Zhouying JIN

Global Technological Change

From Hard Technology to Soft Technology

'This book is the most thoroughly comprehensive look at technology from a Western and Chinese perspective that I have ever had the privilege to read'

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Translated* by Kelvin W. Willoughby**

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Preface to the English Edition

In this remarkable and groundbreaking book, Professor Jin begins the arduous process of organizing a new discipline: soft technology. We live daily with hard technology: it is the domain of tools, machines and equipment. Professor Jin defines it as the 'skills, tools and rules that are employed by humans to alter, accommodate and manage nature for human survival and development'. It is about things. It delivers the elements of our material life.

The new discipline she describes in this book represents the rest of the technological universe; she defines soft technology as 'knowledge derived from the social sciences, non-natural sciences and non-scientific (traditional) knowledge to solve various practical problems'. It is, she says, focused on human thought, not things, and is the realm of 'ideology, emotion, values, worldview, individual and organizational behaviours, as well as human society'.

Soft technology is probably older but hard technology is more systematically codified and understood. Hard technologies exist because of invention but the invention process itself and the uses made of the hard technologies come from the soft side. Moral and ethical considerations are not a part of hard technology. How often have we heard that 'technology cannot itself be evil, the evil lies in the way it's used'? Hard technology relies on laws of nature and information about how to do things; soft technology falls back on the inner self and ancient epistemology.

Both hard and soft technologies involve knowledge systems and both are important because they affect the human condition but they operate on vastly different wavelengths.

One can think of dozens of necessary soft technology inventions. Consider inventing a way to protect intellectual property that rewards the inventor but does not withhold the fruits of the invention from people who need it but cannot afford it. Consider a soft technology for encouraging the use of futures research in decision-making or the development of a new decision science that goes beyond economic cost benefit and includes intuition, explicit risk-taking, artificial intelligence and neuropsychiatry. How can conflict resolution be improved? How can old ethnic hatreds be tamed? Or consider how, in this modern world, children, CEOs, clergy and politicians can learn values and moral behaviour. These are worthy soft technology research projects.

There are a few other prospective soft technology inventions that deserve some thought. Science and the hard technologies that flow from it have contributed to our material world for better or worse, improved health, lengthened life and, despite the poverty gap, increased abundance for most people. But on the horizon are possible developments flowing from science that seem threatening and give us cause to pause. Further, science left to its own mechanisms, seems unlikely to provide solutions to pressing global problems. In a nutshell, how can science help capture the best, and avoid the worst, that the future has to offer? Or to put it a different way, how can soft technology help shape science to make life better and less risky for all?

It is probably unfair to pose such difficult challenges to a new discipline. But the ease with which we can find jobs for it to do illustrates its potential importance. God speed.

*Theodore Jay Gordon**

October 2002

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Introduction

Soft technology - the primary subject of this book - is not new. For thousands of years human beings have been creating soft technology, as well as using it and benefiting from it. However, because of the great impact of industrialization and the brilliant achievements of natural science and technology, soft technology has been overshadowed by hard technology. As a consequence, soft technology has rarely, if ever, been developed consciously as a form of technology. This failure to appreciate the true nature of technology, incorporating what I have labelled 'soft technology', has prevented us from properly grasping the essence of the process of technological innovation. It has also distracted us from dealing properly with the relationship between technological innovation and institutional innovation.

Through exploring the concept of soft technology in this book I stress the importance of innovation and technological competitiveness for closing the gap between developed and developing countries. The book also discusses how qualified soft technology workers may be trained and how soft technology - or 'soft-tech' - industries may be developed. Meanwhile, I challenge developing countries to shift away from the strategy of 'catching up and then surpassing' developed countries by investing the most funds, human resources and energy into hard technology, towards a strategy of consciously developing soft technology. I also stress that leaders in developing countries need to understand and create new rules of the game. Developing countries need to stay alert to new advances in hard and soft technology in developed countries and avoid blindly following old thinking patterns and criteria when choosing new development strategies, routes and industry structures. In order to catch up and ultimately surpass developed countries, developing countries need to bring their own new advantages into play and follow their own route to success.

Soft technology is crucial to the sustainable economic and social development of all nations and all communities. As a citizen and scholar of China, however, I have written this book with an eye trained on the special circumstances of China's economy and technology. China's social and economic development has now come to a critical stage; and for its development process to be sustained the nation's economic structure must face further adjustments and reforms. In the face of economic and technological globalization, a broad-based technological innovation system must be established in order to facilitate overall innovation, boost strategic adjustment and improve comprehensive national power and international competitiveness.

Research on the new paradigm of technology - soft technology - has just begun and this book is an elementary contribution to the field. Many problems and issues addressed in this book will require further study. The weaknesses of this book, of which there are no doubt many, are open to the criticisms and comments of its readers. I sincerely hope that entrepreneurs, scholars, social activists, government officials, managers and administrators (no matter what rank) who are concerned with creativity, innovation and business start-ups, can participate jointly in both the research and the practice of soft technology.

*Zhouying Jin**

August 20, 2001

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Chapter 1: The Evolution of Technology

Technology has advanced greatly in recent years. The dream of people reaching the moon has become a reality. Now it is even possible to clone human beings. Knowledge and technology have caused such a great impact upon economic development that we now routinely speak of the information economy, the digital economy or the knowledge economy.

In the meantime, the ruthless pursuit of economic profits and the unethical application of technology by immoral people, with the many tragedies that have ensued, are generating rising criticisms against the further development of technology. John Naisbitt, a renowned futurist and author of *High Tech and High Touch,*[1] calls the public's attention to the meaning of humanity and suggests that the development of science and technology should be based on the need of humanity and positively benefit it. Recently, Bill Joy, cofounder and chief scientist of Sun Microsystems,[2] wrote an article in *Wired* magazine suggesting that, 'Our most powerful twenty-first century technologies-robotics, genetic engineering, and the billions of technological advancements-are threatening to make humans endangered species.' This statement warns people against the dangers brought upon the human race by unplanned and uncontrolled technological innovations. As a solution, he suggests developing a system of efficient control over the development of some technologies. However, the development of technology as the engine of society and its economic development appear to be irresistible. Its significance can never be over emphasized.

Then how should technologies be controlled and developed? Are there actually any 'good' or 'evil' technologies? What should be noted here is that both Naisbitt and Joy discuss the fact that high-tech is 'threatening to make humans endangered species'. The high-tech that Joy mentions refers to technology as traditionally understood, i.e. the 'hard technology' that is derived from natural science-based knowledge.

In the twenty-first century, with the rapid development of high technology and economic and technological globalization, human concepts of country, enterprise, government functions, knowledge, work and even science are undergoing changes. Should we refute technology? Could the knowledge derived from non-natural science, such as social sciences and the like, form technologies? If so, we will have to rethink the essence of technological competitiveness, rethink the meanings of technology foresight and R&D and reconstruct the frameworks of our technological innovation systems. We may even need to adjust our entire strategic systems for social and economic development.

A. Technology as Traditionally Understood

From the ancient Greek era until today, human beings have studied what technology is and have investigated the essence of technology from a variety of perspectives. For example, it is now widely recognized that primitive men differed from anthropoid apes in at least the following four ways: they were able to walk on two legs, make and use tools, utilize fire and communicate via language. In retrospect, the making and use of tools and the utilization of fire and language are technologies. It is obvious that technology existed in the primitive period. At that time, the so-called tools were produced with the intended purpose of extending or assisting the human body.[3]

During the past two thousand years human understanding of technology has varied a great deal. In the ancient Greece, the scope of technology, in general, was very wide. It included everything from farming techniques and ancient medical

practices involving leeches to political techniques, gymnastics, and arts. The most representative view of technology in ancient Greece is contained in the theoretical work of Plato, one the three great philosophers of ancient Greece. In his *Apology and Other Dialogues,* Plato points out that technology includes the technology of acquisition, as well as the technology of manufacture.

The technology of acquisition included the technologies of learning, acquiring knowledge, making profits, agon* technique and hunting; while the technology of manufacture consists of practical manufacturing technology and image-manufacturing technology, i.e. the techniques of art and craft. Practical-manufacturing technology included farming techniques, ancient medical practices involving leeches, construction techniques and tool technology, while the image-manufacturing technology included the technology of imitation and idolization. Plato considered the creation of art to be a manufacturing activity, so he included the activities of art and tool creation in the technology of manufacture.[4]

The Ten Books of Architecture by Marcus Vitruvius, an architect of ancient Rome (first century, B.C.), is considered the technological encyclopaedia of Roman times. In the first chapter, the author describes the qualities of an architect. Some of these qualities are as follows: fluent writing skills, drawing skills, a knowledge of geometry, optics, mathematics, history, philosophy, music, ancient medical practices involving leeches, law and astronomy, etc. Vitruvius regarded these abilities as organisms of the human body that must be integrated into an entire indivisible system.

