the periods 1979–1984 and 1996–2001, the strengthening dollar helped the European countries improve their competitive position, even as their relative productivity performance lagged.

Notes

1. The US trade surplus in bulk commodities reached $10 billion in 1981. But the rapid expansion in European exports – increasing from $238 million in 1981 to nearly $2 billion in 2005 – reduced this surplus to $2.5 billion in 2005. If the value of trade in processed items is included, the $2.5 billion surplus becomes a $5 billion trade deficit (Source: US Department of Commerce, Bureau of the Census).
2. There are other factors in addition to those elicited here. These include nontariff barriers to trade (e.g., hormone-beef and GM maize moratorium), growth in trade with other countries (e.g., Asia) to the detriment of transatlantic trade, changes in the composition of trade, and enlargement of the European Union, potentially displacing trade with the United States. Lastly, incomes in the United States have grown more rapidly than in the European Union for much of the study period. All of these factors likely played a role in the decreased US terms of trade with Europe.
3. Three countries – Austria, Finland, and Portugal – were excluded from the analysis because of missing data.
4. Equation (13.2) gives the necessary conditions for producer equilibrium in each country. We use the envelope (Shephard's lemma) to obtain the factor demands, but because equation (13.1) is in logs, we obtain the share of each input in the value of output.
5. This follows from application of Euler's theorem to a linearly homogeneous function.
6. The measure of productivity defined by (13.5) makes sense only if revenue equals costs in each period. This is an assumption that we make. Diewert (1992) has shown that under this assumption the price index of productivity change equals the more familiar quantity index of productivity growth.
7. The term characteristicity was coined by Drechsler (1973). It indicates the degree to which index number weights reflect the economic conditions that are specific to the two countries being compared.

8. Assume that optimizing agents choose combinations of outputs Y_j to maximize revenue associated with aggregate output Y. The result is a unit revenue function that is equation (13.7) with all of the envelope properties.
9. The accounting framework is that proposed in Manual on the Economic Accounts for Agriculture and Forestry (Eurostat, 2000). This approach ensures consistency of the accounts across countries and, hence, facilitates international comparisons.
10. Among the European countries, output is valued at basic prices. The "basic price" is the price received by the producer from the purchaser for a unit of a good or service produced as output minus any tax paid on that unit as a consequence of its production or sale (i.e., taxes on production) plus any subsidy received on that unit as a consequence of its production or sale (i.e., subsidies on products) (Eurostat, p. 43).
11. The data on output and intermediate input for the European countries are from the Economic Accounts for Agriculture NewCronos database http://epp.eurostat.ec.europa.eu/ .Comparable data for the United States can be downloaded from the USDA website www.ers.usda.gov/data/agproductivity/.
12. Data on investment for the European countries are from Capital Stock Data for the European Union (Beutel, 1997). The series was extended through 2002 using Eurostat's NewCronos database http://europa.eu.int/comm/eurostat/newcronos/. Data for the United States are from Fixed Reproducible Tangible Wealth in the United States (US Department of Commerce, 2003) and are available online at the US Department of Commerce website www.bea.gov/national/FA2004/SelectTable.ASP#52.
13. A number of European countries offer subsidies on purchases of new capital goods at the rate s of their price, in which case the rental price falls to:

$$c = [rW_K/(1 - F)](1 - s).$$

Hence, the cost of capital services falls by s. To fully realize the reduction in capital costs made possible by the subsidy, the firm would have to sell its existing capital stock and replace it with new units of capital that are eligible for the subsidy. In a simple model with no adjustment costs and perfect resale markets, this would be possible. The subsidy would create a one-time capital loss on existing capital. The prices of used capital goods would have to decline to keep services from them competitive with the lower cost of services available from subsidized, new capital goods.
14. The nominal rate was taken to be the average annual yield over all maturities.
15. Ex ante real rates are expressed as an AR(1) process. We use this specification after examining the correlation coefficients for autocorrelation, partial and inverse autocorrelation, and performing the unit root and white noise tests. We centered each time series by subtracting its sample mean. The analysis was performed on the centered data.
16. See Eswaren et al. (2003). They develop a procedure for evaluating inherent land quality and use this procedure to assess land resources on a global scale. Given the Eswaren, Beinroth, and Reich database, we use GIS to overlay country and regional boundaries. The result of the overlay gives us the proportion of land area of each region that is in each of soil stress categories.
17. Prices in the United States remained at or near record levels long after the momentum of inflation was broken in the early 1980s. A possible explanation for this can be found in the Agricultural and Food Act of 1981. In the 1981 act, the tie between target prices and rates of inflation was broken and specific levels of price support were mandated for each year between 1982 and 1985 on the assumption that high rates of inflation would continue.
18. Furthermore, the European Union, under its Common Agricultural Policy (CAP), embarked on a program of subsidized grain sales to increase its market share of world exports. This came largely at the expense of the United States.
19. Another factor contributing to the decline in relative prices in the European countries was a series of reforms of the CAP that culminated in the MacSharry reforms of 1992. Those

reforms focused on major commodities by lowering guaranteed prices and compensating farmers for lower prices with direct payments. Guaranteed prices were further reduced under Agenda 2000.

20. Spain's impressive productivity performance was not limited to agriculture. Looking at rates of productivity growth across sectors for the 1960–2000 period, Caselli and Tenreyro (2005) find that labor productivity convergence in Spain was driven both by a reallocation of labor from agriculture to more productive sectors and by catching-up of labor productivity within sectors. In contrast, convergence of labor productivity in the other lagging countries was mainly due to the reallocation of labor across sectors, while the contribution of within-industry catch-up to overall labor productivity convergence was actually negative.

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Chapter 14
The Behavior of Relative Food Prices: An Analysis across the European Countries

Luciano Gutierrez, Cristina Brasili, and Roberto Fanfani

Abstract We analyze the behavior of relative food prices for a set of 24 European countries observed during the period January 1996–December 2007. We use recent methods for the analysis of nonstationary panels to show that food price dynamics can be decomposed into a common component and an idiosyncratic component. From this decomposition we compute and analyze the real exchange rates for a set of food products. We find that countries included in the euro area are more market integrated; that is, real exchange rates tend to converge, than countries that did not adopt euro.

14.1 Introduction

This chapter investigates convergence towards absolute purchasing power parity (PPP) in food prices among the eurozone countries and between the eurozone countries and their major European trading partners. If absolute purchasing power holds, the relative prices of similar goods expressed in a common currency should be exactly equal.

In the sections that follow, we will address three main questions: First, how integrated is the food market in Europe? Second, are there differences in the behavior of European food prices? And third, if we assume that food price dynamics across the European countries can be decomposed into a common component and an idiosyncratic component, what is the relative importance of the two components in determining convergence of relative prices?

The notion of PPP is one of the most extensively researched areas in international economics, as can be seen from Taylor and Taylor (2004). The failure of the PPP is generally recognized as evidence that markets are not completely integrated. There

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are a number of factors which may prevent prices of similar products from being the same in different countries when expressed in a common currency. One is the geographical distance between markets. In the absence of tariffs or other trade barriers, there is more likely to be trade between neighboring countries simply because transportation costs are lower. Differences in consumer tastes and/or in product quality may also influence the geographical separation of markets. Discriminatory pricing behavior is another potential source of price dispersion.

We think that it is of interest to study differences in food prices across the European countries for the following reasons. First, since the countries are quite close to each other, price differentials are probably small. Second, there are relatively few restrictions on trade. Finally, since 1999, many of the countries have adopted the euro, and this has reduced the cost of cross-border trade.

In this chapter, we analyze relative food prices for 24 European countries. We focus on aggregated and disaggregated real exchange rates. These are computed using the Eurostat harmonized index of food prices for the period January 1996–December 2007. Our approach is based first on computing the proportion of countries for which we can reject the null hypothesis of no adjustment to PPP for each of the $N(N-1)/2$ possible pairs of countries. We believe that this is a natural way of investigating the level of market integration for countries and for goods.[1] We then show that food price movements for each product and each pair of countries can be usefully decomposed into a common and an idiosyncratic component. This allows us to identify possible differences in the impact of common and idiosyncratic shocks on food prices and real exchange rates. Finally, we investigate the half-life of a shock to relative prices in order to see if there is a difference in the price behavior of different goods.

The outline of the chapter is as follows. Section 14.2 describes the methodology that we use. Section 14.3 presents the data and the empirical results. Section 14.4 concludes.

14.2 Methodology

For each country i , $i = 1, 2, ..., N$, we define the nominal exchange rate as E_{0it} (units of currency 0 per unit of currency i), and P_{it} as the food prices defined using the own currency i. Thus the logarithm of prices, say q_{it}, expressed in terms of currency 0 can be written as

$$q_{it} = q_{0it} = e_{0it} + p_{it} = ln\left(E_{0it}P_{it}\right), \tag{14.1}$$

where e_{0it} is the log nominal exchange rate and p_{it} is the log price.

Assume now that prices q_{it} can be decomposed as

$$q_{it} = d_{it} + F_t\lambda_i + \varepsilon_{it}, \tag{14.2}$$

where d_{it} is a deterministic component, F_t denotes a matrix of unobserved common factors, λ_i indicates the vector of loadings, and ε_{it} is an idiosyncratic component. The common factor may be a proxy for European Central Bank (ECB) monetary policy, such as a monetary aggregate or the ECB discount rate, that influences single country prices with different weights λ_i, or the impact of the international food and nonfood commodity prices on European food prices. Prices may also be influenced by supply side effects such as advances in technology or demand side shocks such as changes in consumer tastes. Otherwise, the idiosyncratic component, which is by definition a component specific to the countries analyzed, can be associated with improvement in, for example, transport. Such improvements lead to greater competitiveness and facilitate convergence toward PPP.

Since $E_{jit} = E_{0it}/E_{0jt}$, the real exchange rate between any pair of countries, say r_{ijt} for $i,j \neq 0$, can be computed as

$$r_{ijt} = q_{it} - q_{jt} = (e_{0it} + p_{it}) - \left(e_{0jt} + p_{jt}\right) = ln\left(E_{jit}P_{it}/P_{jt}\right), \tag{14.2a}$$

Substituting (14.2) in the previous equation we obtain

$$r_{ijt} = \left(d_{it} - d_{jt}\right) + F_t\left(\lambda_i - \lambda_j\right) + \left(\varepsilon_{it} - \varepsilon_{jt}\right) \tag{14.3}$$

Looking at (14.3), we can see that the real exchange rate r_{ijt} will be a stationary $I(0)$ variable (i.e., PPP holds) if either the common factors F_t are $I(0)$, indicating the common trends are stationary variables, or if the common trends are $I(1)$ but $\left(\lambda_i - \lambda_j\right) = 0$ and the difference $\left(\varepsilon_{it} - \varepsilon_{jt}\right)$ is $I(0)$. Finally, the real exchange rate will be a stationary variable if both F_t and $\left(\varepsilon_{it} - \varepsilon_{jt}\right)$ are $I(1)$ and jointly cointegrated. In this case the difference between the idiosyncratic (country) shocks and the common factors follows a common trend in the long run.[2]

The most common test for PPP is the univariate *ADF* test. This involves regressing the first difference of the logarithm of the real exchange rate on a deterministic component, its lagged level, and m_{ij} lagged first differences

$$\Delta r_{ijt} = \mu_{ij} + \rho_{ij} r_{ij,t-1} + \sum_{k=1}^{m_{ij}} \gamma_{ijk}\Delta r_{ij,t-k} + u_{ijt}. \tag{14.4}$$

The null hypothesis of nonstationarity of the real exchange rate r_{ijt} is rejected in favor of level stationarity if $\rho_{ij} < 0$. In order to analyze the statistical properties of real exchange rates, we adopt the pair-wise approach recently proposed in Pesaran (2007), which is basically a vote-counting method. Specifically, we let $Z_{ij} = 1$ if $ADF_{ij}\left(m_{ij}\right) < K_\alpha$ where K_α is the critical value of size α for the $ADF_{ij}\left(m_{ij}\right)$ test with m_{ij} lagged first differences. We can easily compute the fraction of the $N(N-1)/2$ pairs of countries for which the unit root hypothesis in (14.4) is rejected as

$$\overline{Z} = \frac{2}{N(N-1)} \sum_{i=0}^{N-1} \sum_{j=i+1}^{N} Z_{ij}. \tag{14.5}$$

From (14.5) we see that under the null hypothesis H_0 that r_{ijt} is nonstationary or, alternatively, PPP does not hold, $\overline{Z}$ goes to α as $T \to \infty$ and the variance goes to zero as N grows large. Thus when H_0 holds everywhere, we would expect $\overline{Z}$ to be close to the size of the test. Otherwise, if the alternative H_A holds (i.e., PPP holds) then we would expect $\overline{Z}$ to be large and converge to unity for large N and T.

To investigate the PPP hypothesis we use not only the standard Dickey-Fuller ADF test but also the ADF-GLS test of Elliot et al. (1996) and the ADF-WS test of Park and Fuller (1995), as these have been shown to have more power than the standard ADF. We also provide the results for the set of unit root tests proposed by Ng and Perron (2001). These have been proven to have exact size close to the nominal size even in the presence of a large and negative moving-average component. All these tests have the null hypothesis of a unit root (i.e., nonstationarity of the process).

The introduction of the euro in January 1999 has clearly influenced the real exchange rates of the European countries. This requires that a known break in equation (14.4) be taken into account. It is well known that failure to account for a break in the series, when it is actually present, may result in a false acceptance of the nonstationary hypothesis. For this reason, we introduce an intercept dummy in equation (14.4) to capture the break in the series.[3]

As has been shown previously, if we allow for the decomposition in equation (14.3), PPP may not be hold because the common factors F_t have different impacts on the real exchange rate r_{ijt}. In order to investigate this, we compute a new real exchange rate variable which is net of the impact of the common factors. Specifically, for each i, $i = 1, 2, ..., N$, we estimate the common factors and factor loadings using equation (14.3) and define the "defactored" food price as

$$q_{it}^* = \left(q_{it} - \hat{F}_t \hat{\lambda}_i\right) = d_{it} + \varepsilon_{it}. \tag{14.6}$$

Thus using equation (14.6), we can compute the "defactored" real exchange rate as

$$r_{ijt}^* = \left(q_{it}^* - q_{jt}^*\right) = \left(d_{it} - d_{jt}\right) + \left(\varepsilon_{it} - \varepsilon_{jt}\right), \tag{14.7}$$

and apply the same methodology as in equations (14.4) and (14.5) to investigate the stationarity of defactored real exchange rates. Using this decomposition, we are able to analyze whether the proportion of stationary real exchange rates rises after the impact of the common component has been excluded. Note from equation (14.7) that possible nonstationarity of r_{ijt}^* will be attributed to the differences in the idiosyncratic components of food prices. In other words, the method will highlight the relative importance of internal differences in individual countries in determining convergence of relative food prices.

In addition we can compute for each real exchange rate r_{ijt} and defactored real exchange rate r^*_{ijt} the half-life of a price shock, shedding light on possible differences in the speed of adjustment toward PPP across relative food prices. The half-life is defined as the number of periods required for a unit shock to the series to dissipate by half. Thus the half-life is a measure of the speed of convergence toward PPP. Once an estimate for $\hat{\rho}_{ij}$ has been obtained, the half-life can be easily computed from equation (14.4) as

$$\mathrm{HL}_{ij} = \ln(0.5)/\ln\left(1 + \hat{\rho}_{ij}\right). \tag{14.8}$$

The apparently slow speed of adjustment of real exchange rates has been the subject of considerable theoretical and empirical research in recent years. In a recent survey, Rogoff (1996) notes that the consensus estimate of the half-life tends to fall into the 3–5 year range. Interestingly, we show in the next section that estimates of the speed of adjustment in food prices are much faster than this consensus.

A possible criticism of our analysis is the short span of the data. The question whether univariate unit root tests based on quarterly or monthly data are more powerful than those based on the annual data have been investigated by Perron (1989) and Shiller and Perron (1985), among others. They find, using Monte Carlo simulations, that power depends more on the span of the data rather than on the number of observations. By contrast Choi and Chung (1995) show that using data with high sampling frequency can significantly improve the finite sample power of unit root tests. However, if a researcher adopts a longer span of data in order to increase the power of unit root tests, this may give rise to other problems, such as possible breaks in the data process. It is well known that such breaks may alter the results of unit root tests.

One way of increasing the power of unit root tests with a short data span is to use panel unit root tests (see Gutierrez (2006) for a review of the relevant literature). However, the use of panel unit root tests leads to the following problems. First, if a panel of data is used, all real exchange rates must be measured in the same currency and the results will, in general, depend on the choice of the numeraire currency. Second, the null hypothesis of panel unit root tests is that all the series are nonstationary, while the alternative is that some of the series are stationary. Thus, panel unit root tests do not provide information on how many series are stationary and how many are nonstationary. If we use the method proposed in Pesaran (2007) we are able to address this question.

We note, however, that using $\overline{Z}$ is not exempt from problems – the main one is that the single Z_{ij} entries in equation (14.5) are not, in general, independent. The dependence occurs because two pairs of entries, for example Z_{ij} and Z_{kj} with $i \neq k$, share the same country, j in this case. As a result, the statistical distribution of the $\overline{Z}$ test may be altered by the cross-sectional dependence. We look at the empirical distribution of the $\overline{Z}$ test using a sieve bootstrap method, and we show that this cross-sectional dependence can effectively reverse some of the results obtained under the independence hypothesis.

14.3 Data Statistics and Empirical Results

We analyze real exchange rates obtained from the Eurostat data set. We focus on harmonized indices of consumer prices (HICP) for food products observed during the period January 1996–December 2007. The HICP provides comparable prices in the European Economic Area. The list of goods used in the analysis is provided in the following tables. The sample of countries includes Belgium, Denmark, Germany, Estonia, Ireland, Greece, Spain, France, Italy, Cyprus, Latvia, Lithuania, Luxembourg, Malta, the Netherlands, Austria, Poland, Portugal, Slovakia, Finland, Sweden, United Kingdom, Iceland, and Norway. We partition these countries into two groups. The first group includes the countries that adopted the euro during the period of analysis; that is, 11 countries starting in January 1999 plus Greece who adopted the euro in January 2001. The remaining countries, including Malta which only adopted the euro in 2005, are collected in the group of non-eurozone countries.[4]

The first task is to analyze the common factor components. We first ask how many common factors are behind the food price dynamics for each food item. We use the information criteria suggested by Bai and Ng (2002). These criteria are similar in spirit to the common AIC and BIC criteria for time series. To estimate the true number of factors Bai and Ng (2002) propose twelve different criteria. In the chapter we adopt their *IC* criteria.[5] Specifically, the method minimizes the following function

$$IC(K) = \ln(\hat{\sigma}_{\varepsilon}^{2}(K)) + K\left(\frac{\ln(\min(N,T))}{\min(N,T)}\right), \tag{14.9}$$

where K is the number of common factors and $\hat{\sigma}_{\varepsilon}^{2}(K)$ is the sum of squared idiosyncratic components in

$$\hat{\sigma}_{\varepsilon}^{2}(K) = (NT)^{-1}\sum_{i=1}^{N}\sum_{t=1}^{T}\hat{\varepsilon}_{it}^{2}. \tag{14.10}$$

Following Bai and Ng (2002), the differenced idiosyncratic residuals are computed as

$$\Delta\hat{\varepsilon}_{it} = \Delta q_{it} - \Delta\hat{F}_{t}\hat{\lambda}_{i}, \tag{14.11}$$

where $\Delta\hat{F}_t$ and $\hat{\lambda}_i$ are obtained from the principal components of the covariance matrix of Δq_{it}. Because both $\hat{F}_t$ and $\hat{\varepsilon}_{it}$ in equation (14.11) are expressed as differences, the levels are recovered by cumulating $\Delta\hat{F}_t$ and $\Delta\hat{\varepsilon}_{it}$. The $IC(K)$ criteria in equation (14.10) estimates the true number of factors by minimizing $\hat{\sigma}_{\varepsilon}^{2}(K)$, which is a measure of fit, subject to a penalty that depends on the number of factors and the size of the panel.

In Table 14.1 we report the number of factors estimated, allowing for a maximum number of 3 factors for each food item, as well as for the aggregate of all items in the HICP indices. We also present the percentage of variance accounted for by the

Table 14.1 Number of factors[a] and variance explained by factor(s)

		Total countries			Euro countries			Non-euro countries		
		Number	% Var.	% Var.	Number	% Var.	% Var.	Number	% Var.	% Var.
Harmonized indices of consumer prices (HICP)		Factors	1st fact.	Tot. fact.	Factors	1st fact.	Tot. fact.	Factors	1st fact.	Tot. fact.
CP00	All-items HICP	1	0.89	0.89	3	0.98	1.00	1	0.86	0.86
CP01	Food and nonalcoholic beverages	3	0.83	0.93	3	0.94	0.98	3	0.79	0.93
CP011	Food	3	0.84	0.93	3	0.94	0.98	3	0.81	0.93
CP0111	Bread and cereals	1	0.83	0.83	3	0.96	0.99	1	0.77	0.77
CP0112	Meat	3	0.75	0.89	2	0.90	0.95	3	0.70	0.86
CP0113	Fish and seafood	2	0.89	0.92	1	0.94	0.94	2	0.85	0.90
CP0114	Milk, cheese, and eggs	1	0.78	0.78	3	0.88	0.98	1	0.77	0.77
CP0115	Oil and fats	3	0.61	0.84	2	0.60	0.82	2	0.66	0.83
CP0116	Fruit	3	0.68	0.85	2	0.80	0.86	3	0.63	0.87
CP0117	Vegetables	1	0.59	0.59	1	0.71	0.71	3	0.51	0.75
CP0118	Sugar, jam, honey, chocolate, and confectionery	1	0.82	0.82	3	0.91	0.99	1	0.79	0.79
CP0119	Food products n.e.c.	2	0.73	0.86	3	0.84	0.97	2	0.71	0.84
CP012	Nonalcoholic beverages	2	0.54	0.71	3	0.59	0.91	2	0.59	0.77
CP0121	Coffee, tea, and cocoa	2	0.40	0.71	1	0.45	0.45	3	0.41	0.89
CP0122	Mineral waters, soft drinks, and fruit and vegetable juices	2	0.66	0.81	1	0.73	0.73	2	0.69	0.82
CP02	Alcoholic beverages, tobacco, and narcotics	1	0.82	0.82	3	0.90	0.99	1	0.82	0.82
CP021	Alcoholic beverages	3	0.66	0.89	2	0.82	0.92	1	0.62	0.62
CP0211	Spirits	1	0.59	0.59	2	0.81	0.89	1	0.53	0.53
CP0212	Wine	3	0.68	0.87	3	0.73	0.93	3	0.69	0.89
CP0213	Beer	1	0.66	0.66	2	0.80	0.94	1	0.61	0.61
CP022	Tobacco	3	0.90	0.96	2	0.96	0.98	3	0.87	0.96

[a]Three maximum number of factors allowed
Data *Source*: Eurostat

first factors (i.e., the first principal component), and then the percentage of variance explained by the full set of factors chosen using Bai and Ng's (2002) procedure. These statistics are computed for the full set of countries and for the two subgroups of countries.

Looking at the results in Table 14.1 we note first that the number of factors chosen varies, depending on the commodity. Second, the percent of variance accounted for by the first factor is usually large. On average, and for the total set of countries, 72% of the variance in food prices is explained by the first factor. This value grows to 82% for the eurozone countries, but decreases to 69% for those countries that have not adopted the euro. Thus the first common component is much more important in explaining food price dynamics in the eurozone countries than in the non-eurozone countries. Finally, the percent of variance explained by the additional factors is usually small, and on average not more than 20%.

The next problem is determining how many common components are nonstationary. To do this, we use the modified Q_c test procedure proposed in Bai and Ng (2004). This analyzes the rank of the long-run covariance matrix of the factors. The procedure tests whether the smallest eigenvalue of the matrix of a first-order VAR is unity and then proceeds sequentially as in the standard Johansen technique. For reason of space we do not present the test statistics, but they are available upon request. As before, the results vary by food product. On average the number of nonstationary factors is two, both for the set of eurozone countries and for the set of non-eurozone countries.

In summary, we find that the common component explains a large share of the variance in food prices and the importance of this component is higher for the eurozone countries than for countries that did not adopt the euro. We did not examine the relationship between certain observable variables and the estimated statistical factors. We think that the common component may be the result of the European Central Bank monetary policy, which clearly has a greater influence on food prices in the eurozone, or the result of international food and nonfood commodity price dynamics, which may influence the unobserved common factors. Bai (2004) has proposed a method for evaluating whether a given set of economic variables are the underlying factors. We leave this important issue to further research.

Tables 14.2, 14.3, and 14.4 present the results of the proportion of pairs of real exchange rates for which the null hypothesis of nonstationarity can be rejected. As stated above, we use a set unit root test, setting the nominal size of the tests at 10%. Due the importance of the critical value in discriminating between nonstationary and stationary real exchange rates, for all tests the exact critical values for $T = 144$ have been computed using a Monte Carlo experiment with 100,000 rounds. These values are available upon request.

The results for the three *ADF* type tests – *ADF*, $ADF-GLS$ and $ADF-WS$ – are for the lag orders m_{ij} in equation (14.5), determined by the Schwarz Bayesian Criterion. Similar results were obtained using the Akaike Information Criterion. We also compute the results for three of the tests proposed in Ng and Perron (2001): *MZa*, *MSB* and *MZt*. Following Perron and Qu (2007) we use the so-called *GLS* estimates, as for the $ADF-GLS$ type test. In this case the lag order m_{ij} is determined

Table 14.2 Fraction of pairs of r_{ijt} for which the null hypothesis of unit root is rejected at 10% significance level, 24 European countries, 1996.1–2007.12

		Nondefactored			Defactored		
		ADF	ADF	ADF	ADF	ADF	ADF
Harmonized indices of consumer prices (HICP)		OLS	GLS	WS	OLS	GLS	WS
CP00	All-items HICP	31.52	44.57	33.33	37.32	46.74	36.59
CP01	Food and nonalcoholic beverages	19.93	34.42	23.19	25.72	41.30	26.45
CP011	Food	21.01	36.59	23.55	20.65	36.96	20.29
CP0111	Bread and cereals	19.57	29.35	22.46	17.75	31.16	19.93
CP0112	Meat	22.46	27.90	26.09	41.67	63.04	40.22
CP0113	Fish and seafood	26.09	38.77	22.83	33.33	50.36	23.55
CP0114	Milk, cheese, and eggs	14.86	26.45	16.30	19.93	31.52	16.67
CP0115	Oil and fats	21.38	30.43	18.48	24.28	38.04	18.12
CP0116	Fruit	34.78	48.91	34.78	32.97	40.22	36.23
CP0117	Vegetables	43.84	52.54	45.65	53.26	55.80	54.71
CP0118	Sugar, jam, honey, chocolate, and confectionery	18.48	37.32	19.57	14.86	34.42	13.77
CP0119	Food products n.e.c.	22.10	31.88	24.28	37.32	63.04	38.41
CP012	Nonalcoholic beverages	11.96	23.55	14.49	33.33	48.91	26.45
CP0121	Coffee, tea, and cocoa	18.48	31.52	21.74	26.09	45.29	19.57
CP0122	Mineral waters, soft drinks, and fruit and vegetable juices	12.32	23.19	11.59	21.74	40.22	16.30
CP02	Alcoholic beverages, tobacco, and narcotics	17.03	29.71	21.38	19.20	31.16	15.22
CP021	Alcoholic beverages	14.86	33.33	22.10	27.54	47.46	24.28
CP0211	Spirits	11.23	23.19	18.12	14.49	27.17	18.84
CP0212	Wine	20.29	31.52	25.00	23.19	40.22	24.64
CP0213	Beer	20.29	33.33	15.94	16.67	30.43	16.67
CP022	Tobacco	17.39	25.72	23.55	14.13	28.99	13.41

Data *Source*: Eurostat

Table 14.3 Fraction of pairs of r_{ijt} for which the null hypothesis of unit root is rejected at 10% significance level, 12 Euro countries, 1996.1–2007.12

		Nondefactored			Defactored		
		ADF	ADF	ADF	ADF	ADF	ADF
Harmonized indices of consumer prices (HICP)		OLS	GLS	WS	OLS	GLS	WS
CP00	All-items HICP	34.85	33.33	39.39	66.67	69.70	74.24
CP01	Food and nonalcoholic beverages	25.76	36.36	33.33	53.03	66.67	53.03
CP011	Food	25.76	42.42	31.82	48.48	65.15	48.48
CP0111	Bread and cereals	13.64	22.73	16.67	19.70	30.30	31.82
CP0112	Meat	25.76	34.85	25.76	80.30	81.82	68.18
CP0113	Fish and seafood	25.76	34.85	21.21	22.73	33.33	21.21
CP0114	Milk, cheese, and eggs	12.12	12.12	9.09	7.58	10.61	4.55
CP0115	Oil and fats	13.64	21.21	13.64	31.82	42.42	28.79
CP0116	Fruit	40.91	54.55	45.45	51.52	66.67	59.09
CP0117	Vegetables	33.33	51.52	33.33	45.45	57.58	45.45
CP0118	Sugar, jam, honey, chocolate, and confectionery	16.67	24.24	13.64	46.97	66.67	48.48
CP0119	Food products n.e.c.	15.15	18.18	18.18	25.76	37.88	42.42
CP012	Nonalcoholic beverages	12.12	13.64	16.67	36.36	54.55	25.76
CP0121	Coffee, tea, and cocoa	18.18	19.70	22.73	39.39	51.52	30.30
CP0122	Mineral waters, soft drinks, and fruit and vegetable juices	21.21	19.70	18.18	24.24	39.39	21.21
CP02	Alcoholic beverages, tobacco, and narcotics	10.61	28.79	9.09	13.64	22.73	10.61
CP021	Alcoholic beverages	12.12	33.33	19.70	34.85	51.52	25.76
CP0211	Spirits	15.15	19.70	15.15	9.09	21.21	9.09
CP0212	Wine	22.73	28.79	27.27	7.58	16.67	21.21
CP0213	Beer	25.76	34.85	13.64	42.42	71.21	21.21
CP022	Tobacco	13.64	36.36	16.67	12.12	33.33	16.67

Data *Source*: Eurostat

Table 14.4 Fraction of pairs of r_{ijt} for which the null hypothesis of unit root is rejected at 10% significance level, 12 non–euro countries, 1996.1–2007.12

Harmonized indices of consumer prices (HICP)		Nondefactored			Defactored		
		ADF	ADF	ADF	ADF	ADF	ADF
		OLS	GLS	WS	OLS	GLS	WS
CP00	All-items HICP	15.15	34.85	19.70	42.42	51.52	39.39
CP01	Food and nonalcoholic beverages	13.64	31.82	15.15	25.76	50.00	18.18
CP011	Food	16.67	34.85	19.70	24.24	39.39	21.21
CP0111	Bread and cereals	15.15	25.76	15.15	16.67	36.36	15.15
CP0112	Meat	24.24	19.70	24.24	27.27	60.61	28.79
CP0113	Fish and seafood	22.73	28.79	19.70	12.12	39.39	4.55
CP0114	Milk, cheese, and eggs	15.15	24.24	16.67	21.21	42.42	21.21
CP0115	Oil and fats	24.24	39.39	21.21	21.21	34.85	16.67
CP0116	Fruit	50.00	63.64	46.97	75.76	63.64	74.24
CP0117	Vegetables	62.12	54.55	66.67	57.58	54.55	57.58
CP0118	Sugar, jam, honey, chocolate, and confectionery	13.64	30.30	12.12	15.15	39.39	12.12
CP0119	Food products n.e.c.	24.24	37.88	21.21	33.33	62.12	27.27
CP012	Nonalcoholic beverages	9.09	27.27	7.58	31.82	56.06	24.24
CP0121	Coffee, tea, and cocoa	15.15	39.39	18.18	15.15	34.85	10.61
CP0122	Mineral waters, soft drinks, and fruit and vegetable juices	1.52	19.70	1.52	9.09	27.27	6.06
CP02	Alcoholic beverages, tobacco, and narcotics	15.15	25.76	22.73	22.73	40.91	16.67
CP021	Alcoholic beverages	13.64	33.33	15.15	40.91	54.55	31.82
CP0211	Spirits	3.03	13.64	15.15	13.64	30.30	22.73
CP0212	Wine	12.12	27.27	12.12	33.33	53.03	34.85
CP0213	Beer	13.64	25.76	9.09	16.67	37.88	21.21
CP022	Tobacco	16.67	19.70	24.24	27.27	48.48	28.79

Data *Source*: Eurostat

using the Modified Akaike Information Criterion. For all tests we set the maximum m_{ij} lag to be 12. Finally, the deterministic component includes an intercept. Results with intercept and a linear trend are available upon request. For reasons of brevity we do not report the values of the $\overline{Z}$ obtained from *MZa*, *MSB* and *MZt* because they are quite similar to those reported for the *ADF* type tests.

In looking at the results in the Tables 14.2, 14.3, and 14.4, we note first that the fraction of pairs of r_{ijt} for which the null hypothesis of nonstationarity is rejected is usually higher than the nominal size of the tests. The largest rejection is for fruits and vegetables, where the *ADF* tests lead to a rejection of the null hypothesis in more than 50% of the cases. The lowest rejection rate is generally for beverages.

Interestingly, with the exception of a limited number of cases,[6] the rejection rates rise if we net the real exchange rates from the common components. This may mean that the common components F_t have different impacts on r_{ijt} since from the decomposition in equation (14.4) we see that $\lambda_i \neq \lambda_j$ and this induces nonstationarity of real exchange rates or, alternatively, nonconvergence of relative food prices. On average the rejection rates are higher for the group of countries in the eurozone than for the group in the non-eurozone area. This finding adds support to the view that adoption of the euro and the common monetary policy have spurred the convergence of relative food prices in the eurozone.

As stated above, the results may be affected by possible cross-sectional dependence of the test outcomes. To overcome this problem we studied the $\overline{Z}$ test distribution using the sieve bootstrap method proposed in Chang (2004) for studying panel unit root tests with the possible presence of arbitrary cross-sectional dependence. The procedure consists of the following steps:

Step 1: Using OLS, we estimate for each country i, $i = 1, 2, ..., N$, the following regression

$$\Delta q_{it} = \hat{\alpha}_{1i} \Delta q_{it-1} + ... + \hat{\alpha}_{mi} \Delta q_{it-m} + \hat{u}_{it}. \tag{14.12}$$

Step 2: We generate the N-dimensional vector $\hat{u}_t^{(r)} = \left(\hat{u}_{1t}^{(r)}, ..., \hat{u}_{Nt}^{(r)}\right)'$ using the residuals estimates in Step 1 and resample the centered residual $\hat{u}_t^{(r)}$, that is, we resample the vector $\left(\hat{u}_t^{(r)} - T^{-1} \sum_{t=1}^{T} \hat{u}_t^{(r)}\right)$.

Step 3: Using the parameter estimates $\hat{\alpha}_{li}$, we generate recursively the variable $\Delta q_{it}^{(r)}$ as

$$\Delta q_{it}^{(r)} = \hat{\alpha}_{1i} \Delta q_{it-1}^{(r)} + ... + \hat{\alpha}_{mi} \Delta q_{it-m}^{(r)} + \hat{u}_{it}^{(r)} \tag{14.13}$$

Step 4: We obtain $q_{it}^{(r)} = q_{i0}^{(r)} + \sum_{m=1}^{t} \Delta q_{imt}^{(r)}$ with some initial value for $q_{i0}^{(r)}$ that can be shown (see Chang, 2004) which does not affect the asymptotics, as long as it is bounded.

Step 5: We define the bootstrapped real exchange rates $r_{ijt}^{(r)}$ and compute the fraction of the pairs for which the null hypothesis is rejected by the ADF-WS test

Table 14.5 Bootstrapped fraction of rejections – ADF-WS test 12 euro-area countries, 1996.1–2007.12

Harmonized indices of consumer prices (HICP)		Nondefactored Point Estimate	Nondefactored 10% C.V.	Defactored Point Estimate	Defactored 10% C.V.
CP00	All-items HICP	39.4	16.7	74.2	40.9
CP01	Food and nonalcoholic beverages	33.3	15.2	53.0	39.4
CP011	Food	31.8	15.2	48.5	40.9
CP0111	Bread and cereals	16.7	16.7	31.8	39.4
CP0112	Meat	25.8	15.2	68.2	40.9
CP0113	Fish and seafood	21.2	18.2	21.2	40.9
CP0114	Milk, cheese, and eggs	9.1	18.2	4.6	39.4
CP0115	Oil and fats	13.6	16.7	28.8	39.4
CP0116	Fruit	45.5	15.2	59.1	40.9
CP0117	Vegetables	33.3	18.2	45.5	42.4
CP0118	Sugar, jam, honey, chocolate, and confectionery	13.6	13.6	48.5	37.9
CP0119	Food products n.e.c.	18.2	15.2	42.4	39.4
CP012	Nonalcoholic beverages	16.7	18.2	25.8	42.4
CP0121	Coffee, tea, and cocoa	22.7	13.6	30.3	40.9
CP0122	Mineral waters, soft drinks, and fruit and vegetable juices	18.2	16.7	21.2	37.9
CP02	Alcoholic beverages, tobacco, and narcotics	9.1	12.1	10.6	39.4
CP021	Alcoholic beverages	19.7	15.2	25.8	40.9
CP0211	Spirits	15.2	18.2	9.1	40.9
CP0212	Wine	27.3	19.7	21.2	40.9
CP0213	Beer	13.6	16.7	21.2	36.4
CP022	Tobacco	16.7	16.7	16.7	42.4

Data *Source*: Eurostat

using the 10% critical value and repeat steps 2 through 5 with $r = 1000$to obtain the empirical distribution of $\overline{Z}$.

In Table 14.5, we present the 10% quantile of the distribution for the euro-area countries and the full set of food products.[7] We first note that the empirical 10% rejection rate is usually higher, with an average values of 16.5%. The previous procedure has also been to the "defactored" $q_{it}^{(r)}$. The 10% bootstrapped critical values now have an average value of 40%. Using these bootstrapped values we reject the hypothesis that PPP holds for a higher number of food products.

Basically only three products (meat, fruits, and vegetables) have higher point estimates than the bootstrapped critical value for both the actual as well as the "defactored" real exchange rates. In other words, the results show relative food price are stable in the long run only for these food products.

It is interesting to note that these products are usually included in the set of goods labeled as first-stage processed food products, or "agricultural processing", and are distinguished from second-stage processed food products that are labeled "food manufacture". Following Harris and Swinbank (1997), we can assume that the first set of products (i.e., agricultural processing) has the following properties: they are mainly undifferentiated products, supply driven, and the prices are set by the market, and even today (although less than in the past) they are influenced by the common agricultural policy (CAP). The second set of products (i.e., food manufacture) consists mainly of branded products for which demand is market driven, the prices are influenced by competitive forces and retailer power, and they are less influenced by the CAP. Obviously this is not a rigid distinction, but the characterization is nevertheless useful as it highlights why we find more signs of convergence of relative prices for the first group of products than for the second group. Basically, the higher level of competition in the agricultural market does not allow prices to be fixed at different levels, or to follow different paths across countries. By contrast, there is more degrees of freedom in fixing the prices of "food manufacture" products, thanks to greater market power.

With respect to the possible effects of the CAP on food price convergence, it is not easy to connect our results to CAP policy. First, we have to consider that there are great differences in the weight of the raw agricultural product in the value of final food products. Second, the four-digit consumer price index (HICP) usually contains products that are not homogeneous, either in terms of the degree of manufacturing or in terms of transport and distribution costs. Nevertheless, some interesting results seem to emerge. For example, we find that fruits and vegetables have among the highest $\overline{Z}$ values, both in the independent and in the bootstrapped results. This is due, in part, to the high level of intervention of the CAP in the management of market support, which encourages aggregation of supply among producers. It is also probably due to the market withdrawals scheme. This allows the fluctuations in producer prices due to crises in the market to be reduced as demand is inelastic. Similar considerations may be true for the meat products.

From the above results it is clear that when Eurostat data refer to truly "agricultural processing" products, such as fruits, vegetables, and meats, we are able to detected a higher $\overline{Z}$ value. In the case of composite "agricultural processing" and "food manufacture" goods, we find less relative food price convergence in the long run.

Using equation (14.8), we calculate the half-life of a price shock. These results are reported in Table 14.6. We report the values computed using the $ADF-WS\left(\hat{\rho}_{ijt}\right)$ estimates. Similar values were obtained using the ADF and $ADF-GLS$ estimates. In brackets we present the median half-life computed from the set of pairs r_{ijt} for which we reject the null hypothesis of a unit root that the PPP holds. The results show that adjustment after a shock is rapid. The median half-life is around 12 months if we use all the pairs r_{ijt}, and decrease to 7 months if we consider only the stationary pairs. There are no significant differences between the eurozone and non-eurozone countries. Interestingly, the median half-life estimates are lower than those reported by Rogoff (1996) who found that the consensus estimate of the half-life tended to fall into the 3–5 year range.

Table 14.6 Median half-life values (months) – ADF WS test[a]

Harmonized indices of consumer prices (HICP)		Nondefactored						Defactored					
		Total Countries		Euro-Area Countries		Non-Euro-Area Countries		Total Countries		Euro-Area Countries		Non-Euro Area Countries	
CP00	All-items HICP	12.5	(5)	14	(6.5)	12.5	(5)	10	(4)	2	(2)	9	(4)
CP01	Food and nonalcoholic beverages	12	(5)	11.5	(6)	13	(5)	5	(3)	3	(3)	5	(3.5)
CP011	Food	12	(5)	11	(5.5)	13	(5)	5	(4)	3	(3)	4	(3.5)
CP0111	Bread and cereals	18.5	(6)	14.5	(6)	20	(6)	12	(5)	4	(3)	10.5	(5)
CP0112	Meat	12	(6)	10	(5)	11	(5)	4	(3)	5	(3)	5	(4)
CP0113	Fish and seafood	8.5	(4)	7.5	(4)	9.5	(5)	5	(3)	6	(4)	5	(4)
CP0114	Milk, cheese, and eggs	16	(7)	17	(5.5)	15	(5)	10	(4)	3	(3)	8	(4)
CP0115	Oil and fats	15	(7)	17.5	(12)	15.5	(4.5)	6	(4)	9	(3.5)	6	(5)
CP0116	Fruit	5	(2)	3	(2)	5	(3)	2	(2)	3	(2)	1	(1)
CP0117	Vegetables	4	(2)	3	(2)	4	(2.5)	3	(2)	2	(2)	3	(2)
CP0118	Sugar, jam, honey, chocolate, and confectionery	14	(5)	21	(6)	15	(4)	10	(5)	3	(2)	9.5	(4)
CP0119	Food products n.e.c.	13	(5)	16	(7)	10	(4)	8	(4)	6	(4)	6	(4.5)
CP012	Nonalcoholic beverages	12	(6)	16	(6)	12	(7)	8	(4)	5	(3)	8	(4)
CP0121	Coffee, tea, and cocoa	10	(6)	10	(7)	7.5	(5)	9	(4)	10	(4.5)	4	(3)
CP0122	Mineral waters, soft drinks, and fruit and vegetable juices	14	(6)	18	(5)	15	(6)	7	(4)	9.5	(5)	7.5	(5)
CP02	Alcoholic beverages, tobacco, and narcotics	14	(5)	11.5	(4)	11	(7)	12	(5)	3.5	(3)	11	(5)
CP021	Alcoholic beverages	15	(7)	15	(6)	13	(6.5)	5	(4)	7	(4)	11	(5)
CP0211	Spirits	17	(7.5)	17	(6.5)	13	(6)	12	(5)	9.5	(5)	12.5	(5)
CP0212	Wine	13	(6)	15	(5)	12	(5)	6	(4)	7	(4)	5	(4)
CP0213	Beer	15	(5)	20.5	(4.5)	14	(4)	11	(4)	6	(3)	10	(5)
CP022	Tobacco	12	(4)	12	(4)	14	(4.5)	6	(4)	5.5	(4)	6	(4)

[a]In parentheses median half-life values for the set of pairs for which the test is able to reject the null of a unit root
Data *Source*: Eurostat

14.4 Conclusion

In this chapter we analyze the behavior of relative food prices in 24 European countries observed during the period January 1996–December 2007. We split the countries into two subgroups: The first is a group of 12 countries that adopted the euro and the second is a group of non-euro countries.

Some interesting results seem to emerge from the analysis. First, we find that food prices are mainly characterized by a common trend variable which accounts for a large share of their variance. The importance of the common component is more pronounced for the set of countries in the eurozone. We think that this is due to the effects of the common monetary policy established by the European Central Bank, but further research is needed to confirm this. Second, assuming independence between relative exchange rates across countries, it seems that the European countries are integrated (i.e., relative food prices converge). In other words, the hypothesis of purchasing power parity holds among both countries and products. It is also clear that relative food price convergence is more pronounced in the eurozone than in the non-eurozone. Third, agro-foods products are more integrated than are manufactured foods products, such as beverages. When allowance is made for cross-country correlation of the real exchange rates, we find that the previous results are not so strong. To be precise, we find that there is strong relative price convergence only for products such as fruits, vegetables, and meat. This result can be attributed to the higher level of competition in the agricultural market which does not allow prices to be fixed at different levels or follow different path across countries. Fourth, both the common and the idiosyncratic components explain the lack of market integration across countries and products. Thus further research is needed to analyze which factors are behind the common and the idiosyncratic components. Fifth, we find the half-life of a shock to relative food prices varies between products and the adjustment is generally faster, on average about 12 months, than those usually reported in literature. The latter tend to fall into the 3–5 year range.