Francis Bacon (1561-1626), the British philosopher famous for his aphorism ‘knowledge is power’, believed that if knowledge of the Greek period was used to seek kindness and beauty, and the knowledge of the medieval period was used to pursue beliefs, then the third period of knowledge is one which could ensure humans the power of domination over nature. Bacon thought, ‘Human mastery over things depends upon science and technology. Only through submission to nature could a human being control it. That is to say, in the purpose of controlling nature, we should submit to and control it: human technology and recent studies show us how to deal with, understand and manipulate nature.'[5] It is evident that Bacon's theory embraces the idea that 'technology enables mastery over nature.'

In the late eighteenth century, Denis Diderot (1713-84), French scientist and chief editor of *The Encyclopaedia*, stated that technology is the system of various tools and regulations organized for a common purpose.[6]

Friedrich Dassauer (1881-1963) of Germany identified three essential features of technology. He said that it should conform to natural laws, operate with a common purpose and also operate with a creative purpose.[7]

Figure 1: Plato's Concept of Technology

- Technology
  - Technology of acquisition
    - Technology of Leaning / knowledge / profit
    - Technique of agon / hunting
  - Technology of manufacture
    - Practical manufacturing
      - Farming/ancient medical practices
      - Architecture / tools
    - Image manufacturing (art)
      - Imitation image manufacture
      - Idolization image manufacture

In the early twentieth century, the Japanese academic community began arguing over the concept of technology. Tosaka Jun, the leader of the Japanese Materialism Research Association, which was founded in 1932, classified technology as notional technology and material technology. The former includes the means that constitute the subjective existence of technology, such as skill and intelligence; the latter includes means that constitute the objective existence of technology, such as machines and instruments. However, Jun also thought that notional technology was only the means for the subjective existence of material technology and not true technology in itself. Affected by the view that 'technology is embodied by the machine as the important means of labour, production, etc. in large industries; technology is infiltrated into the labour process', the majority of researchers in the Japanese Materialism Research Association think that technology is the means of production or even the system of the means of labour.

Many scholars at that time who opposed the theoretical notion of technology as the means of production believed that even Karl Marx himself did not define technology in such a manner and that his view was actually very similar to that of people such as Bukharin who supported the notion of technology as mechanism. For example, Aikawa Haruki pointed out that the concept of technology should be divided into three categories: the concept of natural science, the social sciences and philosophy. From the perspective of social sciences, 'technology is the existing means of labour during the process of production'. Another Japanese scholar in this group, Takeya Mitsuo, saw technology this way: 'technology is the conscious application of the objective laws during the production practice.' Since the early 1930s, many people of the Japanese philosophical community have begun serious research about technology under the general umbrella of this school of thought.[8]

In the 1960s an advisor to the OECD, Erich Jantsch, who was working in the general field of technology forecasting, made some important contributions to the ongoing debate about the definition of technology. Jantsch pointed out that technology included the conscious application of materials, life science and behavioural science; and also that technology also included all the means of ancient medical practices (involving leeches), agriculture, business and other fields, including hardware and software.[9]

F.R. Bradbury pointed out, in his *Economics of Technology Development,*[10] that 'technology is the way of doing' and 'the values of technological development are dependent upon the improvement of the ways we use resources to satisfy human needs'.

Hazel Henderson used a broad definition of technology: 'Human knowledge applied to human purposes.' She included as technology design of political and economic systems, software and social security.[11]

The Japanese *Yuhikaku Economic Dictionary,* published in 1979, defined technology as the following: 'a process of supplying better means of utilizing nature for the purpose of developing and improving human lives. There are roughly two explanations of technology: the conscious application of the objective laws and the system of labour means.'[12]

In the 1985 Chinese version of the *Concise Encyclopaedia Britannica*, technology is defined as 'the means or activities employed by human beings to change or operate the external environment'.[13]

In 1990 the Nomura Research Institute in Japan published an important document, *The Strategy for Technology in 2000*. This drew attention to 'the technological stream of human sciences'[14] and pointed out that the changes of the definition and coverage of technology was due to the orientation of technological developments in the 1990s. If hard technology was based and focused on natural science, such as physics and chemistry, etc., then the trend of the twenty-first century should be directed towards soft technology based on humanities. Hard technology, aimed at turning natural objects into artefacts, is the technology of controlling the 'object'. The high technology of the future will be based on psychology that will be the technology of controlling and commanding the 'human mind' and the organization of management technology.

China also has a long tradition of thought about the nature of technology. The Chinese notion of technology, stemming from the ancient age, emphasizes technique, skill, feat and methodology.[15]

When talking about the relative differences between science and technology in 1998, the Chinese scholar Dong Guangbi posited a comprehensive description of technology. He said, 'From the perspective of knowledge, science is the theoretical knowledge, while technology is the operable knowledge; from the perspective of methods, the scientific means is to discover, while the technological method is to invent; from the perspective of activities, the purpose of science is cognition, while that of technology is practice.'[16]

From the preceding review of ideas about technology, covering an array of time periods and a diversity of cultures, we may draw the following conclusions:

- The concept of technology has been evolving.

- Throughout the long history of formal discussions of the concept of technology, almost all serious commentators and analysts have included soft dimensions of technology (e.g. regulatory systems, practical activities, processes, arts, techniques, approaches, programmes and the like) as part of the definition of 'technology' - in addition to the hard dimensions of technology (e.g. tools, machines and equipment and other means of labour). Plato's technology of acquisition is an example of 'soft' technology and so is the dimension of technology classified by Erich Jantsch as the application of behavioural science.

- Nevertheless, since the industrial revolution, the concept of technology extant in the literature has gradually evolved to include such notions as 'the means of dominating and controlling nature', 'the initiative relation with nature', 'the system of labour means' and 'the means of changing or controlling the external environment' and so on. Several hundred works on the history of technology have now been published, in a multiplicity of languages - with titles such as *Chronology of Science and Technology, History of Modern Technologies, History of Technology, and Technological History,* etc. I have observed that almost all of these works tend to focus exclusively on research in the natural and physical sciences and upon what I have labelled 'hard technology'.

  This focus has come about because, during the age of industrialism, material production played a vital role in the economy, and natural science and technology made outstanding contributions to the improvement of material productivity. Especially in the past two centuries, the invention and extensive application of new technologies, such as the steam engine, electrical technology, steel technology, chemical engineering, the telephone, wireless communications, the transmitter, the computer, large-scale integrated circuits and so on, have generated technology revolutions that, in turn, have promoted the development of productivity and changed human survival conditions and lifestyles. Human understanding of knowledge has therefore leaned towards the natural and physical sciences; the rules, approaches and means, which were created during the process of problem solving in the material production by applying natural sciences, are usually called 'technology'.

  Contemporary dictionary definitions of technology typically define and connote technology in a manner that emphasizes utilizing and altering nature. For example, *The Modern Chinese Dictionary* defines the term 'technology' as 'experience and knowledge in the process of utilizing and remaking nature', the term 'technology revolution' as 'thorough revolution of production technology' and the term 'technology innovation' as 'improvements in production technology, e.g. improvements in the process of machine components'.[17] *The Economics Dictionary,* published by the Japanese Yuhikaku Press, defines technology as 'the means supplied to utilize nature'.[18]

- The importance of so-called 'non-technological factors' associated with technology has been recognized for quite some time. For example, in the late 1970s, after investigating problems occurring during software development projects, the American Department of Defense discovered that 70% of all failed projects were due to insufficient management and not the lack of technical knowledge.

> Another example may be found in an international study by Kelvin Willoughby of the role of technology in local economic development initiatives from the 1960s onwards. Willoughby found that non-technological factors (which he labelled 'technology practice') surrounding technologies were key determinants of the success or failure of projects in fields ranging from agriculture and water supply to energy and small-scale manufacturing.[19]

Some people refer to these non-technological factors as the second driving force. Non-technological factors are normally critical in determining the success or failure of technological projects. What are we referring to when we say 'non-technological factors' or 'the second driving force of productivity?'

- Many issues that human beings face in the twenty-first century are the devious applications of technology, the disruption of the ecological system, pollution of the environment, crimes, mental diseases, etc. These issues force us to reconsider whether we have overemphasized the 'remaking' of and mastery over nature in the understanding and application of 'technology' and ignored the technologies that involve human beings and human behaviours. We have not conducted enough research regarding how technology changes and controls our subjective environment. Therefore, we need to revert to Plato's technological definition and gain a fresh understanding of technology.