Notes

1. Using our data set we are only able to analyze the market integration issue and we do not address the competitive market equilibrium, see Barrett and Li (2002).
2. Although this case is validated by some test statistics, we believe that it is difficult to explain using sound economic theory.
3. We also include a dummy for the slope but the results, available upon request, do not show appreciable differences from those of the pure intercept break case.
4. In the paper we provide the test results for the seasonally unadjusted series. Similar results are obtained when focusing on seasonal adjusted price series.
5. Actually the twelve criteria usually give the same results, with the exception of the BIC criteria which on average detect a smaller number of factors. However the BIC criteria do not satisfy the consistency property.
6. In these cases the common and idiosyncratic components are non-stationary and cointegrated. Thus when we subtract the common component from the actual real exchange rate, this introduces nonstationarity of the "defactored" real exchange rate.

7. We also compute the bootstrapped critical values for the set of non-euro countries and the full set of 24 countries. The results are similar to those presented and they are available upon request.

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Part V
Commodity Programs and Risk Management

Chapter 15
The Political Economy of the US Crop Insurance Program

Bruce A. Babcock

Abstract Taxpayer support for the crop insurance industry has grown rapidly since 2000 even though total crop acres insured is stagnant and the number of policies sold has declined. Staunch support for the program by key members of Congress meant defeat for proposals in the 2008 Farm Bill to significantly reduce cost. These proposals included large changes in the formulas used to calculate industry reimbursement and for new programs that would be integrated with or reduce the amount of risk insured by the crop insurance program. The reason for this resilience is program complexity and biased analysis, which has allowed the industry to claim that they are undercompensated despite a doubling of taxpayer support. One unforeseen outcome of the strength of the crop insurance industry in protecting its interests is that a new insurance program called Average Crop Revenue Selection (ACRE) was passed in the farm bill. Large unintended consequences that could be brought about by ACRE include the likely demise of the marketing loan and countercyclical programs, increased risk that the United States will violate its amber box limits, and in the not-too-distant future, a complete change in the way that US crop insurance is delivered to farmers.

15.1 Introduction

The difficulty with which Congress passed a US Farm Bill was hampered more by a need to find increased funds than with any broad philosophical debate about the proper direction for US farm policy. At first perusal, the new US commodity policy largely follows the policy set forth in the 2002 farm bill. Direct payments, countercyclical payments, and the marketing loan program still exist and are largely unchanged. Wheat and soybeans have a slightly higher target price and lentils have a slightly lower loan rate. To maintain this program structure largely in tact

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while boosting funding for nutrition programs required Congress to find new funds. Congress had no appetite for reducing direct payments, which left only the crop insurance program that could be tapped for savings.

The debate over how much to take away from the crop insurance program provided many with their first detailed reason to understand a program that has grown tremendously since 2000. The stakes of those with vested interests in the program are now in the billions of dollars annually, which makes change more difficult than when the stakes were in the millions of dollars. Not surprisingly, those with a large vested interest in the crop insurance program came out largely unscathed in the 2008 farm bill. Although supporters of the program lament the large cuts that crop insurance took, the cuts really only took away a small portion of the gains that accrue to its beneficiaries.

One unforeseen outcome of the strength of the crop insurance industry in protecting its interests is that the new insurance program that was passed in the farm bill will be operated completely by the Farm Service Agency (FSA) instead of by the Risk Management Agency (RMA). The new program, called ACRE (Average Crop Revenue Election), will not be integrated into the existing crop insurance program because such integration would have meant less risk being handled by the crop insurance industry.

The remainder of this chapter provides a political/economic analysis of why the United States finds itself with two crop insurance programs and an exploration of the possibly large, unintended consequences of having both programs. The explanation for why we have both programs lies, not surprisingly, in Congress trying to find an outcome that would give a diverse set of interest groups what they want, while providing the necessary funds for expanded nutrition programs, which was a major objective of House leadership. The large unintended consequences that could be brought about by ACRE include the likely demise of the marketing loan and countercyclical programs, increased risk that the United States will violate its amber box limits, and in the not-too-distant future, a complete change in the way that US crop insurance is delivered to farmers.

15.2 Background on the US Crop Insurance Program

The US crop insurance program has two broad public policy objectives: help farmers manage financial risk and eliminate the need for Congress to pass supplemental ad hoc disaster assistance programs. To meet these twin objectives, Congress reformed the program in 2000 with the Agricultural Risk Protection Act (ARPA). The reform was justified by President Clinton in his statement upon signing the Agricultural Risk Protection Act (ARPA) of 2000: "I have heard many farmers say that the crop insurance program was simply not good value for them, providing too little coverage for too much money. My FY 2001 budget proposal and this bill directly address that problem by making higher insurance coverage more affordable, which should also mitigate the need for ad hoc crop loss disaster assistance such as we have seen for the last three years." And in 2006 testimony before the House Subcommittee on Agriculture, Rural Development, Food and Drug Administration, and Related Agencies, former USDA under secretary J.B. Penn said, "One of the overarching goals of the crop insurance program has been the reduction or elimination of ad hoc disaster assistance."

By all accounts, Congress has seemingly succeeded in its objective to help farmers manage risk. Coverage is provided to more than 350 commodities in all 50 states and Puerto Rico. And more than 80% of eligible acres are now insured under the program. However, this success has come at a high cost. Congressional Budget Office (CBO) projections made in 2007 indicate that the crop insurance program will cost taxpayers an average of more than $5 billion per year for the next 5 years, which is about double what the program would have cost without the reform. Actual expenditures will be much higher if crop prices stay high. One might be able to justify this additional cost if the second objective of the program had been met also. But passage of ACRE and a permanent disaster program in the new farm bill indicates that crop insurance provides inadequate coverage for farmers, as does inclusion of $3.5 billion in yet another disaster assistance program in the 2008 Iraq funding bill. Members of the House and Senate Agricultural Committees justify the need for disaster assistance despite large amounts of crop insurance aid because even an expanded crop insurance program cannot provide adequate assistance to farmers in financial stress. The large losses in Iowa from excess rainfall in 2008 will once again test Congress' ability to count on the crop insurance program to deliver adequate aid to farmers.

15.2.1 Taxpayer Support of Crop Insurance

Since 2001, when the provisions of the Agricultural Risk Protection Act (ARPA) came fully into force, more than $22 billion has been spent by taxpayers delivering about $11 billion in net payments to farmers, making crop insurance one of the least efficient means of taxpayer support for the farm sector. It remains to be seen whether 2008 will significantly lower this ratio. That is, every dollar in net payments provided to farmers costs taxpayers that dollar plus another dollar to deliver. Table 15.1 provides summary program information since 2001. Taxpayer costs equal administrative and operating (A&O) subsidies plus net underwriting gains paid to crop insurance providers plus total indemnities paid to farmers minus farmer-paid premiums. Each of these is discussed in turn.

15.2.2 Administrative and Operating Subsidies

It costs money to deliver crop insurance. Company salaries must be paid. Agents' commissions must be paid. Loss claims must be verified and paid. And regulatory requirements must be met. In 1980, Congress decided that delivery of the crop insurance program should be given to the private sector so that the program could

Table 15.1 National crop insurance data

Year	Insured acreage (million acres)	Total premiums ($ million)	Total indemnities	Premium subsidies ($ million)	A&O subsidies	Underwriting gains
2001	211	2,962	2,960	1,772	626	342
2002	214	2,916	4,067	1,741	743	–52
2003	217	3,431	3,25	2,042	859	378
2004	221	4,186	3,207	2,477	869	848
2005	246	3,949	2,351	2,344	861	870
2006	242	4,362	3,415	2,680	950	908
2007	242	6,562	3,519	3,823	1,362[a]	1,969[a]

[a]Estimated from year to date loss ratio

be expanded as rapidly as possible. Companies had an incentive to expand sales because they were essentially paid a sales commission. For each dollar of premium they brought in, companies were given a percentage. That percentage was reduced by 2.3% points (from approximately 20.7% of premium) beginning in 2009. From Table 15.1, it can easily be seen that A&O subsidies would have been $1.23 billion instead of $1.36 billion with this cut. This leaves A&O still 43% above 2003 levels.

15.2.3 Net Underwriting Gains

A gross underwriting gain occurs in the crop insurance program when premiums exceed indemnities. In these years, crop insurance companies get to keep a portion of the difference. The portion they keep is called the net underwriting gain. For example, in 2004, premiums exceeded claims by $979 million. Companies were allowed to keep $848 million of this difference. In years in which premiums are less than insurance claims, companies may have to pay a portion of the difference, an underwriting loss. In 2002, for example, claims exceeded premiums by $1.15 billion. Companies had to pay the government $52 million of this amount.

The 2002 and 2004 examples nicely illustrate why, on average, crop insurance companies expect to generate underwriting gains. In years in which underwriting gains are positive, companies get to keep a larger proportion of the gain than that they have to pay the government in years in which there are underwriting losses. The mechanism by which net gains and losses are determined is the Standard Reinsurance Agreement (SRA).

Companies generate net gains from the SRA in three ways. The first is by determining which of their customers are most likely to generate claims and then giving the premium from these customers and responsibility for any subsequent losses directly to the government. The average customer retained by a company therefore has a better risk profile than the average customer in the overall pool. Thus, average claims from the retained pool will be lower than the overall average, and the company will tend to make money.

However, the overall risk of loss from retained customers is still too large for companies to be willing to take on all losses. Hence the SRA is designed to have the government take on a portion of company losses when claims exceed premiums in exchange for companies giving the government some of their gains when premiums exceed claims. In exchange for companies taking on some of the risk of the crop insurance program, the government is allowing companies to generate some gains. It is almost as if crop insurance companies are selling taxpayers an insurance policy. In years where crop losses are high, taxpayer losses are reduced because some of the losses are covered by the "policy." The premium that taxpayers pay for this policy are the underwriting gains that companies garner in years where crop losses are small. Whether taxpayers are getting a good deal by this bargain depends on the size of the premium paid in good years relative to the payments received in bad years.

Table 15.2 summarizes one set of conservative estimates of the potential gains and losses to private crop insurance companies from operation of the current SRA. These estimates are based on loss experience from 1993 to 2005 and likely understate the actual underwriting gains that companies currently expect to make. The table presents four equally likely scenarios regarding crop insurance claims. With $4 billion in premiums, companies should expect to make $425 million per year in net underwriting gains. In exchange for paying companies an average of $435 million per year, taxpayers reduce their loss exposure by $223 million in 1 year out of 4. It seems that program costs would be much lower if the Federal government simply and directly took all the risk from the crop insurance program rather than buying an overpriced insurance policy from the crop insurance companies.

The third way that companies make money from the SRA is that gains and losses are calculated for each state separately. Given the asymmetry of net gains and losses, separate ceilings on losses for each state will result in lower overall losses that more than compensate the benefits of separate ceilings on gains.

Table 15.2 Potential gains and losses to crop insurance companies under the standard reinsurance agreement

Insurance claim scenario	Loss ratio (indemnity over premium)	Ratio of gain to total premium	Total gain to companies ($ million)
Very low	0.53	0.238	953
Moderately low	0.72	0.136	546
Moderately high	0.76	0.115	462
Very high	1.28	–0.055	–223
Average	0.82	0.108	435

15.2.4 Producer Premium Subsidies

The last taxpayer cost category is premium subsidy. Farmers must pay for crop insurance, but they pay only a portion of the amount needed to cover insured losses. Throughout the 1980s and 1990s, farmers were reluctant to buy enough crop insurance to satisfy Congress. So to get farmers to buy more insurance, ARPA dramatically decreased the portion that farmers must pay. Currently, farmers pay about 41% of the amount needed to cover insured losses. This large subsidy means that most farmers will get substantially more back from the program than they pay it.

It is somewhat of a paradox why farmers require such large subsidies to buy a product that substantially reduces their financial risk. But farmers routinely reduce financial risk in a number of other ways. Growing more than a single crop, raising livestock, working off-farm, employing marketing tools, and adopting risk-reducing management practices – all work to reduce financial vulnerability. In addition, for the lowest-risk farmers, the price of crop insurance may not adequately reflect their risk. So one explanation for this paradox is that for many farmers, the amount of remaining financial risk they face may simply be too small to insure unless the price of insurance is low enough. The current 59% average subsidy seems to have reduced the price of insurance to the point where most farmers now consider it worthwhile to purchase. This premium subsidy is now so large that the average farmer in the program can expect a rate of return on producer paid premium of 143%.

15.3 Beneficiaries of Crop Insurance

Table 15.1 shows that there are two groups of winners from crop insurance: farmers, who have received about $10.5 billion in payments in excess of premiums, and the crop insurance industry, which has received $11.8 billion from taxpayers since 2001. But a closer examination of the distribution of benefits across farmers and across participants in the crop insurance industry shows that there are significant distributional considerations in the program.

Figure 15.1 shows that not all farmers have received indemnities in excess of premiums since 2000. Iowa, Illinois, and Indiana farmers have actually paid more in premium than they have received in indemnities. Farmers in Texas, Kansas, and the Dakotas have other Great Plains states have received significantly more than they have paid in premium. Figure 15.2 shows the ratio of indemnities received to premium paid. Oklahama farmers have received the highest return on their premium dollars followed closely by other Great Plains states. The ratios for Minnesota and Nebraska farmers are about what they should be if premiums are set at actuarially fair levels. While crop losses since 2000 is too short a period to judge actuarial fairness of crop insurance premiums, the discernible geographic pattern shown in Figs. 15.1 and 15.2 should give some insight into which farm groups might support the current crop insurance program.

A report commissioned by the National Crop Insurance Service and prepared by Grant Thornton gives insight into the distribution of benefits within the crop

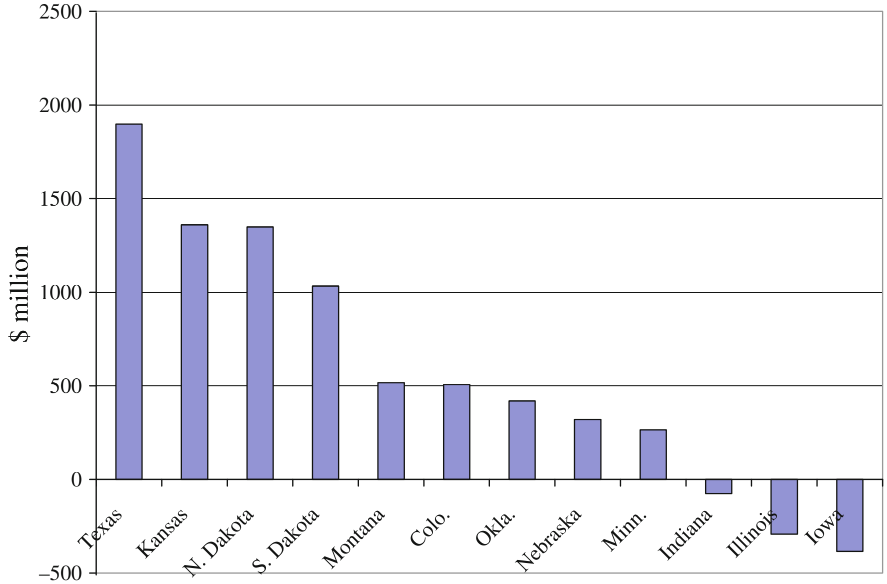

Fig. 15.1 Total indemnities received minus farmer paid premium from 2000 to 2007

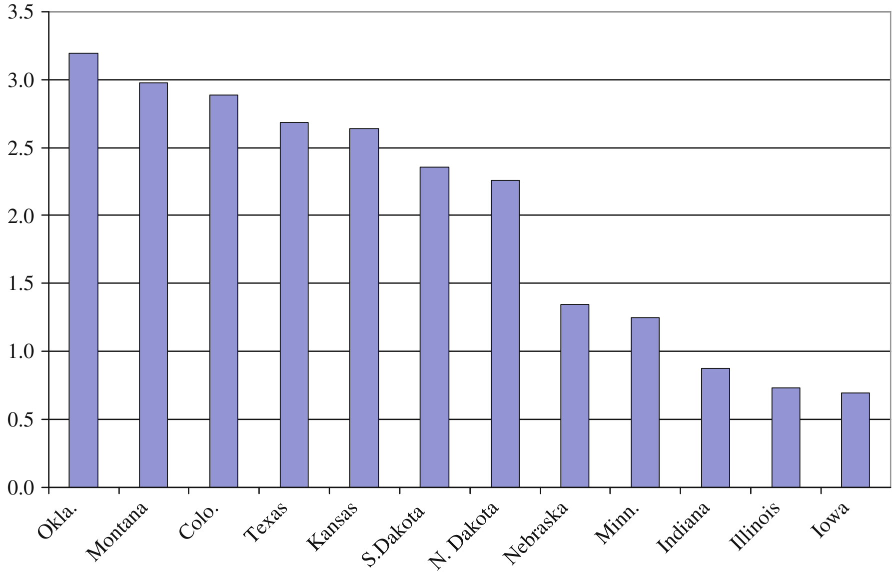

Fig. 15.2 Ratio of indemnities received to premium paid by state since 2001

insurance industry.[1] The report breaks out expenses by category for the crop insurance companies in aggregate. Expense categories include loss adjustment, agents' commissions, and other expenses, which include salaries, information technology, and other miscellaneous expenses. The expenses for each category are expressed as a percent of premium. Table 15.1 shows that total premium has increased dramatically since 2001. Because revenue to the industry is roughly proportionate to premium, total industry revenue has also increased dramatically. Figure 15.3 shows industry revenue over this time period generated from the major insured crops, which represent about 90% of the program.

The Grant Thornton report estimates that crop insurance profits are less than other property and casualty lines of insurance despite the large increase in revenue shown in Fig. 15.3. If true, this implies that the cost of crop insurance must be increasing faster than the cost of other insurance lines. But the types of costs crop insurance companies incur are quite similar to the types of costs incurred by other insurance lines. Salaries of individuals, information technology, agent commissions, loss adjustments, and general office labor are involved in all insurance businesses. Given that these costs are set in competitive markets, crop insurance industry costs should not be increasing faster than the costs of other insurance businesses. If so, then where has the increase in revenue shown in Fig. 15.1 gone?

In a competitive insurance market, industry profits will eventually show up as a reduction in premium rates as companies compete for customers' business. But companies cannot compete by lowering the price of their product because premium rates are set by the RMA. Furthermore, Congress has further blocked competition by making it illegal for companies to discount their products through rebates or for farmers to join together in buying cooperatives to sell themselves crop insurance. So if increased revenue does not show up in lower profits, where does it show up? There does not seem to be a factor of production that is either fixed or supplied inelastically. But which factor is the residual claimant?

From 2001 to 2006, RMA Summary of Business Reports show that the total number of crop insurance policies sold declined by 11.5%. The number of policies in so-called additional business declined by 3.3%. Loss adjustment expenses increased by just 18% over this time period and all other costs increased by just

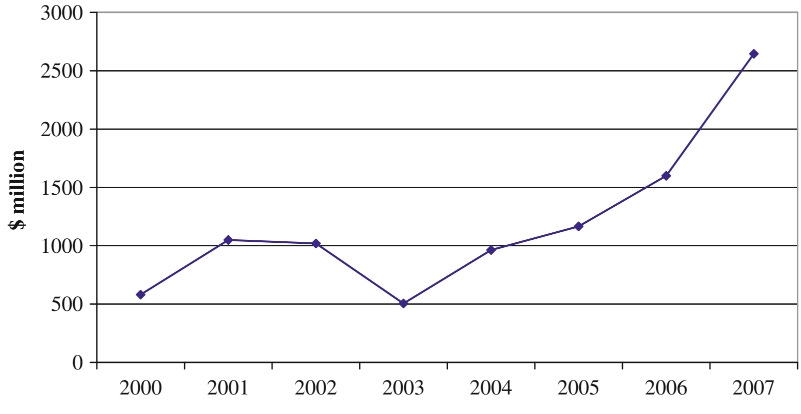

Fig. 15.3 Total crop industry revenue from corn, soybeans, wheat, and cotton since 2000. *Source*: Calculated from data obtained from RMA Summary of Business Reports

21%, according to the Grant Thornton report. These cost increases are roughly in line with general wage inflation over this time period of between 3 and 4% annual increases. One might expect a drop in the number of policies sold to result in less of an increase in these expense categories, but it is clear that loss adjustors and company executives are not the main residual claimants. Nor are shareholders in these companies because Grant Thornton concludes that crop insurance company profits are less than other insurance lines. That leaves crop insurance agents.

There does not seem to be any reason why crop insurance agents should be the residual claimant. Yet the commissions paid to agents increased an astounding 74% over this time period, despite a drop in the number of policies sold. What can explain this paradox that a declining number of customers actually resulted in such a large increase in agent commissions? Agents do not have any specialized skills that cannot be quickly learned by potential new entrants. So why are they the residual claimant?

In a review that the author did for the Board of Directors of the Federal Crop Insurance Corporation of the now-banned Premium Reduction Plan, crop insurance companies reported that the commissions they pay their agents vary dramatically across states. The companies needed to report agent commissions because the Premium Reduction Plan would have reduced the price that farmers pay for crop insurance by reducing agent commissions. Because the actual labor and technology involved in selling and servicing a crop insurance policy vary little across states, there is no cost basis for explaining why Corn Belt agents may be paid in excess of 20% commissions while Texas agents may be paid much less.

The geographic pattern of farmer returns to crop insurance shown in Figs. 15.1 and 15.2 are highly correlated with the pattern of agent commissions. The states where farmers have profited from crop insurance are those states where commissions are low. Those states where farmers have not benefited from crop insurance are where commissions are high. As explained in the previous section, underwriting gains for companies are generated in states where premiums exceed indemnities. Thus, companies find it much more profitable to sell crop insurance in the Corn Belt states of Iowa, Illinois, and Indiana than they do in the Great Plains states of Texas, Kansas, North Dakota, and South Dakota. But why should agents make more money in states that generate large underwriting gains? The explanation lies in a lack of an incentive for farmers to switch agents.

15.4 A Simple Model of Competition in Crop Insurance

There are five main players in the crop insurance industry: Congress, government regulators, farmers, crop insurance agents, and crop insurance companies. Taxpayer subsidies created and provide continual support the industry. Congress reacts to political pressure by passing laws that regulate and subsidize the industry. Regulators implement those laws. Farmers buy crop insurance from a crop insurance agent. Crop insurance agents decide which crop insurance company will receive each farmer's business. Agents make money by earning commission on each policy that they sell. The variable cost of selling policies is much less than the commission on most policies, so the more policies they sell, the more money agents make. Thus agents have an incentive to compete with other agents for a farmer's business. Crop insurance companies make money from underwriting gains and from A&O reimbursements. The noncommission variable costs are much less than A&O and expected underwriting gains in almost all states. Thus, the more policies that they can obtain, the more money they can make. This creates an incentive for companies to compete for agents' books of business. Agents and companies and farmers have an incentive to lobby Congress to pass laws that work to their favor. Because taxpayer subsidies are the only source of revenue for companies or agents, any lobbying that they do uses taxpayer funds.