B. A Fresh Understanding of Technology
- New Paradigm of Technology

1. Many Hard Technologies are Softening
Today we have discovered that some high technologies, which are the great driving forces for economic and social development, are different from traditional technologies. For example, computer software is becoming the strategic technology of economic development and national security. The total value of output of the information industry in the world was 587.71 billion dollars in 2000, of which software makes up 61% and hardware 39%, and it is expected to reach 1022.23 billion dollars in 2005.[20] China's software industry began to develop in the middle of the 1980s and achieved RMB 75 billion in 2001, compared with sales of only RMB 220 million in 1990. During the last ten years Chinese's software industry has averaged an increase of two digits per year and has become the fastest developing high-tech industry ever. It is estimated that China's sales in software may amount to thirty billion dollars in 2005.[21]

However, the 'new' technology is not the factor that has contributed to making the software technology industry grow rapidly. The successful design, implementation and application of software require the integration of technology and different cultures, languages, arts, ways of thinking, working styles and procedures. This gives software the characteristics of humanity and locality. Software technology is thus no longer a technology in the traditional sense (i.e. hard technology). Furthermore, the greater the success of the software industry, the more that it will include 'non-technological' factors and the less that it may legitimately be seen as indifferent to human factors and values. The development of the Linux operating system serves as one such example.

Moreover, it is now widely recognized that the majority of the value-added of many high-tech products mostly come from the service activities associated with the products and not from high technology itself. Thus, high technology industries gradually evolve into service industries. Some technologies derived from natural science are softening because the more that 'human' factors are involved in technology, the more softened the technologies become.

Results of a recent investigation conducted by government authorities of computer users in the Asian-Pacific region concluded that hardware makes up 21% of the overall expense of the computer and the rest goes to software and service, such as the use of products, maintenance, training and the upgrading of products. According to findings of a report produced by Taiwan Market Research Institutions of China, the ratio of the production value of software to that of hardware in the global information industry will be 2:1 in 2010, in contrast with the ratio of 6:4 in 1997. In addition, the output value of software will greatly exceed hardware and 90% of the value of hardware will come from software.[22] Accordingly, general managers of software companies are now, more often than not, primarily management experts rather than technical experts. Take Computer Integrated Manufacture Systems (CIMS) as an example. CIMS experts in China have proved through experience and practice of 15 years that the key to success is the integration of soft technology and hard technology, namely, the integration of various information, automation and manufacturing technologies with the organization, culture, regulation and abilities of the enterprise in question.

2. The Process of Transferring Hard Technologies: Commercialization and Industrialization are Process Technologies

In order to get an upper hand on international competition, all governments have put a great deal of manpower, materials and funds into high technology. However, the same technology in different countries or regions transfers at different rates and brings about different 'results'. What functions, then, bring about the transfer of technology? What 'injects' technology into products and 'pastes' it to the market? What turns knowledge, technology and ideas into products and services, resulting in the creation of value? Is the process of technological transformation from invention to production a kind of technology in itself?

Actually, we cannot expect technology to turn into a product or acquire market share if we rely simply on ‘hard technology’ itself. A series of other functions and facets are involved. For example, we have to set down a correct strategy, raise the necessary funds, design products that satisfy different customers, guarantee the quality of products, perform cost control and promote sales activities before enlarging the market share and making profits possible. All of these are part of a series of commercial technologies, including management technology, that are used within enterprises.

In the meantime, for the sake of their survival, enterprises not only need to adjust their product and organizational structure by means of cooperation, purchasing and merging and foreign investment, they also need to seek help from the ‘external brain’. They need to publicize their products and their images through advertisements and public relations. The regularization and formalization of these external activities may also be considered to be technologies, albeit technologies that differ from ‘technology’ as traditionally understood.

Another familiar example lies with the automobile industry. The automobile, the most common means of transportation, owes its success to continuous innovation of production and organization technologies. In the history of the automobile industry, the technology of the flow production line, developed by Ford, and the method of lean production, originating with Toyota, the new division mode of industrial labour and the strategy of sharing common platform, etc. are the critical soft technologies in the process of the batch production of automobiles which has played a revolutionary role in moving the worldwide automobile industry towards the goal of large scale, low cost and high quality production. Just as was the case with hard technologies, involved in applications such as engineering and the production of new materials, these soft technologies have contributed positively to the human race.

To sum up, in the process of technology transfer and competition, enterprises have developed a series of process technologies that have made practical contributions to industry and which evoke further study of the role of soft technology in industry.

3. Various Commercial Technologies are the Direct Driving Forces of Hard Technology Innovation

A technology that has had a great influence upon the development of society and its economy - and which is familiar to us but is not generally considered to be a kind of technology - is nothing other than what we might call ‘exchange technology’ or ‘commercial technology’. From the early days of ‘double-entry bookkeeping’ and shareholding systems, to the contemporary finance-derivatives tools and e-commerce systems, various social exchange technologies have been invented to facilitate human economic and social activities. These exchange technologies have largely been developed in the manner of learning-by-doing: practitioners and observers summarize the perceived rules of their activities and accumulated experiences, following thousands of tests and experiments (in which the human production activities themselves serve as the laboratory), eventually adapting these results to different cultures, social institutions and technological levels.

For decades Hong Kong has not produced any high technologies of its own, yet it has noted a remarkably fast economic growth. This speedy contribution is to due to Hong Kong's commercial technology.

Charles Jones, the Stanford University economist, has pointed out in his research about 'economic growth over the very long run: 'even by 1790, average per capita consumption in France was no greater than it had been during the days of the Roman Empire.' [23] It was only during the late nineteenth and twentieth centuries that unprecedented rapid growth produced a much higher living standard than the past several thousand years. It also produced electricity, cars and railways, and air flights were widely utilized. Population and educational levels also changed fundamentally. One of the main causes lay with the 'improvement in institutions that promote innovation, such as property rights'. These institutions also include, for example, the patent system, the establishment of limited liability companies, the development of stock markets and venture capital, the establishment and broadening of research institutes within companies and governments, and preferential government policies toward research and development.

I have studied the relationship between the introduction of various commercial technologies and per capita growth of GDP over the last 200 years in the U.S.[24] As is shown in figure 2, the growth of GDP per capita during the 40 years from 1910 to 1950 (even taking into account the effects of the Great Depression that began in 1929, leading to five years of negative growth in the first half of the 1930s) far exceeds the growth of the 90 years from 1820 to 1910; the growth during the 40 years between 1950 and 1990 exceeds twice that of the previous 40 years. Growth has accelerated, especially since the 1940s. These two periods are characterized by the comprehensive application of various technological inventions of the past 200 years, such as wireless communications, automobile production line, electrification of railroads, thermal power stations, large capacity hydroelectric power stations and airplanes. In the meantime, the average human life expectancy grew from 35 years in the Renaissance period and the eighteenth century to 45 years in the late nineteenth century. In addition, it became 55 years in 1920s (see table 1).

It is generally considered that, during these 200 years, four technological revolutions took place: the first was centred around the scientific and technological principles of Newtonian mechanics and mechanical techniques and took place in the middle of the eighteenth century; the second was centred around electromagnetic theory and electrical technology and took place late in the nineteenth century; the third was based on the application of the new technologies of modern physics, computers, nuclear energy and space technology and took place in the middle of the twentieth century; and the fourth was based on the integration of microelectronics, computing and communications technologies and the breakthrough in biotechnology and took place at the end of twentieth century. These revolutions do not seem to relate directly to changes in the American per capita GDP. This may partly be due to the 'delay time' lag effects on the economy. What actually is the direct reason? How can we determine the differences in 'delay time' between different countries?

How is the above growth of American GDP per capita in the twentieth century closely related to American innovations in soft technology?

A series of innovation-encouraging commercial technologies were creatively developed and applied in the late nineteenth and early twentieth centuries. In addition, noticeable innovations in economic institutions were developed during this period. For instance, although patent technology (the patent system) was first introduced in the fifteenth century, it was not applied to all industrialized countries until the end of the nineteenth century. After 1883, the Paris Treaty was issued, with the aim of protecting industrial property but by 1870 America had already performed radical reforms in the patent system (see the details in the patent part of commercial technology history, elsewhere in this book.) [25] The stock market originated in Europe in the early seventeenth century but was later successfully redeveloped in America during the early twentieth century. The research institute system was initiated primarily in Germany in the middle of the nineteenth century but many industrial R&D laboratories were established in America by the beginning of the twentieth century. Frederick Winslow Taylor developed modern management technology and in 1910 Ford initiated production line; radio broadcasting was first introduced to America in the 1920s and the neon sign was introduced, as an advertising medium, in the 1930s.

In the 1950s, modern management technology, public relations, large-scale mergers, venture investments and military technologies such as logistics had their first big impacts in America. What must be noted is that the immigration policy and the intellectual personnel system of America greatly contributed to creating innovative environments, thereby attracting to the USA a great number of scientists and technology experts from other countries.

In the development of America's 'new economy' in the 1990s we can place the role of the fourth wave of soft-tech development on a par with the activating forces of information technology (see details in the section about the history of commercial technology in this chapter). Soft technology innovations, such as global management, venture capital, innovation in the stock market, transnational merger techniques, virtual organization techniques and modern physical distribution technology have prepared the way for the rapid application of information technology, the Internet and biotechnology in the world's markets; and they have enabled overall improvements in industrial efficiency, as well as facilitating the development of intellectual service industries. The interaction between these technologies has not only helped sustain continuous economic development but has also promoted the growth of the information society. In other words, soft technology is another engine of social-economic development.