There exist two sources of competition in this model. Agents compete for farmers business and companies compete for agents business. The agent competition for farmers' business cannot include price competition because of laws passed by Congress at the behest of agents. So agents must compete in terms of service. The types of service that can be offered include educating farmers about the types of insurance coverage offered; lowering the farmer cost of filling out required forms; and keeping farmers informed of any information that may prove useful to farmers. All of these services are of second-order importance to farmers because either they are one-time benefits or because they do not directly increase farmers' profits. By default, a farmer's business remains with an agent year after year. So unless an agent convinces a farmer to switch agents, no switch will take place. To a farmer, the benefit of switching must be greater than the cost of switching, which involves some paperwork, possibly alienating a local neighbor or business person, and search costs for an agent that can provide superior service. Because there are positive switching costs and only indirect benefits, the incentive for most farmers to switch is not very high, although exact measurement of the incentive would be difficult. Consequently, the productivity of agent investments designed to induce farmers to switch will not be high. In equilibrium, each agent invests an optimal amount to keep his or her business and to perhaps attract new business, and each farmer has found the agent where the benefits of further switching are outweighed by the costs. Entry costs, although nominally seemingly low, are actually quite high because new entrants will find it difficult to build up their book of business by inducing an adequate number of farmers to switch. Thus each agent has essentially a captive book of business.

Companies use price to compete for agents' books of business. The price of an agent's business is the agent commission. Because most agents act independently of companies, they are free to sell their book to the highest bidder. There are approximately 15 companies bidding for business. The maximum bid that a company will likely make is the difference between the expected revenue that an agent's book of business will bring in minus all noncommission variable costs. With sufficient competition, commission rates will exactly equal this difference. Thus price competition between companies along with regulatory barriers that limit competition in premium rates make agents the residual claimant in the crop insurance industry. Thus, because expected underwriting gains vary across states as shown in Figs. 15.1 and 15.2, we would expected equilibrium agent commissions to also vary dramatically across states.

The Grant Thornton conclusion that industry expenses have outpaced reimbursements in the crop insurance industry is directly analogous to subsidized farmers claiming that they need higher subsidies because increased land costs have driven up their cost of production. If we reexamine this conclusion, and treat agent commissions as part of the industry supported by taxpayers, then a very different picture emerges. Program costs have skyrocketed even though the number of crop acres insured and the number of policies sold is stagnant. The increase in agent rents is illustrated in Figures 15.4 and 15.5.

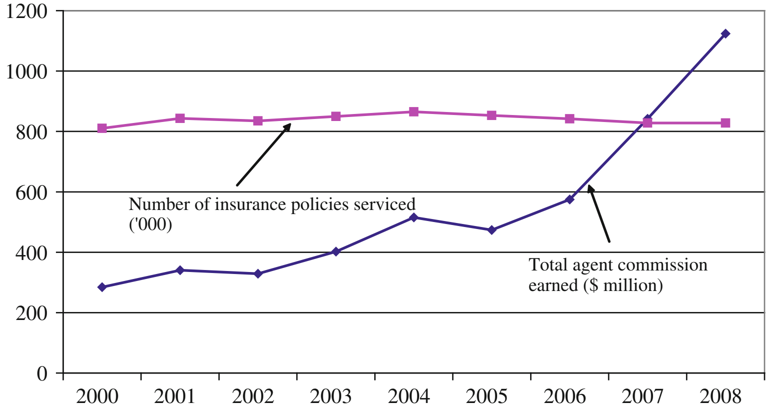

Fig. 15.4 Corn, soybeans, wheat and cotton policies serviced and associated total agent commissions. *Source*: Commissions calculated from "Federal Crop Insurance Program Profitability and Effectiveness Analysis, 2007 Update" prepared on the behalf of National Crop Insurance Services by Grant Thornton LLP. Policy numbers obtained from RMA Summary of Business Reports

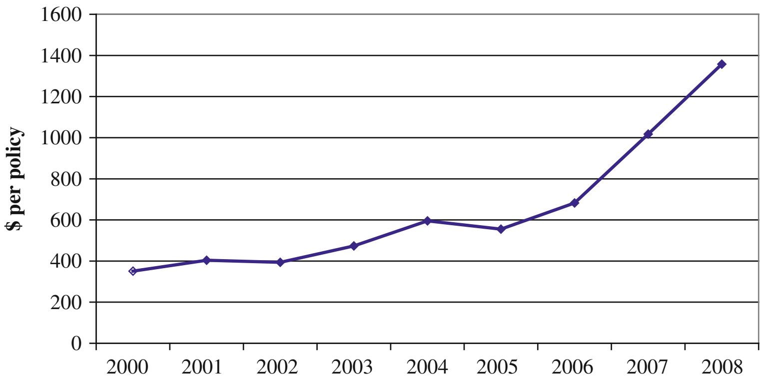

Fig. 15.5 Agent commission per corn, soybeans, wheat, and cotton policy sold. *Source*: Commissions calculated from "Federal Crop Insurance Program Profitability and Effectiveness Analysis, 2007 Update" prepared on the behalf of National Crop Insurance Services by Grant Thornton LLP. Policy numbers obtained from RMA Summary of Business Reports

15.5 Political Implications

With crop insurance agents being the residual claimants to crop insurance profits, we should expect that they would lobby hard to protect the program from any change that would reduce their rents. Any change that would reduce crop insurance premiums or A&O reimbursements would be expected to draw strong opposition by supporters of agents. One proposal that was pushed hard by the National Corn Growers Association would have created a county revenue insurance plan in place of current marketing loans and countercyclical payments. Because a substantial portion of the farm-level risk in the Corn Belt is systemic risk (Barnett et al., 2005; Carriquiry et al., 2008), such a program would dramatically reduce participation in the crop insurance program. Another proposal pushed by American Farmland Trust (AFT) would have created a national revenue insurance program, the payments from which would have reduced any crop insurance indemnity that was owed a farmer. This program would have lowered crop insurance premiums. Both programs were strongly opposed by crop insurance lobbyists. The corn growers' proposal never found a sponsor, whereas the AFT proposal was effectively killed by supporters of the crop insurance program in the Senate Agricultural Committee. Industry supporters were also able to defeat proposals designed to reduce industry revenue back to where it was in 2006. That the cuts that did make it in the farm bill were so small is evidenced by the press release from the main agent lobbying association that fully supported the final bill.

However, with their focus on defeating any proposal that would directly compete with crop insurance or that would substantially reduce industry revenue, supporters allowed a new program to be passed, ACRE, that could have substantial long-term impacts on their industry.

15.6 Average Crop Revenue Elections

ACRE is an optional program that if chosen by a farmer would reduce a farmer's direct payment by 20%, eliminate countercyclical payments, and dramatically reduce the farmer's loan rate. In exchange, a farmer would receive a state revenue guarantee equal to 90% of the product of Olympic average of the previous 5 years of state yields and the average of the previous 2 years' season average prices. If the product of actual state yield and season average price is less than this guarantee, then a farmer will receive the difference (up to 25% of the guarantee) on 85% of planted acres for all program crops. Farmers can choose ACRE beginning with the 2009 crop year. Once chosen, the choice cannot be revoked for the life of the farm bill.

Because this new program looks back in time for the price that it uses to set the guarantee, the actual path of prices will determine how many farmers will find it profitable to choose ACRE. For the 2009 crop year, the price used to set the guarantee were the 2007/2008 and 2008/2009 marketing year prices. Table 15.3

Table 15.3 Key prices in determining ACRE participation

	Corn	Soybeans
	$/bu	
2007 Marketing year price[a]	4.35	10.00
2008 Marketing year price[a]	5.80	11.75
2009 ACRE price	5.08	10.88
2009 Loan rate	1.95	5.00
2010–2012 Loan rate	1.95	5.00
2009 Target price	2.63	5.80
2010–2012 Target price	2.63	6.00
Direct payment rate	0.28	0.44

[a]The midpoint of WASDE estimate published June 10th

presents estimates of each price from the June 10th 2008 WASDE estimates. Also presented are the new farm bill's loan rates and target prices available to a farmer who does not choose ACRE.

Given the Table 15.3 prices, the key to farmer participation will be the 2009 expected season average price. If market prices stay substantially above the ACRE price, then farmers will not be receiving any marketing loan gains or countercyclical payments because the loan rates and target prices are so low relative to expected market price. But ACRE will also be providing an out-of-the-money guarantee so farmers may feel that the 20% cut in direct payments is too high a price to pay for potential ACRE payments. In this case, note that the 2010 ACRE price will be even higher than the 2009 price so farmers would know that their 2010 ACRE guarantee would be even higher than the 2009 guarantee so that there is little downside of signing up in 2009.

If the expected price in 2009 falls, then expected payments under ACRE could increase dramatically. Figures 15.6 and 15.7 show, respectively, the relationship between expected ACRE payments for corn and soybeans for 2009 and the 2009 expected season average price, using the Table 15.3 prices. Of course to receive the

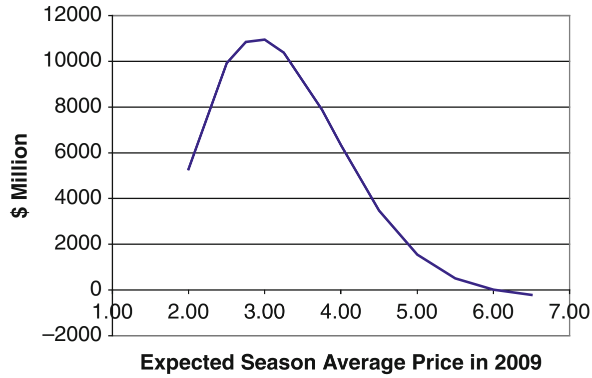

Fig. 15.6 Expected net benefit to US corn farmers from ACRE for various 2009 expected prices

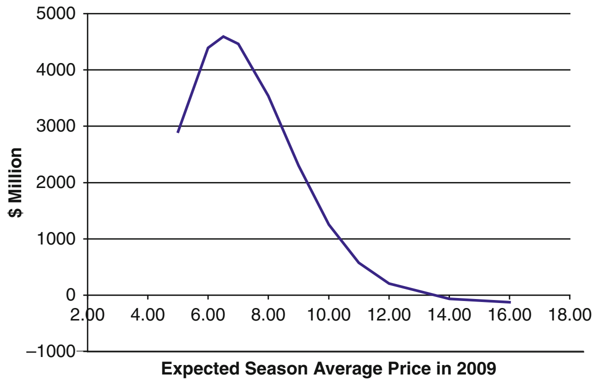

Fig. 15.7 Expected net benefit to US soybean farmers from ACRE for various 2009 expected prices

opportunity to receive these ACRE payments, a farmer would have to give up countercyclical payments and take a 30% reduction in loan rates. Figs. 15.6 and 15.7, respectively show the expected net benefit to corn and soybean farmers as a function of the 2009 season average price. Thus, to be more informative, what is illustrated in Figs. 15.6 and 15.7 are US aggregate expected ACRE payments less the 20% cut in direct payments less expected marketing loan gains and expected countercyclical payments. Thus actual expected ACRE payments are larger than shown.

As can be seen, a drop in corn and soybean prices will trigger large expected ACRE payments. The net benefit to farmers rises sharply as expected 2009 price begins to drop and then the net benefit peaks. The subsequent drop in net benefit shown in Figs. 15.6 and 15.7 is caused by expected LDP and CCP payments to farmers rising more rapidly than ACRE payments. Note, though, that net benefits to ACRE are still large and positive even at these low prices. This suggests that farmers still have a large incentive to choose ACRE even if expected LDP and CCP payments are large.

The net benefit to corn and soybean farmers falls below zero only when expected prices increase. But this does not mean that farmers will not participate in ACRE because higher prices in 2009 simply mean a higher guarantee in 2010 and higher future payments. At these price levels, the only cost of choosing ACRE is a 20% cut in direct payments. Given the results in Figs. 15.5 and 15.6, it is likely that a large proportion of corn and soybean farmers will choose ACRE.

If many farmers participate in ACRE, then marketing loans and countercyclical payments will not play an important role in the next farm. But before we can conclude that all farmers will choose ACRE, we must consider the impact on the ACRE guarantee if market prices fall in 2009 and in subsequent years. It could be that the ACRE guarantee falls so low in 2011 and 2012 that it makes the current program more advantageous.

However, a provision in the ACRE program does not allow the guarantee to increase or decrease more than 10% in any year. This means that the 2013 guarantee can only drop to 65.61% of the 2009 guarantee. Because the 5-year Olympic average of state yields will not typically increase or decrease a dramatic amount, it is reasonable to ask whether an ACRE price of 65.61% of the 2009 ACRE price makes marketing loan gains and countercyclical payments more attractive than ACRE.

If the 2007 and 2008 WASDE estimates of marketing year prices are true so that the 2009 ACRE prices come in at $5.08 and $10.88 for corn and soybeans, then 65.61% of these prices are $3.33 and $7.14, respectively. This is the minimum ACRE price that could be reached in the 2008 farm bill period. At these ACRE prices, the net benefit to ACRE is still positive. Thus, it seems that ACRE dominates the current program for corn and soybean farmers. This suggests that if 2008 market prices are anywhere close to where WASDE projects them to be, then all farmers will have an incentive to choose ACRE.[1]

15.7 Future Implications

The crop insurance lobby was successful at defeating area revenue insurance programs that would have replaced or been integrated with crop insurance. Instead we have the ACRE program that because it is backward looking has the potential for making dramatically higher payments than if a forward-looking program like Group Risk Income Protection had been adopted instead. Although its supporters claim that the program is more market oriented than programs with a fixed guaranteed price, this does not mean that it is less distortionary than current programs because of the potential for in-the-money revenue guarantees at planting time. These in-the-money guarantees could imply difficulty in meeting WTO commitments if price levels continue higher for a year or two and then fall dramatically, perhaps because of a rethinking of US ethanol policy.

It is likely that when the vast majority of farmers choose ACRE in the years ahead, they will find that state-level revenue guarantees are not the same as county- or farm-level guarantees. That is, very low state yields that trigger payments will likely be associated with farm-level losses, but there will be years in which farm-level losses occur, but state losses do not. This will increase pressure in the next farm bill for farmers to push for a more disaggregate guarantee, perhaps at the county level. In addition, the backward-looking price-setting mechanism will be difficult to defend. Using futures prices is a much more transparent and market-oriented means of setting program guarantees. Finally, ACRE will likely lead to a wholesale reevaluation of the crop insurance program as the primary means of delivering risk management support to farmers. Farmers will find that risk management can be delivered from the farm program at much lower cost by simply taking the systemic

[1] Actual ACRE sign up in 2009 was quite low despite the expected advantage that the program confers to farmers. 2009 payments to corn and soybean farmers will be quite modest. Payments to wheat producers in states where yields were not above average and who signed up for ACRE will be receiving substantial 2009 payments.

risk out of the crop insurance program and covering this risk in the farm bill. This has the potential for being a much more cost-effective approach than the current approach of insuring both poolable and systemic risk in the farm bill (Paulson and Babcock, 2008).

Note

1. "Federal Crop Insurance Program: Profitability and Effectiveness Analysis 2007 Update." Grant Thornton, LLP, prepared on behalf of National Crop Insurance Services, Inc.

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Chapter 16
Aggregation and Arbitrage in Joint Production

V. Eldon Ball, Ricardo Cavazos, Jeffrey LaFrance, Rulon Pope, and Jesse Tack

Abstract Two common problems in econometric models of production are aggregation and unobservable variables. Many production processes are subject to production shocks, hence both expected and realized output is unknown when inputs are committed. Expectations processes are notoriously difficult to model, especially when working with aggregated data or risk-averse decision makers. Duality methods for the incomplete systems of consumer demand equations are adapted to the dual structure of variable cost function in joint production. This allows the identification of necessary and sufficient restrictions on technology and cost so that the conditional factor demands can be written as functions of input prices, fixed inputs, and cost. These are observable when the variable inputs are chosen and committed to production, hence the identified restrictions allow ex ante conditional demands to be studied using only observable data. This class of production technologies is consistent with all von Neumann-Morgenstern utility functions when ex post production is uncertain. We then derive the complete class of input demand systems that are exactly aggregable, can be specified and estimated with observable data, and are consistent with economic theory for all von Neumann/Morgenstern risk preferences. We extend this to a general and flexible class of input demand systems that can be used to nest and test for aggregation, global economic regularity, functional form, and flexibility. The theory is applied to U.S. agricultural production and crop acreage allocation decisions by state for the years 1960–1999. Ongoing work includes applying this model to a recently updated data set created by the USDA/ERS through 2004 and estimating the intensive and extensive margin effects for state-level crop production with a stochastic dynamic programming model of risk aversion, asset management, and adjustment costs.

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Disclaimer: The views and findings reported in this chapter are solely those of the author(s). They do not necessarily reflect the views, positions, or other findings of the USDA. The chapter was not reviewed or approved by any agency of the USDA.

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Studies in Productivity and Efficiency 7, DOI 10.1007/978-1-4419-6385-7_16,

16.1 Introduction

Analysis of multi-product behavior of firms is common in agricultural economics. Techniques of analysis might be based on the distance or production functions, or profit, revenue, or cost functions (Akridge and Hertel, 1986; Ball, 1988; Färe and Primont, 1995; Just et al., 1983; Lopez, 1983; Shumway, 1983). There is a large literature on functional structure and duality that helps guide empirical formulations and testing based on concepts of non-jointness and separability (Blackorby et al., 1978; Chambers, 1984; Lau, 1972, 1978). Specifications of non-jointness generally reduce to some form of additivity (Hall, 1973; Kohli, 1983). Separability in some partition of inputs or outputs often results in separability in a similar partition of prices so long as aggregator functions are homothetic (e.g., Blackorby et al., 1977; Lau, 1978). Such restrictions on technology guide empiricists as they think about aggregation based on functional structure.

Two ubiquitous problems in the econometric modeling of production are aggregation and whether or not the variables are observable. Aggregation is unavoidable and useful. Many production processes are subject to production shocks. Planned output and product prices are unobservable when inputs are committed. Expectations processes are difficult to model, especially when working with aggregate data or decision makers who are averse to risk. An alternative solution that avoids this issue might prove useful in applied production analyses.

This chapter presents a new class of variable input demand systems recently derived by LaFrance and Pope (2008b, 2010). The demand models in this class can be estimated with observable data, are exactly aggregable, and are consistent with economic theory for all risk preferences. LaFrance and Pope also extend this class to a general, flexible class of input demands that can be used to nest and test for aggregation, global economic regularity, functional form, and flexibility. Almost all existing input demand systems are restricted cases of this class. However, the focus of this study is on flexible, exactly aggregable full rank input demand systems.

16.2 The Production Model and Two Results

The neoclassical model of conditional demands for variable inputs with joint production, fixed inputs, and production uncertainty is

$$\mathbf{x}(\mathbf{w}, \overline{\mathbf{Y}}, \mathbf{z}) = \arg\min \left\{ \mathbf{w}^{\mathrm{T}}\mathbf{x} : F(\mathbf{x}, \overline{\mathbf{Y}}, \mathbf{z}) \le 0 \right\}, \tag{16.1}$$

where $\mathbf{x} \in \mathbb{R}_+^{n_x}$ is an n_x-vector of variable inputs, $\mathbf{w} \in \mathbb{R}_+^{n_x}$ is an n_x-vector of variable input prices, $\overline{\mathbf{Y}} \in \mathbb{R}_+^{n_y}$ is an n_y-vector of planned outputs,[1] $\mathbf{z} \in \mathbb{R}_+^{n_k}$ is an n_z-vector of fixed inputs, and F: $\mathbb{R}_+^{n_x} \times \mathbb{R}_+^{n_y} \times \mathbb{R}_+^{n_z} \to \mathbb{R}$ is the joint production function (the boundary of a closed and convex production possibilities set with free disposal of one or more inputs and one or more outputs). Denote the variable cost function by $c(\mathbf{w}, \overline{\mathbf{Y}}, \mathbf{z}) \equiv \mathbf{w}^{\mathrm{T}}\mathbf{x}(\mathbf{w}, \overline{\mathbf{Y}}, \mathbf{z})$. We assume throughout that the production process is subject to supply shocks of the general form

$$\mathbf{Y} = \overline{\mathbf{Y}} + \mathbf{h}(\overline{\mathbf{Y}}, \mathbf{z}, \boldsymbol{\varepsilon}), \;\; E\left[\mathbf{h}(\overline{\mathbf{Y}}, \mathbf{z}, \boldsymbol{\varepsilon})|\mathbf{x}, \overline{\mathbf{Y}}, \mathbf{z}\right] = 0. \tag{16.2}$$

In both static and dynamic settings, it is a simple matter to show that equation (16.1) is implied by equation (16.2) and the expected utility hypothesis for *all* von Neumann-Morgenstern preferences (Pope and Chavas, 1994).

Three issues are associated with the estimation of the equation system (16.1) above. First, planned/expected output is a vector of latent, unobservable variables. To estimate equation (16.1) directly, therefore, one needs to either identify and estimate the planning and expectations formation process or address errors in variables associated with using the observable $\mathbf{Y}$ in place of the theoretically correct unobservable $\overline{\mathbf{Y}}$ in the conditional demand equations (Pope and Chavas, 1994). There also is a fairly large literature which proposes various approaches to the specification of ex ante cost functions when output is uncertain under potentially risk-averse behavior (e.g., Chavas, 2008; Chambers and Quiggin, 2000; Pope and Chavas, 1994; Pope and Just, 1996).

The essential problem is that if inputs are applied ex ante under stochastic production, the outputs are not observed. One straightforward solution is to make the correct assumptions such that c exists in some quantity (or quantities). LaFrance and Pope (2010) identify the necessary and sufficient condition to consistently estimate conditional input demands as functions of variables that are observable when the inputs are committed to production – prices of the inputs, the levels of quasi-fixed inputs, and the variable cost of production – so that the variable input demands can be written as

$$\mathbf{x}(\mathbf{w}, \overline{\mathbf{Y}}, \mathbf{z}) = \mathbf{g}(\mathbf{w}, \mathbf{z}, c(\mathbf{w}, \overline{\mathbf{Y}}, \mathbf{z})). \tag{16.3}$$

This is not the typical approach to formulating conditional demands. But it makes particular sense in situations like agriculture where output is observed only ex post. We restate the fundamental result of LaFrance and Pope (2010) on this question as follows.

Proposition 1 *The variable input demand equations have the structure (16.3) if and only if the variable cost function has the structure*

$$c(\mathbf{w}, \overline{\mathbf{Y}}, \mathbf{z}) \equiv \tilde{c}(\mathbf{w}, \mathbf{z}, \theta(\overline{\mathbf{Y}}, \mathbf{z})), \tag{16.4}$$

which in turn holds if and only if the joint production function has the structure,

$$F(\mathbf{x}, \overline{\mathbf{Y}}, \mathbf{z}) \equiv \tilde{F}(\mathbf{x}, \mathbf{z}, \theta(\overline{\mathbf{Y}}, \mathbf{z})). \tag{16.5}$$

In other words, outputs are weakly separable from the variable inputs. Although this result is somewhat restrictive in outputs,[2] it is quite flexible in the inputs. LaFrance and Pope call any such joint production process an ex ante *joint production system*.