4. Social Technology

1) Innovation in Social Sciences and Social Technologies is Extremely Urgent

Typical definitions of social science are as follows: 'The science that probes the behaviours of social groups and organizations and the individual's behaviour and performance in organizations;'[26] and the 'study of human behaviours, human relations, and the relations of humans and their living environment'.[27] These definitions portray social scientists as studying humans' social and cultural behaviours, including economics, politics, sociology, anthropology of society and cultures, social psychology and social and economic geography, as well as various fields of education and others.

Social sciences have developed quite rapidly in the past 200 years. Behavioural science developed in 1949 after a scientific conference at the University of Chicago. Behavioural science has had such an impact on the social sciences that the boundary between the different disciplines has blurred and now the different theories, views and approaches flow freely between them, fusing this scientific complex together. Despite the great progress that has been made, the achievements of the social sciences and social technologies are overshadowed, worldwide, by the significant achievements of the natural sciences and technology. The lag between these two general domains of science and technology (the social versus the natural/physical) has become a bottleneck for sustainable socio-economic development.

In 1955 Misumi Jyuji, a Japanese scholar, pointed out, 'The misfortune of modern society lies in the comparison of the outrageous development of natural technologies and the backward development of social technologies. Furthermore, many roots of modern misfortune lie in the failure to strike a balance between the two technologies.'[28] In 1966 the American scholars Olaf Helmer and Theodore Gordon, et al., stated that when expatiating the mission of social technologies[29] the following happens:

> It has been said that many of the difficulties that beset our world today can be explained by the fact that progress in the social science domain has lagged far behind the physical sciences … we who are in the social science field are faced with an abundance of challenges: how to keep peace, how to alleviate the hardship of social changes, how to provide food and comfort for the poor, how to improve the social institutions and the values of the wealthy, how to cope with revolutionary innovation, etc. However, unlike the physical sciences, where failures normally mean mere delays, the social sciences cannot afford to fail in their major aspirations; to do so could have a direct and catastrophic impact on society.

Table 1: Increase of Average Human Life Expectancy

In China, although failure is evident everywhere, it was caused by inefficient decision-making, forecasting and macro management, and we acknowledge these well-known causes. Social sciences are often misplaced with politics and disregarded by many people as a discipline of science, let alone as the basis for developing social technology. This makes it difficult to systematically study social sciences from the perspective of 'solving' realistic problems of economic and social development. Since the reform and rebirth of China, 155 major labs, 82 national

Figure 2

engineering and technology research centres and 50 national engineering research centres[30] have been established but none of these focus on the application of the technology of social sciences to society, economy and technology.

Today, while hard technology has been making rapid progress, innovations of social sciences and technologies that are the vital sources of soft technology lag far behind. The reasons are analysed below:

- Social sciences still have not been fully developed as scientific disciplines and the existing classification of social science disciplines is obsolete. Although interdisciplinary research activities have become more popular in recent years, these responsibilities still belong to the inner academic circles of traditional social science departments and they tend to be conducted with indifference to the need for application-oriented research.

- Research about micro-economic and meso-economic activities has not been fully developed, nor integrated with natural science.

- Natural scientists and engineers who were educated in the old education system generally lack knowledge of social sciences and many economists and sociologists are not aware of the developments of modern technologies. This means that the 'different trades are separated by mountains', not just by the small hills of academic boundaries.

- The largest barrier, in the mind, is the prejudice against 'technology'. In most situations within the social sciences people focus on studying its various structures and territories as disciplines of science but they fail to devote attention to summarizing and integrating those methodologies, means and rules of soft technology, let alone regard them as 'technology'. Thus, 'the conscious application of social sciences' to practice is continually held back. The traditional, and widely accepted, understanding of technology tends to mislead people about the potential relevance of social sciences and blinds them from seeing the technology that is, and can be, derived from non-natural scientific knowledge.

2) Social Technology

Science and technology in the twentieth century have greatly contributed to the economic development and abundance of material possessions but have also left a great negative 'heritage' in its wake - such as people caring more about the economic benefits of modernity than the negative influences it has created in the human spirit, morals, education and psychology - that tend to be neglected. Moreover, there exist other critical issues - such as public investment, land development, transportation, layout, protection of ecology systems and the environment, prevention and cure of certain diseases, etc. These problems have also appeared as side effects of the establishment of new enterprises, community development plans and urbanization. Many 'social issues independent of the economy and industry'[31] have appeared in our modern society. These problems are hard to solve using natural science and technology alone. Collaboration between social sciences, non-traditional sciences and the infusion of interdisciplinary learning are required in order to solve these problems.

From another perspective, we live in a continually changing society. However, dealing with the effects of the rapid changes in our economy, culture and even in our institutions is a new challenge for us. Social problems resulting from these influences, ranging from the level of the individual person to the global strategic level, have developed with the result that people are apparently turning to the fields of philosophy and social sciences for answers. Only after a thorough study of the application of the characteristics of social sciences - incorporating attention to comprehensiveness, realism, internationalism and compatibility with local and domestic considerations - could it be possible to find solutions to our complicated social problems. This situation raises philosophy and the social sciences to a higher level of importance in the development of the economy and technology. Meanwhile, the current trend of social sciences is to become the handmaiden of practical applications for decision-making in economic development and business.

Some of the progressive literature in the social sciences has begun to refer to the various methods of the social sciences that may be employed as tools to address social problems as 'social technology'. In other words, social technology is often considered to be the applied technology of the social sciences.

However, in reality, social technology as the innovative process of social activities is much more complicated and carries much more significance than is suggested by the above view. This will be further discussed in the fifth section, 'A retrospective of the development of social technology in the twentieth century' in the next chapter.

5. Cultural Technology

1) Culture and Cultural Values

The definition of culture has many meanings; it can be explained differently, at different levels, and from different perspectives.

It was Sir Edward Burnett Taylor, a British anthropologist, who first gave the term 'culture' a clear definition. He stated in his book *Primitive Culture* (published in 1871)[32] that culture or civilization as a whole is complex because everything has to be taken into consideration, including knowledge, beliefs, arts, morals, laws, customs and any other abilities that a community member acquires through learning.

The 1989 edition of *The Comprehensive Dictionary of Chinese Language*[33] defines culture as: 'Culture refers to, in the broad sense, the integration of material and spiritual properties created in the process of historical practice of human society, and in the narrow sense, establishing not only social ideology but also institutions and organizations accordingly.'

In the sociology chapter of the 1991 edition of the *Chinese Encyclopaedia*, culture is defined as: 'Culture, in its broad sense, refers to the summation of all the material and spiritual products and, in its narrow sense, refers only to the spiritual products, including all ideology, such as languages, literature, and arts, etc.'[34] In addition, further definitions from the perspectives of cultural sociology, cultural ecology and cultural psychology are explained.

Some sociologists and anthropologists define culture in the following way: 'Culture is the shared fruits of human groups and society.'[35] These shared fruits include not only the non-material elements of culture, such as values, languages, knowledge and ways of handling things, but also the material elements of culture, such as tools, money, clothes and artwork.

Generally speaking, 'culture is the overall way of life of people' and is learned, taught, imitated and accumulated through social intercourse and will be passed down by generation to generation. Culture usually is a product of inner values, concepts, attitudes, regulations and customs. Cultural values can be represented through folklore, legends, arts, entertainment and other forms of media. Each society must understand its own unique culture so that during the development of politics, economy and the society of a nation, culture does not dominate these important issues but rather functions as 'an invisible hand' in the decision-making process.

Recently, many people's behaviour as consumers has been augmented by a new emphasis on spiritual consumption. In order to meet this requirement, a huge array of cultural knowledge and cultural resources has been developed into cultural products and marketed. As a result, the development of a non-material economy has advanced. Culture has an increasingly important effect upon the development of technology and economy and sometimes its effects surpass the functions of marketing and government. Since the works of culture and the arts have been marketed, culture will no longer function as 'an invisible hand' nor will cultural knowledge and cultural value be considered as non-technological factors or as non-economic factors.

The economic value or market value of culture refers to the economic benefits that come into play when the works or creations of culture and arts are produced as commodities.

The social benefits of culture refer to the question of the degree to which cultural products or commodities contribute to achieving the goal of social and economic development. The goals of social and economic development are multi-dimensional: the amount of income should be raised while decreasing 'classism' by narrowing income gaps between classes; increasing the demands of material life while satisfying the spiritual life of residents; and improving the social and natural environments of life.[36] Like poems, paintings and statues, works of art and culture that were once created, appreciated and well-known will be expected to function in the real world of social and economic development goals, even though they may not be marketed and converted into commodities. These are the social benefits of works of art and culture and the key point is that the effect can be positive or negative; it can either assist in the healthy development of human morals and minds or it can produce harmful effects in human minds.