The second issue, especially in agricultural supply modeling, is that aggregation across economic agents appears to be both an unavoidable and a useful data management strategy. For example, aggregation increases the statistical precision of economic variables like the yield per acre of a crop on a farm with several fields, in a county, state, region, or country. Aggregation from micro-level decision makers to macro-level data has been studied extensively in consumer behavior,[3] but has received little attention in the field of production economics (Chambers and Pope, 1991, 1994; LaFrance and Pope, 2008a, b, 2010).[4]

Taking the class of input demands that can be specified in terms of observable variables as the point of departure, LaFrance and Pope (2008b) extend aggregation theory to multiple output production systems. Their main result on this issue requires the following definition. Let $\omega : \mathbb{R} \times \mathbb{R} \to \mathbb{R}$ be defined by

$$\omega(\eta(\mathbf{w}), \theta) = \begin{cases} \theta, & \text{if } K = 1, 2 \text{ or } K = 3 \text{ or } 4 \text{ and } \lambda'(s) = 0, \\ \theta + \int_0^{\eta(\mathbf{w})} [\lambda(s) + \omega(s, \theta)]\, ds, & \text{if } K = 3 \text{ or } 4 \text{ and } \lambda'(s) \neq 0, \end{cases} \tag{16.6}$$

subject to $\omega(0, \theta) = \theta$ and $\partial\omega(0, \theta)\big/\partial s = \lambda(0) + \theta^2$, for some $\eta : \mathbb{R}_+^{n_x} \to \mathbb{R}$, and some $\lambda : \mathbb{R} \to \mathbb{R}$. With this mathematical device, LaFrance and Pope (2008b) characterize the class of full rank exactly aggregable ex ante joint production systems in the sense of Gorman (1981), Lau (1982), and Lewbel (1987a) with the following result:

Proposition 2 *Let* $\pi : \mathbb{R}_+^{n_x} \to \mathbb{R}_{++}$ *be increasing, concave, and positively linearly homogeneous in* $\mathbf{w}$; *let* $\eta : \mathbb{R}_+^{n_x} \to \mathbb{R}_{++}$ *be homogeneous of degree zero in* $\mathbf{w}$; *let* $\alpha, \beta, \gamma, \delta : \mathbb{R}_+^{n_x} \to \mathbb{C} = \{a + \iota b,\ a, b \in \mathbb{R}\}$, *where* $\iota = \sqrt{-1}$, *the* $\alpha, \beta, \gamma, \delta \in C^\infty$ *are homogeneous of zero degree in* $\mathbf{w}$ *and they satisfy* $\alpha\delta - \beta\gamma \equiv 1$; *and let* $f : \mathbb{R}_+ \times \mathbb{R}_+^{n_z} \to \mathbb{C}$ *satisfy* $\partial f(c/\pi, \mathbf{z})\big/\partial(c/\pi) \neq 0$. *Then the variable cost function for any full rank, exactly aggregable, ex ante joint production system is a special case of*:

$$f\left(\frac{c(\mathbf{w}, \overline{\mathbf{Y}}, \mathbf{z})}{\pi(\mathbf{w})}, \mathbf{z}\right) = \frac{\alpha(\mathbf{w})\omega(\eta(\mathbf{w}), \theta(\overline{\mathbf{Y}}, \mathbf{z})) + \beta(\mathbf{w})}{\gamma(\mathbf{w})\omega(\eta(\mathbf{w}), \theta(\overline{\mathbf{Y}}, \mathbf{z})) + \delta(\mathbf{w})}. \tag{16.7}$$

It is instructive to consider the structure of the input demand functions implied by equation (16.7). This can be accomplished by differentiating with respect to $\mathbf{w}$ and then applying Hotelling's/Shephard's lemma. To make the notation as compact as possible, let a bold subscript $\mathbf{w}$ denote a vector of partial derivatives with respect to the variable input prices and suppress the arguments of the functions $\{\alpha, \beta, \gamma, \delta, \eta, \pi\}$ to yield (after considerably straightforward but tedious algebra):

$$\begin{aligned} \mathbf{x} = \pi_{\mathbf{w}}\left(\tfrac{c}{\pi}\right) \ + \ \pi \Big\{ & \left[\alpha\beta_{\mathbf{w}} - \beta\alpha_{\mathbf{w}} + (\alpha^2\lambda + \beta^2)\eta_{\mathbf{w}}\right]\left(\tfrac{1}{f_{c/\pi}}\right) \\ & + \left[\beta\gamma_{\mathbf{w}} - \gamma\beta_{\mathbf{w}} + \delta\alpha_{\mathbf{w}} - \alpha\delta_{\mathbf{w}} - 2(\alpha\gamma\lambda + \beta\delta)\eta_{\mathbf{w}}\right]\left(\tfrac{f}{f_{c/\pi}}\right) \\ & + \left[\gamma\delta_{\mathbf{w}} - \delta\gamma_{\mathbf{w}} + (\alpha^2\lambda + \delta^2)\eta_{\mathbf{w}}\right]\left(\tfrac{f^2}{f_{c/\pi}}\right)\Big\} \ . \end{aligned} \tag{16.8}$$

Note that this system of demand equations has the finitely additive and multiplicatively separable structure that is required for exact aggregation over $(c/\pi, \mathbf{z})$ across agents (Lau, 1982). Also note that there are up to four linearly independent functions of variable cost and fixed inputs and up to four linearly independent vectors of input price functions. This is the maximum rank for any exactly aggregable demand system (LaFrance and Pope, 2009; Lewbel, 1987b).

A third issue with estimating conditional input demands is that quasi-fixed inputs, planned outputs, total variable cost, and variable input prices are jointly determined with the input demands. Consistent estimation requires methods that address this simultaneity. We address this issue in the empirical application to state-level demands for agricultural inputs.

16.3 Econometric Structure

Let $i = 1, \ldots, I$ index states, $j = 1, \ldots, N$ index variable inputs, and $t = 1, \ldots, T$ index time. In general, the state-level variable input demand equations can be written as

$$x_{ijt} = f_{ij}(\mathbf{w}_{it}, k_{it}, c_{it}, t; \boldsymbol{\theta}) + u_{ijt}, \;\; i = 1, \ldots, I, \;\; j = 1, \ldots, N, \;\; t = 1, \ldots, T, \tag{16.9}$$

where $\mathbf{w}_{it}$ is the $N \times 1$ vector of (normalized) input prices, k_{it} is capital per acre, c_{it} is (normalized) variable cost per acre, $\boldsymbol{\theta}$ is a $K \times 1$ vector of parameters to be estimated, and u_{ijt} is a mean zero random error term. Suppose the errors are intertemporally correlated,

$$u_{ijt} = \sum_{j'=1}^{N} \phi_{jj'} u_{ij't-1} + v_{ijt}, \;\; i = 1, \ldots, I, \;\; j = 1, \ldots, N, \;\; t = 1, \ldots, T, \tag{16.10}$$

while the mean zero random variables v_{ijt} are uncorrelated across time, but correlated across inputs within each state, $E(\mathbf{v}_{i\bullet t}\mathbf{v}_{i\bullet t}^{\mathrm{T}}) = \boldsymbol{\Sigma}_i$, $\mathbf{v}_{i\bullet t} = [v_{i1t} \ldots v_{iNt}]^{\mathrm{T}}$. Let $\boldsymbol{\Sigma}_i^{-1} = \mathbf{L}_i\mathbf{L}_i^{\mathrm{T}}$ be a lower triangular Choleski factorization of the ith state's covariance matrix. Then the typical element of $\boldsymbol{\varepsilon}_{i\bullet t} = \boldsymbol{\Sigma}_i^{-1/2}\mathbf{v}_{i\bullet t} = \mathbf{L}_i^{\mathrm{T}}\mathbf{v}_{i\bullet t}$ is $\varepsilon_{ijt} = \sum_{j'=1}^{N} \ell_{ijj'} v_{ij't}$. The mean zero, unit variance random variables, ε_{ijt}, now are uncorrelated across inputs and time, but are assumed to be correlated across space, $E(\varepsilon_{ijt}\varepsilon_{i'jt}) = \rho(d_{ii'})$, $j = 1, \ldots, N$, where $d_{ii'}$ is the geographic distance between states i and i', $\rho(0) = 1$. The $I \times I$ matrix,

$$\mathbf{R} = \begin{bmatrix} 1 & \rho(d_{12}) & \cdots & \rho(d_{1I}) \\ \rho(d_{12}) & 1 & \cdots & \rho(d_{2I}) \\ \vdots & \vdots & \ddots & \vdots \\ \rho(d_{1I}) & \rho(d_{2I}) & \cdots & 1 \end{bmatrix}, \tag{16.11}$$

is symmetric, positive definite, and for simplicity, we assume $\mathbf{R}$ is constant across j.

16.4 Consistent Estimation and Inferences with Semi-parametric GMM

Let $\mathbf{Z}_i$ denote the matrix of instruments for state i and let $\mathbb{N}_i = \mathbf{Z}_i(\mathbf{Z}_i^{\mathrm{T}}\mathbf{Z}_i)^{-1}\mathbf{Z}_i^{\mathrm{T}}$ the associated projection matrix.[5] Let $\boldsymbol{\tau} = [1\,2\,\ldots\,T]^{\mathrm{T}}$, and stack equation (16.9) by inputs and time. First, we use nonlinear two-stage least squares (NL2SLS) to estimate $\boldsymbol{\theta}$ consistently,

$$\hat{\boldsymbol{\theta}}_{2\mathrm{SLS}} = \underset{\boldsymbol{\theta}}{\operatorname{argmin}} \sum_{i=1}^{I} \left[\mathbf{x}_{i\bullet\bullet} - \mathbf{f}_{i\bullet}(\mathbf{w}_{i\bullet\bullet}, \mathbf{k}_{i\bullet}, \mathbf{c}_{i\bullet}, \boldsymbol{\tau}; \boldsymbol{\theta})\right]^{\mathrm{T}} (\mathbb{N}_i \otimes \mathbf{I}_N) \left[\mathbf{x}_{i\bullet\bullet} - \mathbf{f}_{i\bullet}(\mathbf{w}_{i\bullet\bullet}, \mathbf{k}_{i\bullet}, \mathbf{c}_{i\bullet}, \boldsymbol{\tau}; \boldsymbol{\theta})\right]. \tag{16.12}$$

This consistent estimator of $\boldsymbol{\theta}$ is then used to generate consistent estimates of the errors,

$$\hat{u}_{ijt} = x_{ijt} - f_{ij}(\mathbf{w}_{it}, k_{it}, c_{it}, t; \hat{\boldsymbol{\theta}}_{2\mathrm{SLS}}),\ i = 1, \ldots, I,\ j = 1, \ldots, N,\ t = 1, \ldots, T. \tag{16.13}$$

Second, for $t = 2, \ldots, T$, we estimate the $N \times N$ intertemporal correlation matrix, $\boldsymbol{\Phi}$, by linear seemingly unrelated regressions (SUR) methods,

$$\hat{\boldsymbol{\Phi}} = \underset{\boldsymbol{\Phi}}{\arg\min} \left\{ \sum_{i=1}^{N} \sum_{t=2}^{\mathrm{T}} (\hat{\mathbf{u}}_{i\bullet t} - \boldsymbol{\Phi}\hat{\mathbf{u}}_{i\bullet t-1})^{\mathrm{T}} \hat{\boldsymbol{\Sigma}}_i^{-1} (\hat{\mathbf{u}}_{i\bullet t} - \boldsymbol{\Phi}\hat{\mathbf{u}}_{i\bullet t-1}) \right\}. \tag{16.14}$$

One can complete this stage of estimation with $\hat{\boldsymbol{\Sigma}}_i = \mathbf{I}_N\ \forall\ i$ and iterate once on the state-specific cross-equation covariance matrices. Alternatively, one can start with the $\hat{\boldsymbol{\Sigma}}_i$s calculated from the NL2SLS estimates for $\boldsymbol{\theta}$ with $\boldsymbol{\Phi} = [\mathbf{0}]$. Either approach gives consistent estimates for the elements of $\boldsymbol{\Phi}$ since the weight matrix does not affect consistency. The first method is robust to departures from the assumed covariance structure. The second method can be more efficient if the model is correct. We apply the first method in the empirical application.

Third, we construct consistent estimates of the spatially correlated error terms,

$$\hat{\varepsilon}_{ijt} = \sum\nolimits_{j'=1}^{N} \hat{\ell}_{ijj'} \hat{v}_{ij't}, \tag{16.15}$$

where $\hat{v}_{ijt} = \hat{u}_{ijt} - \sum_{j'=1}^{N} \hat{\phi}_{jj'} \hat{u}_{ij't-1}$ and $\hat{\mathbf{L}}_i = [\hat{\ell}_{ijj'}]_{j,j'=1,\cdots N}$ satisfies $\tilde{\boldsymbol{\Sigma}}_i^{-1} = \hat{\mathbf{L}}_i\hat{\mathbf{L}}_i^{\mathrm{T}}$. We then calculate consistent sample estimates for the cross-state spatial correlations as,

$$\hat{\rho}_{ii'} = \sum_{j=1}^{N} \sum_{t=2}^{\mathrm{T}} \hat{\varepsilon}_{ijt}\hat{\varepsilon}_{i'jt} \Big/ N(T-1), \quad i,i' = 1,\ldots,I. \tag{16.16}$$

We then use the ½$I(I-1)$ spatial correlations to estimate the relationship between the spatial correlations and the geographic distance between states using robust nonlinear least squares to obtain $\hat{\mathbf{R}} = \left[\hat{\rho}(d_{ii'})\right]$. In this study, we use a third-order exponential specification for the spatial correlation function,

$$\rho(d_{ii'}) = \exp\left\{\eta_0 + \sum_{k=1}^{3} \eta_k d_{ii'}^k\right\}. \tag{16.17}$$

Fourth, let $\mathbf{R}^{-1} = \mathbf{Q}\mathbf{Q}^{\mathrm{T}}$, where $\mathbf{Q}$ is a lower triangular Choleski factorization of the inverse spatial correlation matrix, and write $\omega_{ijt} = \sum_{i'=1}^{I} q_{ii'}\varepsilon_{i't}$. Now, the random variables ω_{ijt} are mean zero, unit variance, and uncorrelated across inputs, states, and time. Replacing the unknown parameters and error terms with the consistent estimates developed with the above estimation steps, and substituting backward recursively, we have

$$\begin{aligned}
\hat{\omega}_{ijt} &= \sum_{i'=1}^{I} \hat{q}_{ii'}\hat{\varepsilon}_{i'jt} \\
&= \sum_{i'=1}^{I} \hat{q}_{ii'} \sum_{j'=1}^{N} \hat{\ell}_{i'jj'}\hat{v}_{i'j't} \\
&= \sum_{i'=1}^{I} \hat{q}_{ii'} \sum_{j'=1}^{N} \hat{\ell}_{i'jj'}\left(\hat{u}_{i'j't} - \sum_{j''=1}^{N} \hat{\phi}_{j'j''}\hat{u}_{i'j''t-1}\right) \\
&\xrightarrow{P} \omega_{ijt},
\end{aligned} \tag{16.18}$$

with $E(\omega_{ijt}) = 0$, $E(\omega_{ijt}^2) = 1$, $E(\omega_{ijt}\omega_{i'j't'}) = 0$, $(i,j,t) \neq (i',j',t')$. A final NL3SLS step of the form,

$$\hat{\boldsymbol{\theta}}_{3SLS} = \arg\min_{\boldsymbol{\theta}} \left\{\sum_{i=1}^{I} \hat{\boldsymbol{\omega}}_{i\bullet\bullet}(\boldsymbol{\theta})^{\mathrm{T}} (N_i \otimes \mathbf{I}_N)\, \hat{\boldsymbol{\omega}}_{i\bullet\bullet}(\boldsymbol{\theta})\right\}, \tag{16.19}$$

gives consistent, efficient, asymptotically normal estimates of $\boldsymbol{\theta}$. White's heteroskedasticity consistent covariance estimator can be used for robustness to heteroskedasticity beyond the state-specific input demand covariance matrices.

16.5 Econometric Model, Data, and Empirical Results

We apply this model of exactly aggregable demands for variable inputs that can be estimated with observable data to state-level data on farm labor, fuels and energy, agricultural chemicals, and materials for the period 1960–1999. These data have been compiled by the USDA/ERS and are described in detail in Ball et al. (2004). Land and capital are quasi-fixed inputs, and we include a time trend to proxy for technological change and other nonstationary economic forces.

The specific specification is a full rank three model adapted from LaFrance and Pope (2009) to variable costs in joint production,

$$f\left(c_t/w_{n,t}\right) = \alpha\left(\tilde{\mathbf{w}}_t/w_{n,t}, k_t, t\right) - \left[\frac{\beta\left(\tilde{\mathbf{w}}_t/w_{n,t}\right)}{\delta\left(\tilde{\mathbf{w}}_t/w_{n,t}\right) + \sqrt{\beta\left(\tilde{\mathbf{w}}_t/w_{n,t}\right)}\theta(\overline{\mathbf{Y}}_t, \mathbf{a}_t, k_t)}\right], \tag{16.20}$$

where $f(x) = (x^\kappa + \kappa - 1)/\kappa$, $\kappa \in \mathbb{R}_+$,

$$\alpha\left(\tilde{\mathbf{w}}_t/w_{n,t}, k_t, t\right) = \alpha_{n0} + \alpha_{n1}k_t + \alpha_{n2}t + (\boldsymbol{\alpha}_0 + \boldsymbol{\alpha}_1 k_t + \boldsymbol{\alpha}_2 t)^{\mathrm{T}}\mathbf{g}\left(\tilde{\mathbf{w}}_t/w_{n,t}\right),$$

with $\mathbf{g}(\mathbf{x}) = [g(x_1) \cdots g(x_{n-1})]^{\mathrm{T}}, g(x_j) = (x_j^\lambda + \lambda - 1)/\lambda,\ \lambda \in \mathbb{R}_+,\ \forall j,$

$$\beta\left(\tilde{\mathbf{w}}_t/w_{n,t}\right) = \mathbf{g}\left(\tilde{\mathbf{w}}_t/w_{n,t}\right)^{\mathrm{T}}\mathbf{B}\mathbf{g}\left(\tilde{\mathbf{w}}_t/w_{n,t}\right) + 2\boldsymbol{\gamma}^{\mathrm{T}}\mathbf{g}\left(\tilde{\mathbf{w}}_t/w_{n,t}\right) + 1,$$

and $\delta\left(\tilde{\mathbf{w}}_t/w_{n,t}\right) = \boldsymbol{\delta}_n + \boldsymbol{\delta}^{\mathrm{T}}\mathbf{g}\left(\tilde{\mathbf{w}}_t/w_{n,t}\right),$

The elements of the vector $\tilde{\mathbf{w}}_t = [w_{1,t}\, w_{2,t} \cdots w_{n-1,t}]^{\mathrm{T}}$ are the first $n-1$ variable input prices. The n^{th} variable input is farm labor. We treat this input asymmetrically from the other inputs in both the conditional mean and the stochastic part of the model. The translated Box-Cox functions f and g are observationally equivalent to the standard Box-Cox transformations. If $\kappa = 1$, then we have $f(x) = x$, while if $\kappa = 0$, we have $f(x) = 1 + \ln x$. The same results apply to $g(x)$ for $\lambda = 1$ or 0, respectively. For all other values of $(\kappa, \lambda) \in \mathbb{R}_+^2$, we have functional forms of the PIGL class in input prices and cost, allowing us to nest this class of demand models with a rank three generalized translog and a rank three generalized quadratic production model. To conserve on and simplify the notation from this point forward, we drop the $\sim$ over the first n–1 input prices and omit the ratio notation for cost and input prices by defining $N = n - 1$.

Applying Hotelling's/Shephard's lemma to (16.20) gives the variable input demands for energy, chemicals, and materials in per acre expenditures for state i in year t as

$$\begin{aligned}\tilde{\mathbf{e}}_{i,t} = c_{i,t}^{1-\kappa}\boldsymbol{\Delta}\left(w_{i,j,t}^{\lambda}\right)&\Bigg\{\boldsymbol{\alpha}_{0,i} + \boldsymbol{\alpha}_{1,i}k_t + \boldsymbol{\alpha}_{2,i}t + \left[\frac{f(c_{i,t}) - \alpha_i\left(\mathbf{w}_{i,t}, k_{i,t}, t\right)}{\beta\left(\mathbf{w}_{i,t}\right)}\right]\\ &\left[\mathbf{B}\mathbf{g}\left(\mathbf{w}_{i,t}\right) + \boldsymbol{\gamma}\right] + \left[\mathbf{I}_N - \frac{\mathbf{B}\mathbf{g}\left(\mathbf{w}_{i,t}\right)\mathbf{g}\left(\mathbf{w}_{i,t}\right)^{\mathrm{T}}}{\beta\left(\mathbf{w}_{i,t}\right)}\right]\boldsymbol{\delta}\frac{\left[f(c_{i,t}) - \alpha_i\left(\mathbf{w}_{i,t}, k_{i,t}, t\right)\right]^2}{\beta\left(\mathbf{w}_{i,t}\right)}\Bigg\}\\ &+ \mathbf{u}_{i,t},\ i = 1, \ldots I,\ t = 1, \ldots, T.\end{aligned} \tag{16.21}$$

As discussed in the previous section, due to the three-dimensional nature of the error covariance matrix, estimation is by a four-stage GMM procedure. The instruments we choose are the national averages of cost per acre, capital per acre, and normalized variable input prices lagged two periods, and the following general economy variables: real per capita disposable personal income; the unemployment rate; the real rate of return on AAA corporate 30-year bonds; the real manufacturing wage rate; the real index of prices paid by manufacturers for materials and components; and the real index of prices paid by manufacturers for fuel, energy, and power. Per capita disposable personal income is deflated by the consumer price index for all items, while the aggregate wholesale price variables are deflated by the implicit price deflator for gross domestic product.

There are far too many parameters to present and discuss in detail in this chapter. Thus, we will focus on a relatively small number of parameters of interest. We first present and discuss the properties of the error terms. The estimated 3×3 intertemporal autocorrelation matrix, with White/Huber robust asymptotic standard errors in parentheses, is:

$$\hat{\boldsymbol{\Phi}} = \begin{bmatrix} 0.464 & 0.110 & -0.055 \\ (0.054) & (0.176) & (0.070) \\ 0.0095 & 0.700 & 0.030 \\ (0.0101) & (0.047) & (0.026) \\ 0.022 & -0.116 & 0.711 \\ (0.013) & (0.062) & (0.044) \end{bmatrix}. \tag{16.22}$$

For all four variable inputs, the implied dynamics are stable, with the largest Eigen value of the 4×4 difference equation equal to 0.7, indicating no evidence of nonstationarity. In addition, the estimated error terms $\varepsilon_{i,j,t}$ from equation (16.15) above show no statistical evidence of further serial correlation.