2) Cultural Technology

Cultural knowledge and resources, like all natural science knowledge, do not naturally turn into valuable products or commodities. Only by the means of careful re-creation, development, processing and production could we convert cultural knowledge, cultural resources and values into products, commodities and services that can be appreciated, used or 'consumed' for their true value. The means and processes of converting cultural knowledge and resources into products, commodities and services - i.e. the means and approaches by which a culture can show its value, including economic value and social value - is cultural technology. This is the innovative process of human cultural and artistic activities

In this sense, cultural technology is a technology of culture-creation and cultural innovation. This so-called culture-creation refers to the creation, renewal and development, according to the context of today, of new cultural resources and values that are conducive to social development; while, on the other hand, cultural innovation refers to the conversion of cultural contents and resources into products and service with social and economic values, i.e. improving the added value of culture. Today, cultural resources include education, science, arts, morals, laws, customs, beliefs, natural environment and historical heritage. Globalization has enriched the content of cultural innovation and the key of cultural innovation will lie in discarding the dross and in selecting what is essential to the process of achieving coexistence and harmony between different cultures.

It is worth recognizing that because of the duality of cultural value, culture creation and cultural innovations differ from hard-tech innovations. The Chinese economist Li Yining has extensively studied this subject. He stated that the use-value of a product does not possess ethical quality in the field of material production, since opium, morphine and cyanide are commodities. The problem lies with those who use them and with how they are used, not in the use-value itself. Therefore the production and sale of these products should be strictly controlled to decrease their improper use.

However, works of art and culture are different from material products. Because they are products of spiritual endeavour and contain normative implications and features, their use-value varies according to social evaluations. For example, although books, magazines and audio-video products that contain pornography and scenes of murder and violence or other socially offensive material will sell once they are marketed, they can harm some customers and may harm society instead of helping to enrich it. Therefore, with regard to these products, the issues are not who uses them how to use them, or how to 'use them properly'. Under no conditions should the production and sale of these harmful products be permitted. The key point is that the so-called 'strict control over production and sales' over these works of art and culture cannot even exist.[37]

Thus, it is evident that the relationship between cultural technology and marketing is different from the relationship between traditional technology and marketing. Why is this? Because from the perspective of the consumers' psychology, cultural products and services are produced to help pursue the pleasures of life and to meet different life style demands, and once they are produced they are almost certainly bound to sell. But if social impacts are negative, they should not be developed, produced or sold, even if customers exist for the products. For instance, the 'Law of Unhealthy Publication' is one institution that assists in eliminating this kind of cultural trash before it is even developed. In the past 30 years in China, the non-commodity feature of cultural products has been overemphasized. Today, in contrast, in the market economy, we need to take a stand against the tendency to put 'benefits first' or 'money orientation' primary in cultural industries.

6. Chinese Medicine: Another Type of Soft Technology

- A Special Thinking Mode and Problem-Solving Approach

The diagnostic and therapeutic technology of traditional Chinese medicine is another example of soft technology that can be successfully applied to the human body using the Chinese concept of the relationship between man and nature, and disease and health. This field is worthy of additional extensive research and development.

Since medical work began, as documented in 'Emperor Inner-Cycle Theory' (770 B.C.-222 B.C.), which came out more than two thousand years ago, traditional Chinese medicine has formed and developed a systematic theory of unique treatments and therapies. It considers the human body to be whole, with the viscus and the 'Jingluo - the inner cycle-channel' as the core. There are 'Yin' and 'Yang', which obey the law of unity of opposites, in all human beings and in nature (refer to the postscript of this book). Diseases are considered to be the process of maladjustment between 'Yin' and 'Yang', or in other words, the maladjustment between evil and good. With regard to the relationship between the whole and its parts, the former is emphasized. In traditional Chinese medicine the 'QI', 'Spirit', 'Zangxiang', 'Jingluo' and 'symptom', etc., exist only at the level of the entire human body.[38] This approach embodies a unique theory for approaching humans, nature, illness and health. Even more remarkable is that after several thousand years of practice, it has evolved unique and efficient means of solving problems, under the guidance of the traditional Chinese medicine theory, such as diagnostic technology, therapeutic technology, health care technology, longevity technology, etc.

The clinical system of traditional Chinese medicine is a typical example of soft technology. First, the diagnosis of the symptoms is based on collecting information in four ways: looking, listening, questioning and feeling, and analysis by application of IAI (illness analysis and identification, which includes 'the eight principal IAI', 'viscera IAI', 'QI, blood, saliva and fluid IAI', 'six channels IAI' and 'maintaining QI and nourishing blood IAI'.) The treatment principle and medicine prescription is then based upon the patient's symptoms. In other words, in Chinese traditional medicine, diagnosis and treatment are based on an overall analysis of the illness and the patient's condition. Once the diagnosis is made, a detailed therapy process is established under the guidance of the traditional Chinese medical theories, based upon perception and rational mental analysis. The soul of therapy and treatment technology in traditional Chinese medicine is soft technology.

Secondly, from the perspective of operational object (see table 6: contrast between soft technology and hard technology) and basic thinking mode, traditional Chinese medicine is derived from its fundamental theories and operating techniques, which include the 'Yin', 'Yang' and the 'five elements theory'; the viscera and 'Jingluo' theory; the 'QI, blood, saliva and fluid' theory; the pathogenic and pathogenesis theory; the drug properties theory; and the preserving health and recovering theory; the IAI method, rule and principles of treatment, as well as diagnostic technology, therapy technology like acupuncture, massage, etc.,[39] which are different from abstract thinking and visualized presentation thinking, because they involve acquiring concrete sensation by sense organs. Here, subjective experiences, such as pain, danger, fear, stimuli, happiness and discomfort, etc., are felt directly though sense, mood and action. Thus, a type of technology that is different from technology in the traditional sense comes into effect. During the past two thousand years of history, traditional Chinese medicine has been focusing on perfecting the inner and individualized insight, feeling technology and thinking technology.

From the perspective of technological parameters, in traditional Chinese medical theories human beings are considered to be an organic part of nature and society.[40] Factors regarding humanity, society, time and geography are all important parameters of traditional Chinese medicine. Almost all of the traditional Chinese medical theories and technological operations have embodied this different diagnostic result and prescribe, on one the hand, according to different human conditions, such as body constitution, heredity, nourishment, opportunity and the environment in one's life and, on the other, with regard to the different time (year, season, time of day, prevailing period of diseases, etc.), and also with regard to place (geographical orientation, topography, temperature in the sun, humidity, etc.).

From the perspective of human status, technology standards and regional features, in traditional Chinese medicine the body is considered to be a being with consciousness, emotions and thinking capabilities, rather than just a biological machine (as is sometimes the case in the western medical tradition). In other words, traditional Chinese medicine respects the integrity of human life and makes the entire human body and the living individual the focus of observation and thinking. Moreover, since human beings are a part of nature and society, people with different characteristics and conditions react and behave differently at different times, in different places and in different environments. This means that the problem-solving approach of traditional Chinese medical technology (including both diagnosis and therapy) does not readily accommodate standardization; instead, it allows individualized explanations for the same phenomenon, customized to take regional considerations into account.

To sum up, traditional Chinese medicine contrasts sharply with western medicine. In addition, the history of Chinese medicine can be considered part of the history of soft-tech development in the medical field. Excellent doctors that practice traditional Chinese medicine rely on their outstanding abilities with thinking technology and LPFE (Learning through Personal Feeling and Experience) technology and not on the use of complicated instruments.

China is a multi-national country and Chinese national medicine incorporates Mongolian medicine, Tibetan traditional medicine and many other minority medical traditions. Tibetan traditional medicine, for example, has a history of two thousand years and the foundation of its approach involves concentrating on specific geography, climatic environment and culture. Its theory considers three factors, including 'lung' (main breath), 'chiba' (quantity of heat) and 'peigen' (body fluid) that make up the material foundations of the body that are essential for its maintenance. If the three factors are balanced and harmonious, the human body is healthy; if not, the human body will become sick. According to this theory, Tibetan medicine mirrors dialectic prescribing . This theory expresses the wisdom and soul of the medical experience of this snow-covered nation. As a result, the Tibetan traditional medical industry is beginning to gain wider acknowledgement and acceptance.

Throughout China (according to data compiled in 1993) there are 2,457 hospitals that practice traditional Chinese medicine, 129 ethnological hospitals, 222,000 Chinese medical beds and 249,000 doctors who practice traditional Chinese medicine. In addition, there are 30 colleges that teach traditional Chinese medicine, 51 secondary medical schools that teach it, 77 independent academic institutes and more than ten thousand professionals as well. However, for obvious reasons, during the last hundred years China's economic and technological progress has lagged far behind that of western industrial countries. As a result, China has assembled neither the intellectual resources nor the financial resources to enable research into traditional Chinese medicine and medical technology to progress and develop. Even worse, Chinese traditional medicine and technologies are not considered to be part of advanced science and technology and have sometimes even become associated with superstition, false beliefs and fetishes.