The estimated spatial correlation function, with White/Huber robust standard errors in parentheses, is:

$$\hat{\rho}(d_{ii'}) = \exp\left\{ \begin{array}{cccc} -0.583 - 1.80 \times 10^{-3} d_{ii'} & + 8.86 \times 10^{-7} d_{ii'}^2 & - 1.42 \times 10^{-10} d_{ii'}^3 \\ (0.066) \quad (2.49 \times 10^{-4}) & (2.48 \times 10^{-7}) & (6.81 \times 10^{-11}) \end{array} \right\}. \tag{16.23}$$

A two-dimensional plot of the empirical data, estimated correlation function, and 95% confidence band are presented in Fig. 16.1.

There is no statistical evidence of remaining spatial correlation or heteroskedasticity in the cross-state error terms. Hence, we conclude that this estimation procedure reasonably captures the properties of the spatial/temporal error terms. One interesting property is that the spatial correlation is very flat from a distance of approximately 800 miles out to 2,500 miles, so that the error of states as far apart as Washington and Florida or Maine and California remains positively correlated. Failing to account for this property would lead to biased and inconsistent statistical inferences.

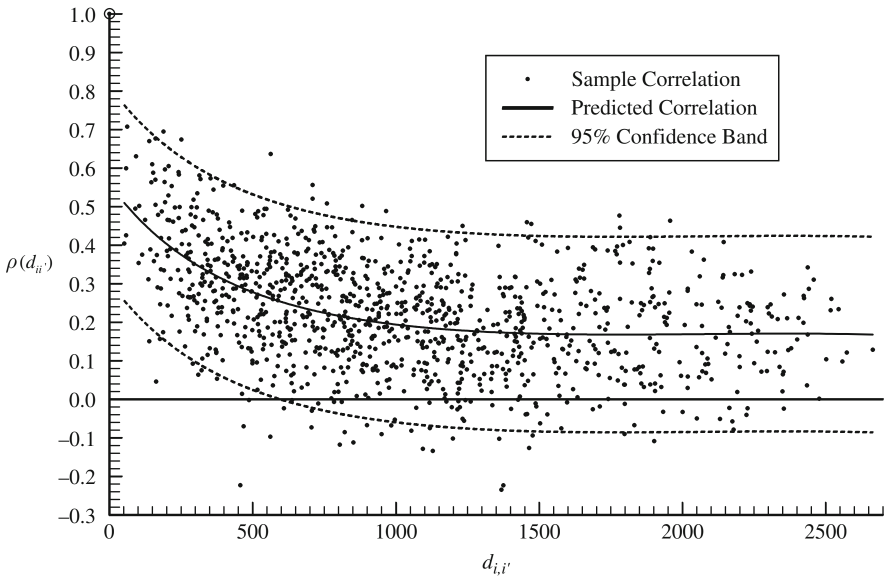

Fig. 16.1 Spatial correlation across the 48 contiguous states

We turn next to a subset of the parameter estimates for the structural model. Table 16.1 presents the estimates of the parameters in the functions $\beta(\mathbf{w})$ and $\delta(\mathbf{w})$, along with the Box-Cox parameters, (κ, λ).

It is clear from the table that the additional flexibility of the power functions in prices and variable cost due to the Box-Cox transformation is very important.

Table 16.1 Estimated coefficients and robust asymptotic standard errors

Coefficient	Estimate	S E	T-ratio	P-value
β_{11}	0.14118	0.04877	2.89	0.004
β_{12}	-0.113×10^{-2}	0.00191	−0.595	0.552
β_{13}	-0.300×10^{-2}	0.00350	−0.856	0.392
β_{14}	0.38002	0.06544	5.81	0.000
β_{22}	-0.406×10^{-5}	0.386×10^{-4}	−0.105	0.916
β_{23}	-0.497×10^{-5}	0.723×10^{-4}	−0.069	0.945
β_{24}	-0.355×10^{-2}	0.509×10^{-4}	−0.696	0.486
β_{33}	0.182×10^{-3}	0.146×10^{-3}	1.25	0.212
β_{34}	-0.822×10^{-2}	0.968×10^{-2}	−0.849	0.396
δ_1	0.714×10^{-3}	0.540×10^{-4}	1.32	0.186
δ_2	-0.984×10^{-5}	0.119×10^{-4}	−0.825	0.409
δ_3	-0.197×10^{-4}	0.219×10^{-4}	−0.901	0.368
δ_4	0.170×10^{-2}	0.00120	1.417	0.158
κ	0.327	0.0320	10.233	0.000
λ	0.409	0.0346	11.824	0.000

Indeed, the industry standards of logarithmic or linear transformations of both of these sets of variables are rejected at any reasonable significance level. This is consistent with results we have found in the area of consumer choice behavior. On the other hand, rank three appears to seriously overfit this data, as evidenced by the insignificance of all of the δ_j parameter estimates. Indeed, a Wald test for the joint significance of these coefficients produces an asymptotically $\chi^2(4)$ test statistic of 2.11 with an implied probability value of 0.716. As a result, we currently are analyzing the structure of the simpler full rank two models in this general class.

16.6 Ongoing Work: Crops, Acres, and Capital Investment Decisions

Although the organizational form of farms can vary widely, a recent report by Hoppe and Banker (2006) finds that 98% of U.S. farms remained family farms as of 2003. In a family farm, the entrepreneur controls the means of production and makes investment, consumption, and production decisions. In this section, we develop and analyze a model of the intertemporal nature of these decisions. The starting point is a model similar in spirit to Hansen and Singleton's (1983), but generalized to include consumption decisions and farm investments as well as financial investments and production decisions. The additional variable definitions required for this are as follows:

W_t = beginning-of-period total wealth,
b_t = current holding of bonds with a risk free rate of return r_t,
f_t = current holding of a risky financial asset,
$p_{F,t}$ = beginning-of-period market price of the financial asset,
$\rho_{F,t+1}$ = dividend plus capital gains rate on the financial asset,
$a_{i,t}$ = current allocation of land to the ith crop, $i = 1,\ldots,n_Y$,
A_t = total quantity of farm land,
$p_{L,t}$ = beginning-of-period market price of land,
$\rho_{L,t+1} = (p_{L,t+1} - p_{L,t})/p_{L,t}$ = capital gain rate on land,
$\bar{y}_{i,t}$ = expected yield per acre for the ith crop, $i = 1,\ldots,n_Y$,
$y_{i,t+1}$ = realized yield of the ith crop,
$p_{Y_i,t+1}$ = end-of-period realized market price for the ith farm product,
$\mathbf{q}_t$ = vector of quantities of consumption goods,
$\mathbf{p}_{Q,t}$ = vector of market prices for consumer goods,
m_t = total consumption expenditures,
$u(\mathbf{q}_t)$ = periodic utility from consumption.

As with all discrete time models, timing can be represented in multiple ways. In the model used here, all financial returns and farm asset gains are assumed to be realized at the end of each time period (where depreciation is represented by a negative asset gain). Variable inputs are assumed to be committed to farm production activities at the beginning of each decision period and the current period market prices for the variable inputs are known when these decisions are made. Agricultural production per acre is realized stochastically at the end of the period such that

$$y_{i,t+1} = \bar{y}_{i,t}(1 + \varepsilon_{i,t+1}), \quad i = 1, \ldots, n_Y, \tag{16.24}$$

where $\varepsilon_{i,t+1}$ is a random output shock with $E(\varepsilon_{i,t+1}) = 0$. Consumption decisions are made at the beginning of the decision period and the current market prices of consumption good are known when these purchases are made. Utility is assumed to be strictly increasing and concave in $\mathbf{q}_t$. The total beginning-of-period quantity of land is $A_t = \boldsymbol{\iota}^{\mathrm{T}}\mathbf{a}_t$, with $\boldsymbol{\iota}$ denoting an n_Y–vector of ones. Homogeneous land is assumed with a scalar price, $p_{L,t}$.

We require two somewhat unusual pieces of matrix notation for this section. First, we define the $n \times n$ diagonal matrix $\boldsymbol{\Delta}(x_j)$ such that x_j is the jth main diagonal element for each $j = 1, \ldots, n$. Second, the Hadamard/Schur product of two $n \times m$ matrices $\mathbf{A}$ and $\mathbf{B}$ is the matrix whose elements are element-by-element products of the elements of $\mathbf{A}$ and $\boldsymbol{B}$, $\mathbf{A}\bullet\mathbf{B} = \mathbf{C} \Leftrightarrow c_{ij} = a_{ij}b_{ij}\ \forall i,j$. There are three ways to write the Hadamard/Schur product of two vectors, $\mathbf{x}\bullet\mathbf{y} = \Delta(\mathbf{x})\mathbf{y} = \Delta(\mathbf{y})\mathbf{x}$.

Revenue at $t + 1$ is the random price times production

$$R_{t+1} = \sum_{i=1}^{n_Y} (p_{Y_i,t+1}\bar{y}_{i,t}a_{i,t}(1 + \varepsilon_{i,t+1})) \equiv (\mathbf{p}_{Y,t+1}\bullet\mathbf{a}_t\bullet\overline{\mathbf{Y}}_t)^{\mathrm{T}}(\boldsymbol{\iota} + \boldsymbol{\varepsilon}_{t+1}). \tag{16.25}$$

Wealth is allocated at the beginning of period t to investments, the variable cost of production, and consumption,

$$W_t = b_t + f_t + p_{L,t}A_t + K_t + c_t(\mathbf{w}_t, \mathbf{a}_t, K_t, \overline{\mathbf{Y}}_t) + m_t. \tag{16.26}$$

Although some costs occur at or near harvest (near $t + 1$), we include all costs in equation (16.26) at time t because they are incurred before revenues are received. Consumer utility maximization yields the quasi-convex indirect utility function conditioned on consumer good prices and expenditures,

$$\upsilon(\mathbf{p}_{Q,t}, m_t) \equiv \max_{\mathbf{q}\in R_+^{n_Q}} \left\{u(\mathbf{q}) : \mathbf{p}_{Q,t}^{\mathrm{T}}\mathbf{q} = m_t\right\}. \tag{16.27}$$

Realized end of period wealth is

$$W_{t+1} = (1 + r_t)b_t + (1 + \rho_{F,t+1})f_t + (1 + \rho_{L,t+1})p_{L,t}A_t + (\mathbf{p}_{Y,t+1}\bullet\mathbf{a}_t\bullet\overline{\mathbf{Y}}_t)^{\mathrm{T}}(\iota + \boldsymbol{\varepsilon}_{t+1}). \tag{16.28}$$

Thus, the decision maker's wealth is increased by net returns on assets and farm revenue. The owner/operator decision maker's intertemporal utility function is assumed to be

$$U_T(\mathbf{q}_1, ..., \mathbf{q}_T) = \sum_{t=0}^{\mathrm{T}} (1+\rho)^{-t} u(\mathbf{q}_t). \tag{16.29}$$

The producer is assumed to maximize von Neumann-Morgenstern expected utility of the discounted present value of the periodic utility flows from goods consumption.

By Euler's theorem, constant returns to scale implies linear homogeneity of the variable cost function in capital, land, and output. For the variable cost function derived and estimated in this chapter, this implies

$$\begin{aligned} c_t(\mathbf{w}_t, \mathbf{a}_t, A_t, K_t, \overline{\mathbf{Y}}_t) \equiv & \frac{\partial c_t(\mathbf{w}_t, \mathbf{a}_t, A_t, K_t, \overline{\mathbf{Y}}_t)}{\partial \mathbf{a}_t^{\mathrm{T}}} \mathbf{a}_t + \frac{\partial c_t(\mathbf{w}_t, \mathbf{a}_t, A_t, K_t, \overline{\mathbf{Y}}_t)}{\partial A_t} A_t \\ & + \frac{\partial c_t(\mathbf{w}_t, \mathbf{a}_t, A_t, K_t, \overline{\mathbf{Y}}_t)}{\partial K_t} K_t \frac{\partial c_t(\mathbf{w}_t, \mathbf{a}_t, A_t, K_t, \overline{\mathbf{Y}}_t)}{\partial \overline{\mathbf{Y}}_t^{\mathrm{T}}} \overline{\mathbf{Y}}_t. \end{aligned} \tag{16.30}$$

The vector of expected crop outputs satisfies

$$\overline{\mathbf{Y}}_t = \bar{\mathbf{y}}_t \cdot \mathbf{a}_t, \tag{16.31}$$

where $\bar{y}_{j,t}$ is the expected yield per acre and $a_{j,t}$ is the number of acres planted for the jth crop. The variable cost function might depend on time due to technological change or other dynamic forces, and the subscript t indicates this possibility. To distinguish quasi-fixed from variable inputs and to account for the possibility of hysteresis in agricultural investments, we allow for adjustment costs for total farmland and capital,

$$C_{Adj}(A_t - A_{t-1}, K_t - K_{t-1}) = \tfrac{1}{2}\gamma_A (A_t - A_{t-1})^2 + \tfrac{1}{2}\gamma_K (K_t - K_{t-1})^2, \tag{16.32}$$

with $\gamma_A, \gamma_K \geq 0$.

This problem is solved by stochastic dynamic programming working backward recursively from the last period in the planning horizon to the first. In the last period, the optimal decision is to invest or produce nothing and consume all remaining wealth, that is, $m_T = W_T$. Denote the last period's optimal value function by $v_T(W_T, A_{T-1}, K_{T-1})$. Then $v_T(W_T, A_{T-1}, K_{T-1}) = \upsilon(\mathbf{p}_{Q,T}, W_T)$ is the optimal utility for the terminal period. For all other time periods, stochastic dynamic programming using equations (16.26), (16.27), (16.28), and (16.29) to optimize agricultural production, asset ownership, and net investment decisions in each period yields the (Bellman) backward recursion problem for arbitrary $t < T$. In this stochastic dynamic programming decision problem is

$$\begin{aligned}\ell_t = {} & \upsilon(\mathbf{p}_{Q,t}, m_t) + (1+r)^{-1} E_t \left\{ V_{t+1} \left[(1+r)b_t + (1+\rho_{F,t+1}) f_t \right.\right. \\ & \left.\left. + p_{L,t+1} A_t + (1+\rho_{K,t+1}) K_t + (\mathbf{p}_{Y,t+1} \bullet \overline{\mathbf{y}}_t \bullet \mathbf{a}_t)^{\mathrm{T}} (\iota + \varepsilon_{t+1}), A_t, K_t \right] \right\} \\ & + \lambda_t \left\{ W_t - m_t - b_t - f_t - p_{L,t} A_t - K_t + c_t(\mathbf{w}_t, \mathbf{a}_t, A_t, K_t, \overline{\mathbf{y}}_t \bullet \mathbf{a}_t) \right. \\ & \left. - {}^1\!/_2 \gamma_A (A_t - A_{t-1})^2 - {}^1\!/_2 \gamma_K (K_t - K_{t-1})^2 \right\} + \mu_t (A_t - \iota^{\mathrm{T}} \mathbf{a}_t),\end{aligned} \tag{16.33}$$

where $E_t(\bullet)$ is the conditional expectation at the beginning of period t given information available at that point in time, $\rho_{K,t+1}$ is the proportional rate of change in the value of the capital stock K_t from the beginning of period t to the beginning of period t+1, λ_t is the shadow price for the beginning-of-period wealth allocation constraint, and μ_t is the shadow price for the land allocation constraint. The first-order, necessary, and sufficient Kuhn-Tucker conditions are the two constraints and the following:

$$\frac{\partial \ell_t}{\partial m_t} = \frac{\partial \upsilon_t}{\partial m_t} - \lambda_t \le 0,\ m_t \ge 0,\ m_t \frac{\partial \ell_t}{\partial m_t} = 0; \tag{16.34}$$

$$\frac{\partial \ell_t}{\partial b_t} = E_t \left(\frac{\partial V_{t+1}}{\partial W_{t+1}} \right) - \lambda_t \le 0,\ b_t \ge,\ b_t \frac{\partial \ell_t}{\partial b_t} = 0; \tag{16.35}$$

$$\frac{\partial \ell_t}{\partial f_t} = (1+r)^{-1} E_t \left[\frac{\partial V_{t+1}}{\partial W_{t+1}} (1+\rho_{F,t+1}) \right] - \lambda_t \le 0,\ f_t \ge 0,\ f_t \frac{\partial \ell_t}{\partial f_t} = 0. \tag{16.36}$$

$$\begin{aligned}\frac{\partial \ell_t}{\partial A_t} = {} & (1+r)^{-1} E_t \left(\frac{\partial V_{t+1}}{\partial W_{t+1}} p_{L,t+1} + \frac{\partial V_{t+1}}{\partial A_t} \right) \\ & - \lambda_t \left[p_{L,t} + \frac{\partial c_t}{\partial A_t} + \gamma_A (A_t - A_{t-1}) \right] + \mu_t \le 0,\ A_t \ge 0,\ A_t \frac{\partial \ell_t}{\partial A_t} = 0;\end{aligned} \tag{16.37}$$

$$\begin{aligned}\frac{\partial \ell_t}{\partial K_t} = {} & (1+r)^{-1} E_t \left[\frac{\partial V_{t+1}}{\partial W_{t+1}} (1+\rho_{K,t+1}) + \frac{\partial V_{t+1}}{\partial K_{t+1}} \right] \\ & - \lambda_t \left[1 + \frac{\partial c_t}{\partial K_t} + \gamma_K (K_t - K_{t-1}) \right] \le 0,\ K_t \ge 0,\ K_t \frac{\partial \ell_t}{\partial K_t} = 0;\end{aligned} \tag{16.38}$$

$$\begin{aligned}\frac{\partial \ell_t}{\partial \mathbf{a}_t} = {} & (1+r)^{-1} E_t \left[\frac{\partial V_{t+1}}{\partial W_{t+1}} (\mathbf{p}_{Y,t+1} \bullet \overline{\mathbf{y}}_t) \bullet (\boldsymbol{\iota} + \boldsymbol{\varepsilon}_{t+1}) \right] - \lambda_t \frac{\partial c_t}{\partial \overline{\mathbf{Y}}_t} \bullet \overline{\mathbf{y}}_t - \mu_t \boldsymbol{\iota} \le 0, \\ & \mathbf{a}_t \ge 0,\ \mathbf{a}_t^{\mathrm{T}} \frac{\partial \ell_t}{\partial \mathbf{a}_t} = 0;\end{aligned} \tag{16.39}$$

$$\frac{\partial \ell_t}{\partial \overline{\mathbf{y}}_t} = (1+r)^{-1} E_t \left[\frac{\partial V_{t+1}}{\partial W} \mathbf{p}_{Y,t+1} \bullet \mathbf{a}_t \bullet (\iota + \boldsymbol{\varepsilon}_{t+1}) \right] - \lambda_t \frac{\partial c_t}{\partial \overline{\mathbf{Y}}_t} \bullet \mathbf{a}_t \leq 0,$$
$$\overline{\mathbf{y}}_t \geq 0, \ \overline{\mathbf{y}}_t^{\mathrm{T}} \frac{\partial \ell_t}{\partial \overline{\mathbf{y}}_t} = 0. \tag{16.40}$$

We also have the following implications of the envelope theorem:

$$\begin{aligned} \frac{\partial V_t}{\partial W_t} &= \lambda_t; \\ \frac{\partial V_t}{\partial A_{t-1}} &= \lambda_t \gamma_A (A_t - A_{t-1}); \\ \frac{\partial V_t}{\partial K_{t-1}} &= \lambda_t \gamma_K (K_t - K_{t-1}); \end{aligned} \tag{16.41}$$

where the variables $\{\lambda_t, A_t, K_t\}$ are all evaluated at their optimal choices.

Combining the Kuhn-Tucker conditions with the results of the envelope theorem and assuming an interior solution for consumption, bonds, and risky financial assets, we obtain the standard Euler equations for smoothing the marginal utility of consumption and wealth,

$$\frac{\partial \upsilon_t}{\partial m_t} = E_t \left(\frac{\partial \upsilon_{t+1}}{\partial m_{t+1}} \right) = \frac{\partial V_t}{\partial W_t} = E_t \left(\frac{\partial V_{t+1}}{\partial W_{t+1}} \right) = \lambda_t = E_t(\lambda_{t+1}), \tag{16.42}$$

and the standard arbitrage condition for excess returns to risky financial assets,

$$E_t \left[(\rho_{F,t+1} - r) \frac{\partial V_{t+1}}{\partial W_{t+1}} \right] = 0. \tag{16.43}$$

From complementary slackness of the Kuhn-Tucker condition (16.40), for each crop we obtain the supply condition under risk,

$$E_t \left[\frac{\partial V_{t+1}}{\partial W_{t+1}} \left(p_{Y_i,t+1} - (1+r) \frac{\partial c_t}{\partial \bar{Y}_{i,t}} \right) \bar{Y}_{i,t} \right] = 0, \ i = 1, \ldots, n_y. \tag{16.44}$$

Hence, for each crop that is produced in positive quantity, this reduces to the well-known result that the conditional covariance between the marginal utility of future wealth and the difference between the ex post realized market price the marginal cost of production must vanish. The multiplicative factor $1+r$ is multiplied by ex ante marginal cost so that these two economic values are measured at a common point in time – in the present case at the end of the production period.

To obtain the arbitrage condition for the level of investment in agriculture, we combine the positive linear homogeneity property of the variable cost function in $(\mathbf{a}_t, A_t, K_t, \overline{\mathbf{Y}}_t)$ from equation (16.30) with the complementary slackness properties of the Kuhn-Tucker conditions from equations (16.37), (16.38), and (16.39),

$$0 = \frac{\partial \ell_t}{\partial \mathbf{a}_t^{\mathrm{T}}}\mathbf{a}_t + \frac{\partial \ell_t}{\partial A_t}A_t + \frac{\partial \ell_t}{\partial K_t}K_t, \tag{16.45}$$

which, after considerable rearranging and combining of terms, gives

$$\begin{aligned} E_t \Big\{ \partial V_{t+1} \big/ \partial W_{t+1} \big[& s_{K,t}(\rho_{K,t+1} - r) + s_{L,t}(\rho_{L,t+1} - r) + \pi_{t+1} \\ & + s_{K,t}\gamma_K \left(K_{t+1} - (2+r)K_t + (1+r)K_{t-1} \right) \\ & + s_{A,t}\gamma_A \left(A_{t+1} - (2+r)A_t + (1+r)A_{t-1} \right) \big] \Big\} = 0, \end{aligned} \tag{16.46}$$

where $\rho_{L,t+1} = (p_{L,t+1} - p_{L,t}) \big/ p_{L,t}$ is the proportional rate of change in the market value of farmland over period t, $s_{K,t} = K_t \big/ (p_{L,t}A_t + K_t)$ is capital's share of the value of the total investment in agriculture in period t, $s_{L,t} = p_{L,t}A_t \big/ (p_{L,t}A_t + K_t)$ is farmland's share of the value of the total investment in agriculture in period t, $s_{A,t} = A_t \big/ (p_{L,t}A_t + K_t)$ is the ratio of the quantity of farmland to the market value of the investment in agriculture at the beginning of the production period, and

$$\pi_{t+1} = R_{t+1} - (1+r)c_t \tag{16.47}$$

is the ex post net return to crop production over the variable cost of production. The first three terms inside of the square brackets of equation (16.46) represent the total sum of the excess returns to agriculture, including this net return. The last two terms in square brackets capture the effects of adjustment costs for farm capital and farmland.

To implement this system of Euler equations, we assume that the indirect utility function for consumption goods is a member of the certainty equivalent class,

$$\upsilon(\mathbf{p}_{Qt}, m_t) = \frac{m_t}{\pi_C(\mathbf{p}_{Qt})} - \tfrac{1}{2}\,\beta \left(\frac{m_t}{\pi_C(\mathbf{p}_{Qt})} \right)^2, \tag{16.48}$$

where $0 \leq \beta < \pi_C(\mathbf{p}_{Qt}) \big/ m_t \;\forall\; t$ and $\pi_C(\mathbf{p}_{Qt})$ is the consumer price index (CPI) for all items. Then the marginal utility of money in each period is

$$\lambda_t = \frac{1 - \beta \left[m_t \big/ \pi_C(\mathbf{p}_{Qt}) \right]}{\pi_C(\mathbf{p}_{Qt})}. \tag{16.49}$$

This allows us to identify the effects of risk aversion separately from those of adjustment costs and hysteresis in agricultural investment decisions. Our current research effort focuses on choices for the aggregator, θ_t to implement this model and estimate equations with both national- and state-level data, which will allow us to draw coherent inferences on economic responses of agricultural producers and investors to input and output prices, risk, agricultural policies, and adjustment costs.

16.7 Conclusions

Common reasons for the choice of functional form for empirical demand analysis include parsimony, ease of estimation and interpretation, generality, flexibility, aggregation, and consistency with economic theory. This chapter presents and applies a new, highly flexible structural model of micro-level production behavior that is exactly aggregable across cost differences between producers. We applied this model to a panel of state-level data on variable input choices in U.S. agriculture with a three-dimensional semi-parametric version of the generalized method of moments. We also developed a framework to incorporate the results of the model for variable input demands within a general life cycle model of investment and agricultural asset management under risk.

Notes

1. The nonstandard notation of a bold and capital $\overline{\mathbf{Y}}$ to denote expected/planned crop outputs is intended to distinguish this from expected crop yields per acre, $\overline{\mathbf{Y}}$, which will be used later in the chapter.
2. Among other things it implies that marginal rates of product transformation are independent of the variable inputs and factor intensities. Of course, if these restrictions are deemed too strong, an alternative approach to formulating the variable cost function becomes necessary.
3. An important subset of the literature on this topic includes: Banks et al. (1997); Beatty and LaFrance (2005); Burt and Brewer (1971); Blundell (1988); Brown and Walker (1989); Cicchetti et al. (1976); Deaton and Muellbauer (1980); Diewert (1971); Diewert and Wales (1987, 1988); Gorman (1953, 1961, 1981); Howe et al. (1979); Jerison (1993); Jorgenson (1990); Jorgenson and Slesnick (1984, 1987); Jorgenson et al. (1980, 1981, 1982); LaFrance and Pope (2009); LaFrance et al. (2000, 2002, 2005, 2006); Lewbel (1987a, 1988, 1989a, b, 1990, 1991, 2003, 2004); Muellbauer (1975, 1976); Phlips (1971); Russell (1983, 1996); Russell and Farris (1993, 1998); van Daal and Merkies (1989); and Wales and Woodland (1988). The focus in the literature has been interior solutions and smooth demands. We remain faithful to this approach throughout the present chapter.
4. This is somewhat surprising in light of the fact that agricultural input demand and output supply data are generally only available at the county or state level of aggregation, with few exceptions.
5. In the empirical application, we use the same instruments for all states, so that $\mathbb{N}_i \equiv \mathbb{N}\ \forall\ i = 1, \ldots, I$.

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Chapter 17
Standard and Bayesian Random Coefficient Model Estimation of US Corn–Soybean Farmer Risk Attitudes

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Abstract We estimated standard and Bayesian random coefficient models (RCMs) to examine the risk attitudes of US corn–soybean farmers by revenue class using national survey data covering the 2000–2006 growing seasons. Attitudes toward risk are shown to depend on revenue class, with the magnitude of the effect being relatively small. The hypothesis of risk-neutral preferences is not rejected for small- or medium-revenue farmers but is rejected, in favor of a very slight level of risk tolerance, for large- and very large-revenue farmers and for the entire sample of farmer types. The hypothesis of downside risk neutrality is not rejected for small-revenue farmers but is rejected, in favor of a very slight level of downside risk aversion, for medium-, large-, and very large-revenue farmers. Although risk neutrality is rejected for the entire sample of farmer types, the magnitudes of our estimates of the coefficients of absolute risk aversion and absolute downside risk aversion are extremely small. This suggests that the frequent assumption of risk-neutral preferences adopted in the agricultural economics literature is justifiable for the case of US corn–soybean farmers during 2000–2006.

17.1 Introduction

Attitudes and perceptions about the future results of economic decisions affect the form and timing of those decisions. Intuition suggests that this is especially true for farmers because of the substantial lags separating production and financial management decisions and the marketing of crops and livestock. Farmer attitudes about uncertainty (i.e., risk attitudes) may therefore affect their involvement in government support programs; their use of government subsidized crop insurance, futures

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and options markets, pest and nutrient management practices, and new production technologies; and their level of crop and livestock enterprise diversity (e.g. Chavas et al., 2004; Just and Pope, 2002; Roumasset et al., 1979). Information about risk attitudes can, therefore, provide information useful for examining government programs and farmer behavior under uncertainty. For example, a simplifying assumption used by many agricultural economists is that farmers are risk neutral; however, the assumption is rarely justified empirically. The purpose of this study is to test the validity of this assumption for US corn–soybean farmers.

We estimate standard (Swamy, 1970, 1971) and Bayesian (Koop) random coefficient models (RCMs) to examine the coefficients of absolute risk aversion (AR) and absolute downside risk aversion (DR) (Arrow, 1965; Pratt, 1964) using a pseudo panel generated from US Department of Agriculture (USDA, 1996–2007) Agricultural Resource Management Survey (ARMS) data. The pseudo panel consists of observations on 40 farmer types: small-, medium-, large-, and very large-revenue farmers in 10 states with similar acreage and input use patterns. We estimate risk attitudes for the entire sample of farmer types and for each of the revenue classes separately to determine whether risk attitude may depend on revenue class.

We estimate standard and Bayesian RCMs, because Gardebroek (2006) reports that incorporating prior information about risk attitudes increases the precision of his estimates of AR and DR for organic and conventional farmers in the Netherlands during 1990–1999 relative to the standard RCM. This does not occur in our sample. The Bayesian RCM provides little in the way of extra information about risk attitudes, relative to the standard RCM, and little, if any, gain in precision. According to the standard RCM results, risk neutrality cannot be rejected for small- or medium-revenue farmers but is rejected, in favor of a very slight level of risk tolerance, for large- and very large-revenue farmers and for the entire sample. A very low level of downside risk aversion is detected for medium-, large-, and very large-revenue farmers and for the full sample. Downside risk neutrality cannot be rejected for small-revenue farmers.

Although risk tolerance and downside risk aversion cannot be rejected for the entire sample of farmer types and for the medium-, large-, and very large-revenue farmers, the magnitudes of the AR and DR estimates are extremely small. This suggests that the frequent assumption of risk-neutral preferences adopted in the agricultural economics literature is justifiable for the case of US corn–soybean farmers during 2000–2006.

In the next three sections, we describe the theoretical model and the standard and Bayesian RCMs used to estimate risk attitudes. The data, estimation methods, and results are described in following sections, and the chapter is closed with concluding remarks in the final section.[1]

17.1.1 Theoretical Model

Both of the RCMs we use to examine risk attitudes are based on Antle's (1989) nonstructural approach, which is based on Antle's (1983) moment-based analysis of output probability distributions. Following Just and Pope (1979), Antle (1983) shows that ad hoc error specifications used to estimate production functions impose ad hoc restrictions on the moments of the probability distribution of output and, therefore, ad hoc restrictions on the behavior of firms under uncertainty. Noting that the probability distribution of output in period t for farmer j is a unique function of a finite number of moments, μ_{ijt}, he examines and tests firm behavior under uncertainty by relating the μ_{ijt} to farmer input use decisions. Modelling the moments of the probability distributions of output for each farmer directly imposes few, if any, restrictions on the distributions and farmer behavior under uncertainty. In addition, it is not necessary to estimate production functions and input use jointly.

Antle (1989) uses his moment-based approach to examine the risk attitudes of rice farmers in India. Applying his model to our data, we assume that the cumulative distribution of total income for each farm type j (see Section 17.1.4) is a function of the first three central moments,

$$F\left(\pi_{jt}|\mu_{1jt},\mu_{2jt},\mu_{3jt}\right), j = 1...40, \; t = 2000...2006; \tag{17.1}$$

where π_{jt} is total income (the sum of net farm income, off-farm income, and government payments) per acre received during year t. The form of F is common to all farm types. Farm types are assumed to choose the level of variable inputs to maximize the expected utility of income each year,

$$V\left(\gamma_j,\boldsymbol{\mu}_{jt}\right) = \int U\left(\pi_{jt},\gamma_j\right) dF\left(\pi_{jt}|\boldsymbol{\mu}_{jt}\right), \tag{17.2}$$

where $\boldsymbol{\mu}_{jt} = \lfloor\mu_{1jt},\mu_{2jt},\mu_{3jt}\rfloor$, and γ_j are parameters of type j's utility function that characterize risk attitudes. Annual changes in maximized expected utility per acre are approximately

$$\Delta V_{jt} = \sum\nolimits_{i=1}^{3}\left(\partial V\left(\gamma_j,\mu_{jt}\right)/\partial\mu_{ijt}\right)D_{ijt}. \tag{17.3}$$

The term in parentheses is the marginal expected utility of the ith moment of the income probability distribution, which is multiplied by the discrete change in the ith moment from $t-1$ to t (i.e., $D_{ijt} \equiv \Delta\mu_{ijt}$). Dividing each side of equation (17.3) by the marginal expected utility of the first moment, or the marginal expected utility of mean income per acre, provides a simple equation that can be used to estimate risk attitudes,

$$\Delta\tilde{V}_{jt} = \sum\nolimits_{i=1}^{3}\frac{\partial V\left(\gamma_j,\boldsymbol{\mu}_{jt}\right)/\partial\mu_{ijt}}{\partial V\left(\gamma_j,\boldsymbol{\mu}_{jt}\right)/\partial\mu_{1jt}}D_{ijt} = \sum\nolimits_{i=1}^{3} r_{ij}D_{ijt}; \tag{17.4}$$

where $\Delta\tilde{V}_{jt}$ is the monetized change in expected utility per acre; r_{ij} is the monetized, marginal expected utility of the ith moment of the income probability distribution, or the ith risk attitude coefficient; and $r_{1j} = 1$ for all j by definition.

17.1.2 Standard RCM

Risk-attitude equation (17.4) can also be written

$$D_{1jt} = \Delta\tilde{V}_{jt} - r_{2j}D_{2jt} - r_{3j}D_{3jt} + u_{jt} = \beta_{1j} + \beta_{2j}D_{2jt} + \beta_{3j}D_{3jt} + u_{jt}, \qquad (17.5)$$

or in matrix notation as

$$\mathbf{y}_j = \mathbf{X}_j\boldsymbol{\beta}_j + \mathbf{u}_j. \qquad (17.6)$$

$\mathbf{y}_j$ is an n_j-by-one vector of the annual changes in the mean of the income probability distribution. $\mathbf{X}_j$ is n_j-by-k and contains a column of ones and the annual changes in the second and third moments of j's income probability distribution (i.e., $k = 3$). The number of observations, n_j, varies by farm type. Antle (1987) shows that $-2\beta_{2j}$ approximates type j's AR and $6\beta_{3j}$ approximates j's DR.

β_{1j} takes the place of $\Delta\tilde{V}_{jt}$ in equation (17.5) and represents the average of the annual changes in monetized, expected utility per acre during the sample period. A simple way to estimate this model, while allowing average annual utility changes and risk attitudes to vary by farm type, is to estimate a RCM. As in Swamy (1970), we make the following distributional assumptions:

$$\mathbf{u}_j \sim \mathrm{N}\left(\mathbf{0}, \boldsymbol{\sigma}_j^2\mathbf{I}\right) \qquad \text{and} \qquad \boldsymbol{\beta}_j \sim \mathrm{N}\left(\boldsymbol{\beta}, \boldsymbol{\Delta}\right); \qquad (17.7)$$

where $\mathbf{I}$ is a k-by-k identity matrix, and N is the multivariate normal distribution. We allow the variance of the disturbance term, $\boldsymbol{\sigma}_j^2$, to differ for each farm type; however, we do not allow correlation in the disturbances across time for any farm type, nor do we allow the disturbances for any farm type to vary with the disturbances of any other farm type. The random coefficients for each farm type, $\boldsymbol{\beta}_j$, are multivariate normal – with common population mean $\boldsymbol{\beta}$ and covariance matrix $\boldsymbol{\Delta}$ – and uncorrelated across farm types.

17.1.3 Bayesian RCM

Using a 1990–1999 pseudo panel of organic and conventional farmers in the Netherlands, Gardebroek reports that he obtains imprecise AR and DR estimates using the standard RCM. He suggests that this is due to low degrees of freedom and reports that by incorporating prior information on risk attitude coefficients he is able to obtain more precise estimates using a Bayesian RCM (Koop, 2003, pp. 155–157). We estimate risk attitudes using a 2000–2006 pseudo panel; therefore, low degrees of freedom may also reduce the precision of our estimates using the standard RCM. This is because there are at most only six observations on annual moment changes, D_{ijt}, for each farm type in our sample. For this reason, we also estimate ARs and DRs using a Bayesian RCM.

The only difference between the standard (equations 17.6 and 17.7) and Bayesian RCMs is that hierarchical priors are added to equation (17.7) to characterize uncertainty with respect to the moments, $\boldsymbol{\beta}$ and $\boldsymbol{\Delta}$, of the multivariate normal distribution characterizing uncertainty with respect to the risk attitude coefficients, $\boldsymbol{\beta}_j$, $\boldsymbol{\beta} \sim \mathrm{N}\left(\underline{\boldsymbol{\beta}}, \underline{\mathbf{V}}\right), \boldsymbol{\Delta}^{-1} \sim \mathrm{W}\left(\underline{\upsilon}, \underline{\boldsymbol{\Delta}}^{-1}\right)$, and $h \sim \mathrm{G}\left(\underline{s}^{-2}, \underline{\delta}\right)$. The mean of the multivariate normal distribution for $\boldsymbol{\beta}_j$, is also multivariate normal with prior mean, $\underline{\boldsymbol{\beta}}$, and variance, $\underline{\mathbf{V}}$.[2] The inverse of the covariance matrix of the multivariate normal for $\boldsymbol{\beta}_j$ is distributed Wishart, which is a multivariate generalization of the gamma distribution commonly used to model uncertainty with respect to covariance matrices. Priors for the Wishart distribution include the degrees of freedom parameter, $\underline{\upsilon}$, and precision matrix, $\underline{\boldsymbol{\Delta}}^{-1}$.

Instead of specifying a distribution to characterize uncertainty with respect to the error variance, σ^2, it is common in Bayesian econometrics to work with its reciprocal, h, which is known as the error precision. This simplifies the derivation of posterior parameter distributions (Koop, 2003, pp. 15–23). We adopt the common practice of using a gamma distribution with prior mean, $\underline{s}^{-2}$, and degrees of freedom, $\underline{\delta}$.

We describe how the standard and Bayesian RCMs are estimated in a later section, which includes a discussion on the prior values used to estimate the latter. Before we describe the estimation procedures, however, we describe the means by which the annual changes in the moments of the income probability distributions, D_{ijt}, were generated.

17.1.4 Data

The ARMS is a three-phase, two-frame, stratified, probability-weighted sampling design involving a series of interviews with farmers about their farm business and household. Different farmers are surveyed each year to reduce respondent burden; therefore, it is impossible to construct a panel. The surveys are conducted from June through April during the reference year and the subsequent year. Phase one is conducted during the summer of the reference year, during which farmers selected for inclusion in the sample are screened to verify their operating status and to determine whether they are producing specific commodities.

Data collection begins with phase two, which is conducted in the fall and winter of the reference year. Randomly selected farmers passing the first phase are interviewed to collect data on their production practices and chemical use for a randomly selected field on their farm. Phase two was only conducted for corn–soybean farmers in 2001 and 2005; therefore, observations on fertilizer, seed, and gasoline use levels are imputed for all years. Phase three is conducted in the spring of the year following the reference year and always includes corn–soybean farmers. A nationally representative sample of farmers is interviewed to obtain information on their costs and returns at the farm level for the reference year.

USDA uses two sampling frames to select farms: a list frame and an area frame. The list frame is a list, which includes most large farms and farms expected to produce specific commodities. It accounts for 100% of the second phase and 95% of the third-phase respondents. The area frame is used only to capture farms not on the list frame and consists of randomly selected agricultural land segments. Each year USDA conducts a spring survey selected from the area frame to estimate crop acreage and land use within each segment, and a sample of farms not on the list frame is selected from the results and potentially surveyed during the third phase.

The farm population is classified into strata at the state level by revenue, in the list frame, and by land use or crop type in the area frame; and farms in different strata are sampled with a different probability of selection. For this reason, when using these data to estimate aggregate totals, means, standard deviations, and standard errors, weights must be used to account for the probability of farm selection, the extent of aggregation, and the calibration scheme.[3] Because our level of aggregation is by farm type, however, it is not necessary to use weights and delete-a-group, jackknife routines to compute means and standard errors.[4]

The most important limitation of our study is that we were unable to construct a panel. Instead, we generated a pseudo panel of observations on total income, input use, and farmer characteristics for 40 groupings of farmers, which we refer to as farmer types. We are assuming, therefore, that observations on different farmers with similar characteristics can be used as observations on a single farmer type over time, and that each farmer type can be treated as a single decision-making entity. Another important limitation of our study is that, aside from observations on acreage and work hours, variable input use levels are constructed from expenditure data and price estimates.

We specify 40 farm types based on farmers' states (IA, IL, IN, KS, MI, MN, MO, NE, TX, and WI) and revenues, r. There are four revenue categories: small (\$1000 $\leq r <$ \$100,000), medium (\$100,000 $\leq r <$ \$250,000), large (\$250,000 $\leq r <$ \$500,000), and very large ($r \geq$ \$500,000). In the ARMS data, there is often more than one observation per farmer type per year; therefore, observations included in our pseudo panel are those for which harvested corn acres and imputed fertilizer and seed use levels are similar and close to reasonable benchmark values, respectively.

For each farmer type, a 95% confidence interval for the mean of harvested corn acres was computed. If there was more than one observation for the type for a given year, the observation with a harvested corn acreage within or closest to the confidence interval was a candidate for inclusion in the pseudo panel. If there was more than one observation for each farm type for a given year after this step, the observation with imputed fertilizer and seed use levels closest in magnitude to the 2003 state-level fertilizer use estimate (USDA-NASS, 2005) and the mean of the 2001 and 2005 state-level seed use estimate (ARMS, phase two), respectively, was used in the pseudo panel. The final data set consists of seven observations for 38 farmer types and six observations for two farmer types.

Means by revenue class of the variables used to generate annual changes in the moments of the income probability distributions are reported in Table 17.1. To generate the D_{ijt}'s, we regressed total income per operated acre on a constant, year

Table 17.1 Farm type variable means by revenue class[a]

Variable	Farms Small	Medium	Large	Very large
Total income per operated acre	\$193.93	\$86.75	\$100.44	\$98.69
% total income per operated acre from farming	7%	26%	36%	48%
% total income per operated acre from govt. payments	10%	26%	32%	34%
% total income per operated acre earned off the farm	83%	47%	33%	17%
Operated acres	360	913	1,787	3,119
Harvested corn acres	153	423	674	1,462
% cropland planted to corn	53%	53%	51%	53%
% cropland planted to soybean	31%	37%	35%	34%
Hours = operator + spouse hours worked/acre	8.82	4.64	3.32	2.02
Fertilizer = fertilizer use/acre (tons)	0.18	0.10	0.09	0.12
Gasoline = gasoline use/acre (gallons)	4.76	2.08	1.90	1.53
Seed = seed planted/acre (80,000 kernel bags)	0.27	0.24	0.21	0.23
% operated acres owned by operator	73%	34%	32%	24%
% operator's spouses who worked off the farm	31%	43%	47%	37%
% operators with some college or more	33%	56%	46%	53%
Operator's age	59	51	51	50
Corn's % share of total value of production	66%	63%	61%	63%
% operators with debt-to-asset ratios > = 0.40	50%	65%	80%	76%
Production contract's % share of total value of production	6%	16%	15%	28%

[a]With the exception of fertilizer, gasoline and seed these variables are based entirely on the phase 3 ARMS data. Fertilizer, gasoline, and seed were imputed using the phase 3 expenditure data and state level prices (fertilizer and gasoline) and farm-type-level prices (seed). Fertilizer prices were based on hedonic least-squares regressions of regional fertilizer prices (USDA-NASS 1996–2006) on yearly dummies and the percentages of nitrogen, phosphorous, and potassium in the fertilizer products. The 2001 and 2005 seed prices are from ARMS, phase 2, and are based on farmer responses about seed prices and seed types. There are genetically modified herbicide-resistant, insect-resistant, and herbicide-insect-resistant seed types, non-genetically modified herbicide-resistant seed types, and other seed types, each of which is accounted for in the imputation of seed use levels

dummies, revenue class dummies, farmer and household characteristics (e.g., age, education, whether the spouse works off the farm), an exogenous input level (the sum of operator and spouse hours worked per acre), predicted endogenous input levels from first-stage regressions (tons of fertilizer applied, 80,000 kernel bags of seed planted, and gallons of gasoline used per acre), and cross products of the input levels (Table 17.2). This regression was used to estimate annual changes in the mean of total income per acre, and the squared and cubed residuals from this regression are regressed on the same independent variables to estimate annual changes in the variance and third central moment of total income per acre. In the variance equation, the two-stage, least-squares parameter estimates minimized the sum of squared residuals subject to the constraint that the predicted variances are nonnegative.