The vacuum created by China's failure to adequately support a disciplined scientific approach to traditional Chinese medicine has been filled by pseudo-science. Fortunately, something is now finally being done about this problem but the pace is very slow and only meagre resources have been allocated to its solution. Not until 1986, after China's reform and rebirth, was the State Administration of Chinese Traditional Medicine established. Two years later another organization, the State Administration of Chinese Traditional Pharmaceuticals, was set up. Furthermore, research on 'channels and collaterals' (key topics within traditional Chinese medicine) was listed as a priority of the national research foundation of the late 1980s. In keeping with this slow process of establishment and recognition, traditional Chinese medical research did not appear as a project within China's national high-technology research and development plan until the late 1990s. Although the content and goals of the project were not quite clear, at least the topic has finally been recognized.

An important reason for the obscurity of the content and goals of traditional Chinese medicine and medical technology is that China has neglected research on the essence of traditional Chinese medicine science. In addition, its methodology has not been subject to research and development as a unique domain of technology. This means that even those R&D efforts that occurred have taken quite the wrong approach - because they have tried to force the 'square peg' of hard technology frameworks into the 'round hole' of the soft technology of traditional Chinese medicine. This has forced traditional Chinese medicine to face the fact that there was no scientific platform upon which it could develop and even that it had made some serious mistakes, in spite of its long history and rich cultural heritage. It cannot be denied that traditional Chinese medicine is a discipline of medicine that must developed and integrated with hard technology but the soul of traditional Chinese medicine is soft technology (which takes a special thinking mode and problem solution approach), not hard technology.

Owing to their different cultural background and different way of thinking, it has been difficult for the western world to accept and understand the theory of traditional Chinese medicine and its diagnostic and therapeutic technologies.

However, people around the world have gradually begun to realize that traditional Chinese medicine is different from traditional science and technology because it integrates science, Chinese culture and traditions in a unique way and that this technology is closely related to its culture.

From the perspective of soft technology, some exciting reasons to study traditional Chinese medicine and its various technologies are related to its thinking processes and its approach to understanding and analysing problems. In addition, there is much to learn from the approaches developed by the traditional Chinese medicine to deal with contradictions. These features may assist in the comparative study of life and non-life systems and they may also help promote our understanding of the complex social systems in their entirety. In addition, they may help us to understand and deal with the relationship between the various factors that make up the society-economy-technology system,[41] as well as to understand the individual relationships between each factor and the entire system. To some extent, this may provide a more efficient platform for building harmony, integration and balance for mutual learning, infiltration and coexistence of the East and the West than is possible through politics.

As China succeeds in promoting its traditional Chinese medicines in the larger world, complete with the 'Chinese Brand' within international markets, it will have succeeded in making a great contribution to the twenty-first century. Improved Chinese medicine will constitute a new kind of industrial technology, and if developed wisely with appropriate investments, it will attract the world's attention.

Since China's reform and opening up, it has begun to place due importance on research and the application of traditional Chinese medical theory and its soft technology. Examples of this new attitude may be found in *Concrete Thinking and Comprehensive Notions* (1994) and *Experimental Science and Experience Science - Contrast between Traditional Chinese Medicine and Western Medicine* (1996), both by Liu Tianjun; *Medicine and Human Culture* (1993) by Qiu Hongzhong; and *Future Medical Thinking* (1999) by Ji Sha.

7. Technology Focused on the Human Mind

As intimated above, technology started at the stage when humans first walked on two legs and used their two hands as tools. Then the technology of making tools and using artificial tools gradually developed and with it has come the increasing application of the human body as a tool, followed by labour-saving technology, as popularized in economics.[42] Further, automatic technology and robotics-based production has been pursued. Thus, human beings have become increasingly separated from 'human body technology' through the pursuit of mechanical technology. The primary emphasis in these developments has been placed on external (nature) matter rather than the internal dimensions of the human spirit.

From the point of view of problem-solving, technology may be seen as an extension of human abilities: the human body, sense and consciousness, etc. These all owe their externalization and expansion to the development of technology. Throughout most of its evolution, science and technology involving the human body - medical science and technology - have successfully treated the 'human body' as a complex organic system that is composed of a digestive system, a circulatory system, a metabolism system, a genetic system, a nerve system and a motor system. Contemporary inquiry in the life sciences has come to focus on the human memory system, cells, genes and the actual sources of life. The majority of current 'high-tech' approaches to the life sciences assume the human body to be an organic 'system' or a special kind of 'material structure'. Conventional science-based technology approaches in medicine have not been oriented towards the human mind.[43]

With improvements in the level of material civilization, people have come to care more about the sensate aspects of life - involving sight, sound, taste, smell and touch - and also the intangible aspects of life - involving intuition, moods, emotions, feelings and moral sentiments - and they expect these aspects of their experience to be treated with dignity and respect. To fulfil this requirement, future technology should not simply focus on 'efficiency first' or 'benefits first' but rather we should focus our study on the development of technological means that, even at some cost of efficiency, can make our living and working conditions easier, more comfortable and more convenient and that will respect human moods, feelings and morals. These factors are the driving force behind the recent 'softening' of hard technology and they are also the main ingredients behind the rise of soft technology, especially through the inclusion of values and important service innovations alongside technical considerations in the design of technology.

A new concept of health suggests that human psychological activities should be in balance and harmony with the physiological system, such as the circulatory system and metabolic system, i.e. that psychological health should be harmonious with physiological health. It may be argued that in modern society people face more complicated and more profound social problems and their nerves are therefore more fragile. It is reported that there are over 400 million people with various mental diseases in the world. This is the reason that various methodologies of psychology have been combined extensively with clinical practice.

In short, we need to define a broader concept of technology, incorporating the range of intangible and psychological dimensions of human life discussed above. As shown in figure 3, the broad concept of technology includes the hard technology with which we are more familiar and another type of technology. The latter includes commercial technology, social technology, cultural technology and the LPFE technology mentioned above. The picture in figure 3 represents an entirely new paradigm of technology that differs from technology as traditionally understood. I have given the label 'soft technology' to this new technological paradigm.

It is also evident from Figure 3 that hard technology is basically a technology related to material production, while soft technology is a technology related to non-material production.

C. The Need to Renew the Notion of Technology

1. A New Understanding of Knowledge

Ever since the beginning of the 1980s international scholarly attention has been focused on a new phenomenon, a knowledge-based economy. Scholars from a variety of countries have conducted empirical research demonstrating that knowledge is the driving force behind social and economic development, thus allowing us to renew our understanding of the value of knowledge as an important productive force. Furthermore, this research has deepened our understanding of knowledge from the perspective of its sources, its character, those who possess it, its functions and its levels.[44]

As shown in table 2, the sources of knowledge are not only natural sciences but also non-natural sciences, such as the social sciences and cognitive science. Knowledge of an unscientific nature, as found in art and religion, is also included. Through the analysis conducted earlier in this chapter, it became evident that knowledge derived from the non-natural sciences and from non-scientific sources also has a direct and powerful effect on social and economic development. Such impacts are not the exclusive province of the physical sciences. Technology is an operable knowledge system and knowledge is one of the main sources of technology. As the content and the notion of knowledge have been enriched over time, so the contents of the term 'technology' have also evolved. Surely this process will continue.

Technologies derived from sources other than the physical sciences and physical contexts are certainly different from traditional technologies; in this book they are applied to the field of soft technology.

2. The Changing of Values and the Softening of the Economy

Today's global economic conditions have accelerated the softening of the economy. The proportion of the economy occupied by the tertiary sector has already surpassed that of the primary and secondary sectors. As far back as the early seventeenth century, while reflecting on the situation then facing Britain, Sir William Petty pointed out that industry (i.e. the manufacturing and processing sectors) and commerce could typically turn out more profits than agriculture. He therefore predicted that, as a consequence, the labour force would turn to industry from agriculture and then to commerce. Petty also stated that along with economic development, the centre of industry would gradually shift from tangible production to intangible service production. John Maurice Clark discovered the same economic rule after conducting research on the classification of primary, secondary and tertiary sectors in 1940: with the economic development, the centre of employment structure would shift from primary industries to secondary industries and shift again to tertiary industries. This theory is now called the Petty-Clark Economic Law.[45]

Although the individual circumstances vary in each case, the above rule has been followed during the last 200 years of the industrialization process in the countries that we now call 'developed.' As shown in tables 3 and 4, most countries, in their

Figure 3: A General Classification Map of Technology

- Technology
  - Hard-Tech
    - Tech of Control and Change in Nature
    - Tech of Operation in Natural Matter
    - Tech of Operation in Artificial Matter
    - Tech of Operation of Human Body as 'Matter'
  - Soft-Tech
    - Behavioural
      - Commercial Tech of Economics
      - Social Tech of Social Activities
      - Operation Tech
      - Cultural Tech that Enriches Spiritual Life
      - Military Soft Tech
    - Psychological
      - Thinking Tech
      - Operation Tech
      - LPFE Tech
      - Life Soft Tech

processes of industrialization, show that the proportion of industry exceeds that of agriculture in GDP and the number of employed persons in the industry also exceeds that of agriculture. When industrialization rises to a certain level, the development of the service industry that caters to the needs of production will accelerate. Both the proportion of the GDP accounted for by the service sector and the proportion of employed persons accounted for by the service sector exceed those of secondary industry and agriculture. This becomes an important index of the progress of industrialization in a country. After World War II, the economic structure of all developed countries shared the above characteristics (the USA in 1950s, for instance).

When the above change has taken place not only in the developed countries but also in most countries around the world, then we can say that the world economy would have 'softened'.

Table 2: The Understanding of Knowledge - Knowledge in General

In Japan, the number of people employed in tertiary industry exceeded 50% of all employed persons by the middle of the 1970s. At that time, many scholars employed the term 'economic softening' to describe this phenomenon and quite a lot special research on the subject began to appear. Japanese scholar Aoki Ryozo[46] thinks that 'economic softening' in general refers to the situation in which 'more importance is attached to increases in the market value of the soft dimensions of business activity, such as information and service activities, than is attached to increases in the market value of the hard dimensions of business activity, such as materials, goods, and energy'. In order to analyse the softening trend of the Japanese economy, two symbols of 'softening' have been designed by Japanese scholars. One symbol is whether or not the number of persons employed in the third industry exceeds 50% of all employed persons. The other symbol is the rate at which the input proportion of raw materials and energy to all industries decreases (while the informational and other non-material input increases).

In addition, the Japanese Softening Economy Centre at that time designed and calculated two 'softening rate' indices by applying industrial input and output models. The Centre discovered that the first softening rate (the rate of information input and other immaterial input, divided by input of the endogenous sector) of 17 industries out of the 24 industries chosen for the study were increasing during the 1970s to the 1980s. Thus, the softening rates of fine mechanics, food products and commerce reached 53.5%, 17.9% and 76.2% respectively. The second softening rate (the rate of information and other immaterial inputs plus personnel expenses and the soft component of capital expenditure, divided by the sum of production), except high energy-consuming products like petroleum, coal, water, electricity and gas) went up in all industries. The second softening rates for finance, insurance, commerce, education, research and the medical industry amounted to 66.8%, 61.6% and 73.1% respectively. At that time, Aoki Ryozo thought of the softened economy as 'the economy of producing, circulating, and consuming information and service'.

Now the trend of economic softening is a phenomenon that is spreading quickly around the world. So what is it that makes the economy soften? Here are some answers.

1) Highly efficient agriculture and industry that increases the possibility of producing a sufficient supply of food and manufactured goods for an increasing population, using proportionally lower inputs of human labour and raw materials than before. Increased productivity and the reduction of costs, causes the centre of value-added to shift from material production to non-material production and especially to the service industries.

2) At present, the GDP per capita of many developed countries generally amounts to more than $20,000 and the GDP per capita of the entire world reached $5,020 in 1999. People probably spend more money on other things than on food because material demands are greatly satisfied. For instance, the Engel's coefficient for Japan, which indicates the quotient of food consumption, reached 67% after WWII - the hardest time in Japan's history, and decreased in 1960 to 38% and continued to drop to 23% by 1993. The Engel's coefficient of Chinese urban citizens decreased from 52.9% in 1992 to 41.9% in 1999 and

Table 3: GDP proportions of the three industry sectors in various countries

Table 4: GDP proportions of the three industry sectors in the United States

continued to drop to 39.2% by 2000. This indicates that the focus of consumers in the market has shifted from pursuing material goods necessary for sustaining life towards pursuing a high quality of material life and spiritual enjoyment; this in turn creates a demand for a more extensive range and high quality services. The lifestyle and thinking modes of today are entirely different from those of the past. Even in China it is common to go to a concert or watch a game at the cost of several hundred RMB; it is fashionable for a whole family to go on a trip exceeding the cost of their monthly income; and young people sometimes even spend money on experiences and entertainments designed to produce the thrill and excitement of exceeding normal human limits. Dennis Gobar, a British Nobel Laureate in physics, considers that this change of values is a result of a mature society. Gobar believes that in a mature society, human beings pay more attention to the quality of life and the value of spirit than to the quantity of material possessions.

We can see that the above are some of the reasons for economic softening. Increases in the production efficiency and the reduction of costs in primary and secondary industries have made the market value of tertiary industries increase comparatively. An even more direct cause relates to the fact that the contrast between the market value of services and manufacturing costs in the general economy is continuously increasing, along with the general increase in the living standard and great changes in people's values. This new mode of consumption, with its concomitant changes in the concept of value, has promoted the development of non-material production over material production, with drastic changes in the entire structure of industry ensuing.

It is apparent that the 'technology' applied to non-material production is certainly different from that applied to material production. As shown in figure 3, it is directed towards economic activities, social activities, cultural life and psychological activities. The whole phenomenon, including the means required to produce non-material products and commodities, is given the label 'soft technology' throughout this book.

3. Social Progress Requires the Integration of Technology and Art

In modern society, people generally do not consider art to be a technology. The arts and technology are, however, essentially one indivisible whole. The term technology is derived from a combination of Greek words *techne* (techniques and skills) and *logos* (word and speech), which mean the exposition of modelling arts and applied technology.[47] In 400 B.C., Plato placed artistic creation within technology. During the nineteenth century, Sir Edward Burnett Taylor, the British anthropologist, believed that 'we should not only study culture according to the achievements of arts and spiritual civilization, but also investigate culture according to technology and moral perfection in the development phase of various countries'.[48]

Since the middle of the nineteenth century, the dichotomies in the ways in which humanistic scholars and natural scientists look at the world have become wider. Humanistic scholars have tended to lack interest in natural science and technology and, therefore, have lacked knowledge of natural science and technology. Natural scientists have tended to focus on scientific and technical specialization and have often thereby become insensitive to the humanities, with some eventually even preferring to have nothing to do with the subjects of art, beauty and society. 'This inharmoniousness of these two groups of educated people, who are indispensable to the constructive criticism of the economic system and of social institutions, has caused great losses to the development of the times.'[49] In other words, the industrialized society that was the crucible for the mechanization of technology has caused technology and human nature to increasingly drift apart, while the arts have become alienated from serving technological and economic development.

Japanese scholar Hondasyuro[50] followed in the tradition of Plato's ideology by broadly advocating the integration of technology and art. Hondasyuro employed the label 'profit technology' to describe technology as traditionally understood and the label 'technology of beauty' to describe the arts. 'Science is rational exploration and art is the creation of emotion; only the interaction of scientific reason and artistic passion and enthusiasm can drive the imagination to invent new technologies.' Therefore, technology is not simply subjective techniques or intelligence. Neither is it only an objective scientific and technological system. It is the human activity system that integrates subjectivity and objectivity.

Today's entertainment technology serves as an example. Entertainment technology combines music, movies, TV, video games and the Internet into common media, thus integrating technology and art. Furthermore, entertainment technology finally integrates the technology of beauty with economic profits. The editorial board of *American Science*[51] stated that in 'the future of entertainment technology', the integration of technology and arts will further new tendencies, such as 'interaction technology without heroes', 'movies without professional actors' and 'the integration of the medias with the principles of families'. This requires a redefinition of technology to include culture and arts: soft technology. The combination of technology and arts will become an inexhaustible source of technology innovation.

To sum up, in twenty-first century the explosion of knowledge, the softening of the economy, the changing of values, the integration of art and science and the human mission of sustainable development require us to transform the traditional

Figure 4: Science-Technology-Arts

understanding of technology from a narrowly defined concept to a broadly defined one. In addition it will be necessary to enhance research, development and the application of soft technology. In other words, in the wake of several previous industrial revolutions, it is time for human beings to create a conceptual revolution in technology.

* The Agon was an ancient Greek festival featuring sports, musical and theatrical competitions.

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Chapter 2: Historical Antecedents of Soft Technology

A. The History of Commercial Technology: A Brief Analysis

Soft technology has existed since human beings started their production activities. To list some examples, it has ranged from the ancient Chinese *Sun Zi Bing Fa* and the diagnosis and therapy technology of traditional Chinese medicine, through accounting technology, insurance technology and stock technology in the sixteenth and seventeenth centuries, then the R&D-institute mechanisms of the nineteenth century, to the modern tools of finance, virtual technology and incubator technology. Soft technology has a history just as long as the history of hard technology.

This section will provide a retrospective of commercial technology. It will be treated as an example of soft technology, even though people have tended not to see commercial technology as a unified field of technology in its own right. The topic of how soft technology has promoted the use of technological innovations, institutional innovations and industrial innovations will also be discussed. In the meantime, the history of each technology will reveal how soft technology was invented, how we humans explore creative ideas and receive enlightenment after solving difficult problems and how the business 'game' (business technology) was invented, along with an explanation of the game rules (relevant institutions).