Table 17.2 Two-stage least squares estimates of the first three central moments of total income per operated acre[a]

Variable	First	Second	Third
Intercept	−16.30	−9.97E + 03	4.09E + 07
d2000	−30.10	−7.89E + 02	−1.58E + 06
d2001	−66.00	−6.89E + 02	−3.05E + 06
d2002	−40.10	−2.99E + 02	−7.89E + 06
d2003	−82.10	2.71E + 04	−4.60E + 07
d2004	33.80	−1.30E + 03	1.03E + 07
d2005	52.20	−1.84E + 03	1.07E + 07
Small farm	−31.90	2.64E + 04	−2.96E + 07
Medium farm	−6.02	3.51E + 03	2.48E + 06
Large farm	30.50	2.40E + 03	3.58E + 06
Seed	635.00	−4.25E + 04	2.00E + 08
Hours	−9.25	4.26E + 03	−1.22E + 07
Seed^2	1390.00	−1.05E + 04	−1.33E + 08
Hours^2	0.84	1.86E + 02	2.94E + 05
Gasoline^2	4.19	2.17E + 02	−4.93E + 05
Fertilizer^2	1350.00	−5.36E + 05	1.17E + 09
Seed × hours	−59.30	−2.01E + 04	2.98E + 07
Seed × gasoline	−232.00	−9.26E + 03	2.43E + 07
Seed × fertilizer	468.00	6.94E + 05	−1.45E + 09
Hours × gasoline	3.51	2.92E + 02	−8.33E + 05
Gasoline × fertilizer	−21.70	−2.67E + 04	5.29E + 07
Fraction acres owned	84.40	−7.09E + 03	2.17E + 07
Spouse works off farm	69.30	−4.52E + 03	1.61E + 07
Operator some college	47.60	−2.19E + 03	6.56E + 06
Operator's age	−0.28	1.37E + 02	−5.28E + 05
Share of corn production	−81.30	5.21E + 04	−8.19E + 07
Debt-to-asset ratio ≥ 0.4	−3.05E + 01	−1.03E + 04	7.99E + 06
Contract production share	1.71E + 01	−2.24E + 03	6.37E + 06

[a]Because seed (constant, harvested acres, harvested acres^2, corn share, corn share^2, soybean share, soybean share^2, and size: $R^2 = 0.65$), gasoline (constant, cropland, cropland^2, soybean share, soybean share^2: $R^2 = 0.24$), and fertilizer (constant, corn share, other seed, harvested acres, harvested acres^2, damage, size: $R^2 = 0.80$) are likely endogenous, the predicted values from first-stage regressions (in parentheses) were used in the moment regressions. Input levels are per operated acre. For the second central moment the two-stage, least-squares parameters minimize the sum of squared residuals subject to the constraint that the predicted variances are non-negative. These estimates were not corrected for heteroscedasticity, but are still consistent, therefore, the statistical significance of individual coefficients is not reported. 278 observations were used

Predicted values from the two-stage, least-squares regressions were used to compute the first, second, and third central moments of the income probability distributions for each farm type for each year during 2000–2006. The annual changes in the moments, the D_{ijt}'s, were then computed for 2001–2006. The pseudo panel used to estimate risk attitudes contains six observations for 38 of the farm types and five observations for two of the farm types, or 238 observations.[5]

17.1.5 Standard RCM Estimation

In the standard RCM, predicted annual changes in the mean of total income per acre were regressed on a constant and predicted annual changes in the variance and third central moment of total income per acre using ordinary least-squares for each farm type individually. Let the coefficient estimates of $\boldsymbol{\beta_j}$ (equation 17.6) be denoted $\hat{\boldsymbol{\beta}}_j$. The asymptotic covariance matrix of the mean of the population's coefficient vectors (equation 17.7)

$$\hat{\Delta} = \left(\sum_{j=1}^{n} \hat{\boldsymbol{\beta}}_j \hat{\boldsymbol{\beta}}_j' - (1/n) \sum_{j=1}^{n} \hat{\boldsymbol{\beta}}_j \sum_{j=1}^{n} \hat{\boldsymbol{\beta}}_j'\right) \Big/ (n-1) - (1/n) \sum_{j=1}^{n} \hat{\sigma}_j^2 \left(\mathbf{X}_j'\mathbf{X}_j\right)^{-1}; \tag{17.8}$$

where n (= 40) is the number of farmer types, and $\hat{\sigma}_j^2$ is the least-squares estimate of σ_j^2. The standard RCM estimator for the mean, $\boldsymbol{\beta}$, of the population's coefficient vectors, $\boldsymbol{\beta}_\text{j}$, is

$$\hat{\boldsymbol{\beta}} = \hat{\mathbf{C}} \sum_{j=1}^{n} \left(\hat{\boldsymbol{\Delta}} + \hat{\sigma}_j^2 \left(\mathbf{X}_j'\mathbf{X}_j\right)^{-1}\right)^{-1} \hat{\boldsymbol{\beta}}_j \; \hat{\mathbf{C}} = \left[\sum_{j=1}^{n} \left(\hat{\boldsymbol{\Delta}} + \hat{\sigma}_j^2 \left(\mathbf{X}_j'\mathbf{X}_j\right)^{-1}\right)^{-1}\right]^{-1}; \tag{17.9}$$

where $\hat{\mathbf{C}}$ is the asymptotic covariance matrix for $\hat{\boldsymbol{\beta}}$.

Results using the full sample and for each revenue class are reported in Table 17.3. The hypothesis that all of the coefficients are equal to zero for the full sample is rejected ($p < 0.001$), and both risk-attitude coefficients are statistically significant ($p < 0.001$). The intercept is not significant for the full sample, which indicates that the average annual change in monetized, expected utility per acre is not statistically different from zero. The AR for the full sample is statistically significant and slightly negative (−0.007, $p < 0.001$), with a 95% confidence interval, [−0.009, −0.005]. Our AR estimate is within the range reported by Antle (1989) for rice farmers in India [−0.10, 1.40] and Pennings and Smidts (2000) for hog farmers in the Netherlands [−0.88, 0.33], but much lower than those reported by Chavas and Holt (1996) for a representative US corn–soybean farmer [3.52, 15.92]. Although both risk neutrality and risk aversion is rejected for the full sample on the basis of our AR estimate, our estimate of DR (2.1e-05, $p < 0.001$) is consistent with a very low level of DR aversion. Chavas and Holt's estimate of DR (157.3 ± 85.65) is, again, much larger.

Contrary to the results reported by Chavas and Holt, our results suggest that US corn–soybean farmers are, on average, slightly risk tolerant. The magnitude of the difference between our 95% confidence interval and the range of ARs reported by Chavas and Holt, however, is disconcerting. They used aggregate data on corn and soybean acres planted, prices received, and production costs during 1954–1985 to estimate jointly the parameters of a representative farmer's production and utility

Table 17.3 Standard RCM estimates[a]

F-stat		β_1	β_2	β_3	AR	DR
All Farm Types[a]						
11.04***	Estimate	8.7	3.3E-03***	3.6E-06***	−6.6E-03***	2.1E-05***
	SE	6.7	5.2E-04	5.2E-07		
Small-Revenue Farms[b]						
18.72**	Estimate	−25.4	−1.3E-03	2.8E-06	2.5E-03	1.7E-05
	SE	27.2	1.5E-03	2.1E-06		
Medium-Revenue Farms[c]						
8.67**	Estimate	9.8*	2.8E-03	3.5E-06*	−5.5E-03	2.1E-05*
	SE	3.6	2.3E-03	1.4E-06		
Large-Revenue Farms[b]						
9.43**	Estimate	7.7*	3.4E-03	3.5E-06***	−6.9E-03*	2.1E-05***
	SE	2.9	1.6E-03	7.7E-07		
Very-Large-Revenue Farms[b]						
14.77**	Estimate	6.0*	6.5E-03***	4.9E-06***	−1.3E-02***	3.0E-05***
	SE	2.7	1.3E-03	8.2E-07		

Standard RCM estimates are reported for the full sample and for each size-category sub-sample. For the full sample and each of the sub-samples, risk-attitude equation (17.6) was estimated using ordinary least-squares for each farm type individually to estimate the mean of the covariance matrix of the population's coefficient vectors (equation 17.8), which was then used to estimate the mean of the population's coefficient vectors and its covariance matrix (equation 17.9). The F statistic is computed using Swamy's formula (pp. 318, equation 5.2). Recall that AR $= -2\beta_2$ and DR $= 6\beta_3$,. See Section 17.1.4 for a description of the data used. Estimates are significant at the 0.001***, 0.01**, and 0.05* levels. For the full sample, the F-stat is F with $k = 3$ and $n - k = 37$ degrees of freedom, where $n = 40$ is the number of farm types in the population. For each of the revenue classes the F-stat is F with $k = 3$ and $n - k = 7$, because there are 10 farm types in each of the sub-samples

[a] The t statistics (not shown) are t with $N - k(n + 1) = 115$ degrees of freedom, where $N = 238$ is the number of observations in the full sample, and $n = 40$ is the number of farm types

[b] The t statistics (not shown) are t with $N - k(n + 1) = 27$ degrees of freedom, where $N = 60$ is the number of observations, and $n = 10$ is the number of farm types

[c] The t statistics (not shown) are t with $N - k(n + 1) = 25$ degrees of freedom, where $N = 58$ is the number of observations, and $n = 10$ is the number of farm types

functions. We applied a nonstructural approach to less-aggregated data on 40 representative farmer types covering a later time period. Variation in the estimated values of the same variable reported in different studies is often attributed to the use of different types of data sets, which may cover different periods, and the use of different estimation techniques. This may explain the discrepancy in our estimates.

Although Chavas and Holt account for the effects of government price support programs, the income variable that enters the utility function of their representative farmer does not appear to include off-farm income. We estimated the standard RCM for the full sample using an income variable that only included net farm income and government payments and found that β_1 (8.4, $p < 0.001$) and β_3 (2.2e-06, $p < 0.001$)

were statistically different from zero, but β_2 was not. The AR estimate using the income variable without off-farm income (–0.001, $p = 0.51$) was consistent with risk-neutral preferences, and the estimate of DR (1.3e-05, $p < 0.001$) was consistent with a very low level of downside risk aversion. Our use of a different income variable, therefore, cannot explain the discrepancy between our estimates and those reported by Chavas and Holt.

Chavas and Holt report substantial variation in their AR estimates for different time periods: 15.92 for 1960, 13.14 for 1965, 12.49 for 1970, 3.52 for 1975, 9.0 for 1980, and 11.15 for 1985. Our findings of risk neutrality and risk tolerance, however, suggest a dramatic change in the risk attitudes of US corn–soybean farmers has since taken place. This, in turn, suggests that other characteristics of farmers that may be associated with risk attitudes – including wealth, educational attainment, farm enterprise diversification, farm corporate structure, and access to government and private risk management instruments – may have been markedly different during 1954–1985 and 2000–2006.

Returning to Table 17.3, the hypothesis that all of the coefficients are equal to zero is rejected at the 0.01 level for all of the revenue classes. The intercepts are statistically significant at the 0.05 level for the medium-, large- and very large-revenue farmers but not for the small-revenue farmers. These results suggest that the average annual change in monetized, expected utility per acre was positive for medium- (\$9.8 ± \$7.4), large- (\$7.7 ± \$6.0), and very large- (\$6.0 ± \$5.6) revenue farmers, but not for small farmers. Expected growth in the utility of income per acre declined with revenue class; however, the point estimates are not statistically different at the 0.05 level.

β_2 is not statistically different from zero at the 0.05 level for the small- and medium-revenue farmers; therefore, risk-neutral preferences cannot be rejected. Risk-averse and risk-neutral preferences can be rejected, in favor of risk tolerance, for large- (AR $= -0.007$, $p < 0.05$) and very large- (AR $= -0.013$, $p < 0.001$) revenue farmers; however, the magnitudes of the coefficient estimates are very small. β_3 is statistically different from zero for the medium-, large-, and very large-revenue farmers and, although this is consistent with DR aversion, the DR estimates are also extremely small.

Although the AR estimates decline monotonically with revenue class, the AR estimates for the medium-, large-, and very large-revenue farmers are not statistically different, and the AR estimates for the small-, medium-, and large-revenue farmers are not statistically different. However, the AR estimate for small-revenue farmers is statistically different (higher) than the AR estimate for the very large-revenue farmers. This suggests that attitudes toward risk depend on a farmer's revenue class, with the magnitude of the effect being relatively small.

17.1.6 Bayesian RCM Estimation

Recalling the variables defined in equation (17.6), the likelihood function for the Bayesian RCM is

$$L = \prod_{j=1}^{n} \left(\frac{h}{2\pi}\right)^{n_j} \left\{ \exp\left(-\frac{h}{2}\left(\mathbf{y}_j - \mathbf{X}_j\boldsymbol{\beta}_j\right)'\left(\mathbf{y}_j - \mathbf{X}_j\boldsymbol{\beta}_j\right)\right)\right\}. \tag{17.10}$$

Multiplying the likelihood function by the prior distributions (see Section 17.1.3) provides the posterior distributions for the parameters of interest (see Koop, 2003, pp. 155–157). Using upper bars to denote posterior values and lower bars to denote prior values, the posterior distributions for the farmer types' coefficients are

$$\boldsymbol{\beta}_j \sim \mathrm{N}\left(\bar{\boldsymbol{\beta}}_j, \overline{\boldsymbol{\Delta}}_j\right), \text{ where } \overline{\boldsymbol{\Delta}}_j = \left(h\mathbf{X}_j'\mathbf{X}_j + \boldsymbol{\Delta}^{-1}\right)^{-1} \text{ and } \bar{\boldsymbol{\beta}}_j = \overline{\boldsymbol{\Delta}}_j\left(h\mathbf{X}_j'\mathbf{y}_j + \boldsymbol{\Delta}^{-1}\boldsymbol{\beta}\right); \tag{17.11}$$

and the posterior distributions for the hierarchical coefficients are

$$\begin{aligned}
&\boldsymbol{\beta} \sim \mathrm{N}\left(\bar{\boldsymbol{\beta}}, \bar{\mathbf{V}}\right) : \bar{\mathbf{V}} = \left(n\boldsymbol{\Delta}^{-1} + \underline{\mathbf{V}}^{-1}\right)^{-1} \quad \text{and} \quad \bar{\boldsymbol{\beta}} = \bar{\mathbf{V}}\left(\boldsymbol{\Delta}^{-1}\sum_{j=1}^{n}\boldsymbol{\beta}_j + \underline{\mathbf{V}}^{-1}\underline{\boldsymbol{\beta}}\right)\\
&\boldsymbol{\Delta}^{-1} \sim \mathrm{W}\left(\bar{\upsilon}, \bar{\boldsymbol{\Delta}}^{-1}\right) : \bar{\upsilon} = n + \underline{\upsilon} \quad \text{and} \quad \overline{\boldsymbol{\Delta}} = \sum_{j=1}^{n}\left(\boldsymbol{\beta}_j - \boldsymbol{\beta}\right)\left(\boldsymbol{\beta}_j - \boldsymbol{\beta}\right)' + \underline{\boldsymbol{\Delta}}\\
&h \sim G\left(\bar{s}^{-1}, \bar{\delta}\right) : \bar{\delta} = \sum_{j=1}^{n} t(j) + \underline{\delta} \quad \text{and} \quad \bar{s}^2 = \frac{\sum_{j=1}^{n}\left(\mathbf{y}_j - \mathbf{X}_j\boldsymbol{\beta}_j\right)'\left(\mathbf{y}_j - \mathbf{X}_j\boldsymbol{\beta}_j\right) + \underline{\delta s}^2}{\bar{\delta}}.
\end{aligned} \tag{17.12}$$

Empirical posterior distributions are obtained by sequentially drawing from the conditional posterior distributions, equations (17.11) and (17.12), using the Gibbs sampling procedure. Given a set of starting values, a value from the posterior distribution of a parameter is drawn. This value is then used to draw from a conditional posterior distribution for another parameter. We used 5,000 burn-in replications to eliminate the impact of the initial value specifications. The number of Gibbs replications was 30,000. We used coefficient estimates obtained from the standard RCM as prior values for $\underline{\boldsymbol{\beta}}$, $\underline{\mathbf{V}}$, and $\underline{h}$, and as initial values for the farmer-type coefficients and mean-squared errors. Because we had no information to specify the remaining priors, we used default values in Koop's Bayesian RCM Matlab code: $\underline{\boldsymbol{\Delta}}^{-1}$ was a three-by-three identity matrix, $\underline{\upsilon} = 2$, and $\underline{\delta} = 1$. The seeds of the pseudorandom number generators were never reset, which means we used the same sequences of pseudorandom variables to estimate risk attitudes for the full sample and for each revenue class. We did this for two reasons: first, so that we could compare risk attitudes across revenue classes without having to account for the ways in which different sequences of pseudorandom numbers would have affected the comparisons; second, because resetting the seeds of the pseudorandom number generators each time a pseudorandom number is drawn dramatically increases the standard deviations of the parameters' posterior distributions.

The results using the Bayesian RCM are virtually identical to those obtained using the standard RCM (Fig. 17.1). As shown, the AR estimates are almost exactly the same as those obtained using the standard RCM, the latter of which were used as prior values in the Bayesian RCM. All of the coefficient estimates for the individual

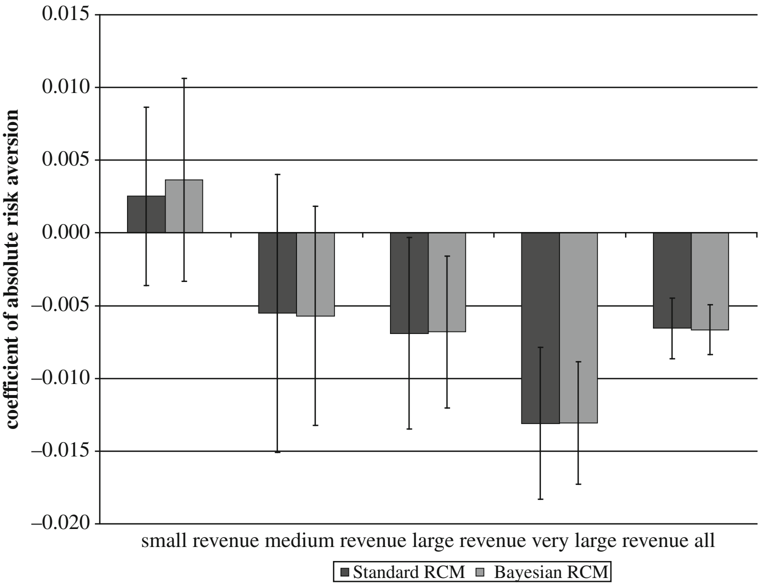

Fig. 17.1 Population coefficients of absolute risk aversion (ARs) for small-, medium-, large-, and very large-revenue farms and for all farm types with 95% confidence intervals

farmer types are also almost exactly the same, although different sets of individual farmer types have statistically significant AR and DR estimates. Using the standard RCM, the AR estimates for small-revenue farmers in Kansas (–0.024, $p < 0.01$), large-revenue farmers in Nebraska (−0.011, $p < 0.05$), and very large-revenue farmers in Indiana (−0.012 $p < 0.001$) and Kansas (−0.017, $p < 0.05$) are statistically different from zero. Using the Bayesian RCM, the AR estimates for small-revenue farmers in Iowa (−0.011, $p < 0.05$), Kansas (−0.023, $p < 0.001$), Missouri (−0.015, $p < 0.05$), Texas (0.028, $p < 0.05$), and Wisconsin (−0.004, $p < 0.05$) are statistically significant. Only one of the individual farmer types has a statistically significant AR estimate using both methods, small-revenue farmers in Kansas. In addition, risk tolerance and risk neutrality can only be rejected in favor of risk aversion for one farmer type, small-revenue farmers in Texas.

Using the Bayesian RCM provided little in the way of new information about the levels of the risk-attitude coefficients, because the error precision was so low, meaning the mean-squared error was so high in these regressions. This is because of the data used in the analysis to estimate risk attitudes, which recall are the annual changes in the mean, variance, and third moment of total income per acre. The dependent variable is small in magnitude relative to the variance and third-moment changes; therefore, small changes in the risk-attitude coefficients lead to relatively large changes in predicted mean income changes. This is a noteworthy drawback of the nonstructural approach to risk-attitude estimation. When the prior values of the risk attitude coefficients were set to values consistent with the Chavas and

Holt estimates – $\beta_1 = 1$, $\beta_2 = -3.52/2$, $\beta_3 = (157.3-85.65)/6$ – the Bayesian RCM returned the same values for the means of the posterior distributions for these parameters, but the means of the posterior distributions for the individual, farmer-type parameter estimates were almost exactly the same as the initial estimates using the default priors. This is a noteworthy drawback of the Bayesian approach to non-structural risk-attitude estimation. The extremely low-error precision overwhelms any effect the data have on the posterior estimates of the means of the populations' and the individual farmer types' multivariate normal risk-attitude coefficients. The means of the posterior distributions do not, therefore, differ appreciably from the prior value specifications.

17.2 Conclusions

We estimated standard and Bayesian random coefficient models (RCMs) to examine the risk attitudes of US corn–soybean farmers using a pseudo panel generated from national survey data covering the 2000–2006 growing seasons. According to the standard RCM estimates, the hypothesis of risk-neutral preferences is not rejected for small- or medium-revenue farmers but is rejected, in favor of a very slight level of risk tolerance, for large- and very large-revenue farmers and for the entire sample of farmer types. Additionally, the hypothesis of downside risk neutrality is not rejected for small-revenue farmers but is rejected, in favor of a very slight level of downside risk aversion, for medium-, large-, and very large-revenue farmers. Although risk neutrality is rejected for the entire sample, the magnitudes of the AR and DR estimates are extremely small. This suggests that the frequent assumption of risk-neutral preferences adopted in the agricultural economics literature is justifiable for the case of US corn–soybean farmers during 2000–2006.

Our AR estimate for very large-revenue farmers is statistically lower than our AR estimate for small-revenue farmers but is not statistically different from the AR estimates for medium- and large-revenue farmers or the entire sample. This suggests that attitudes toward risk depend on a farmer's revenue class, with the magnitude of the effect being relatively small.

Our AR and DR estimates are much lower than those reported by Chavas and Holt for US corn–soybean farmers during 1954–1985. However, our estimates are within the ranges of those reported by Antle (1989), for rice farmers in India, and Pennings and Smidts, for hog farmers in the Netherlands.

Finally, the Bayesian RCM provided little in the way of new information about risk attitudes. The nonstructural econometric model examined using the Bayesian RCM is overwhelmed by a very low-error precision. The extremely low-error precision overwhelms any effect the data have on the posterior estimates of the means of the populations' and the individual farmer types' multivariate normal risk-attitude coefficients. The means of the posterior distributions do not, therefore, differ appreciably from the prior value specifications.

Notes

1. All of the Matlab programs used to generate the results reported in this study are available from Livingston upon request.
2. Throughout the discussion, variables with lower bars are prior values, or exogenously specified values, and variables with upper bars are posterior values, which are simply functions of prior values and the data.
3. Calibration refers to the practice of modifying weights so that, for example, the weighted sum of planted corn acres reported by the surveyed respondents equals the official NASS estimate for the reference year.
4. Visit http://www.ers.usda.gov/data/arms/GlobalDocumentation.htm for more information about the ARMS.
5. There are 5581 usable phase 3 observations on corn–soybean farmers during 2000–2006. Substantial data filtering was conducted in arriving at the data set used to estimate risk attitudes.

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