1. Currency Technology

Exchange technology is the most ancient technology in human development history and it has continuously developed, even up to the present day. It can be said that the history of exchange technology is at the centre of the process of economic and social development. In the words of Adam Smith, 'Each individual supplies what the other one needs, exchanging article by article and these mutual transactions' are 'the fundamental elements owned by and unique to human beings'. [1] Human beings have developed innumerable exchange technologies. We will now discuss currency exchange mechanisms, the commercial means with which we are most familiar, as an example of the historical evolution of exchange technology.

So-called 'currency technology' is the means by which value flows and it is the most fundamental aspect of exchange technology. The most primitive currency technology, bartering, is also very direct and can be highly efficient (within certain circumstances). However, if one lacked what the other needed or if the available quantity was inadequate, it was difficult for a deal to be struck.

In order to overcome this inconvenience, another medium of bartering was invented that has been labelled ‘necessary currency’. Necessities differ according to culture but as the medium of exchange, each necessity must possess universal value. For example, some tribes in South Africa accept cows as their necessary currency; Guatemala, in South America, accepts corn; Melanesian tribes in the south Pacific, typified by those in Papua New Guinea, accept pigs as a medium of exchange.[2] In ancient China textiles were accepted as a necessary currency; and up to Middle Ages, boiled-off silk was accepted as a medium for tributes to the palace.

Another necessary currency is common salt for it possesses both use value and exchange value. Salt can be long preserved and is necessary in life. In Ethiopia, Egypt and ancient Rome, salt was used as the means of exchange. A vestige of this tradition is found even today in the English word ‘salary’, which is derived etymologically from ‘salt’. This derives partly from the fact that Roman soldiers were paid with salt. In the slavery trade of ancient Greece, as a further example, a slave was exchanged for his same weight in salt. In the language of economics, necessary currency must possess the duality of both use value and exchange value.

‘Decoration currency’ eventually evolved from necessary currency. Decoration currency possesses a ‘rarity’ value; it is beautiful to look at and may be a piece of artwork. The stone currency used on the island of Yap of the Micronesian Archipelago in the West Pacific and cowry currency, once extensively used in China, Japan, Africa and some European countries, are some examples. In Chinese characters the word of business (__), goods (_), currency (__) and property (__) all contain the character of cowry (from the ocean) ‘_’, i.e. cowry was the main decoration currency at that time in China. As a matter of fact, besides knife currency and textile currency, all kinds of material currencies and measurement currencies, such as pearl, jade, tortoise shell, cowry, gold, silver and tin, existed in various places in China before Qin Shi Huang united the currency system. The government of the Qin Dynasty decided that, in terms of measurement, gold was the superior currency and the round copper coin with a square hole in the middle that was coined monopolistically by the government was regarded as the inferior currency. All other currencies were prohibited.[3]

Before paper currency was invented, gold had been the worldwide means of exchange. Today the gold reserve and the price of gold are still retained as an important international financial index.

China was the first country in the world to use paper currency. During the Song Dynasty and the Jin Dynasty (at around the eleventh A.D.) military expenditure was high and gold and silver flowed outward because of trade and this promoted the invention of paper currency called, at that time, 'Jiao Zi'.[4] During the thirteenth , Italian and French craftsmen used paper with words on it to show that they had received a certain quantity of gold, i.e. a note of deposit was used to make value flow both convenient and safe.[5] This was the earliest paper currency in Europe.

Later banks appeared. Paper currency guaranteed that you could make an exchange at any time necessary so long as you had sufficient gold deposited in the bank to cover the exchange. Paper currency was issued in the form of a coin certificate. This tradition lasted until the end of World War I. After World War I paper currency was no longer restricted to the form of a convertible note and its use and popularization spread worldwide. In China, Sun Yat-sen suggested switching to the sole use of paper currency in 1912. He pointed out that the currency evolution from textiles, silk, knives and cowry to gold and silver and then to paper currency was natural evolution. This process was called 'the revolution of currency' in China.

Currency, as exchange value separate from use value, came into independent existence with the emergence of paper currency. The paper, which no longer possessed the features of the convertible note and did not guarantee a corresponding gold reserve, could represent different values mainly because of the trust in the country that issued the currency. In other words, paper currency is a product of trust.

To sum up, currency technology is the most extensively applied soft technology. It integrates trust and imagination. It has greatly contributed to establishing and perfecting the concept of commodities, market mechanisms and value mechanisms as means of exchange and as measures of value.

In the information age in which we now live e-commerce is becoming widespread. As a consequence, traditional ways of doing business and the conventional means of exchange with which we are familiar are undergoing fundamental change. The use of e-money is now emerging as a new kind of exchange mechanism.

Bernard Lietaer recently published a book entitled *The Future of Money: Creating New Wealth, Work and a Wiser World.* In this book he summarizes and analyses complementary currency systems that can make up for the defects of the national currency systems. Although the rudiment of complementary currency can be dated back to the ancient bartering period, the pioneering example of a complementary currency system in the contemporary era was the WIR, established in Switzerland in 1934. WIR (which, in German, is also the equivalent of the English pronoun 'we') is an abbreviation for *Wirtschaftsring-Genossenschaft* and may be translated roughly as 'economic mutual support circle'. More recently, in 1982, LETS (Local

Exchange Trading System) was established in Canada. By 1999 there were over 2,000 complementary currency systems running in developed countries alone.[6]

In Japan, Tsutomu Hotta, a highly respected former Attorney General and Minister of Justice, created a private organization in 1995 called the 'Sawayaka Welfare Institute'. The Institute has been implementing a special currency called *Hureai Kippu* (literally, 'caring relationship tickets'). It was designed specifically for elderly care and the unit of account equals an hour of service. About a hundred different non-profit organizations agreed to use the same standard unit. The working time of the volunteers is recorded in a 'time deposit book', which calibrates the time and value of a variety of services rendered. In addition, many prefer to transfer part or all of their *Hureai Kippu* credits to their parents, who may live in another part of the country. Kato Toshiharu has applied the label 'ecological currency' to the various currencies of this kind, reflecting the fact that they have been extensively applied to welfare services, medical treatment, education, disaster prevention, environmental protection, nursing for the aged, cultural communication, nursing for the sick and related purposes.

While complementary currencies have garnered less public attention than other new forms of exchange, such as the IC card or the Internet purse, they represent a more profound currency revolution than that heralded by such developments as the IC card or the Internet purse. Complementary currencies have been created to address social needs rather than as the expression of new capabilities in information technology. Thus, it is evident that the time-honoured example soft technology - currency - is still in the process of innovation and development.

2. Accounting Technology

Accounting is a commercial language that no business or serious practical operation can do without. It is an approach to 'confirming, measuring and passing on economic information and a process for enabling information users to judge and make strategic decisions on the basis of it'.[7]

In the Sumerian culture, originating from Mesopotamia in about 3200 B.C., some symbols of accounting records are found on pieces of pottery; officials in charge of the accounting department had to complete something equivalent to a training course in accounting in ancient Babylonia and Egypt in 3000 B.C.

In Greece in around 1400 B.C. the work of accounting was normally the responsibility of slaves. In ancient Greece, slaves were usually forced to conduct audits. Careless slaves could be punished at any time while the law protected free people from such complications. However, later, in Greece, accounting gradually became a honourable job and various accounting records of the costs of governmental constructions were inscribed.

In Persia, under the rule of Darius (king of ancient Persia, 521 B.C. - 485 B.C.), there were special officials who audited the accounts within the areas of their jurisdiction; similar officials existed in the Hebrew culture where the main audit officials held the second most important positions in government.

Constantine established a public administration school during the period of the Byzantine Empire in the early fourth and accounting was among the courses offered. The Holy Roman Empire, under the government of Charlemagne (742 - 814 A.D.), followed the accounting and auditing system of ancient Rome and Persia. After Charlemagne's death the system was abolished and the empire collapsed.[8]

The accounting system in Europe began to decay in the Middle Ages and was not revived again until the Italian religious wars.

Double-entry bookkeeping appeared in the early fourteenth : the first buds of this technique were evident in Genoese accounting records in 1340. At the same time, financial departments were set up in Britain.

In the fifteenth branches of the Medici Bank had to submit an annual balance sheet to the headquarters in Florence.

In 1631 the investors in Plymouth and Massachusetts, in the American colonies, sent an accountant from the Netherlands to investigate the cause of increasing liabilities there, thus giving the people of the New World the experience of their first audit.

Over the past several thousand years, large-scale accounting activities have been mainly related to governmental activities, especially taxation, but the industrial revolution brought about other demands in accounting. The size of enterprises and the funds required to maintain them increased gradually while management services became increasingly complicated. This was accelerated by the functional separation of investors and managers. Once the function of management became the responsibility of people other than investors, the investors themselves needed to know the operating status of their capital; i.e. they required their managers to report accounting information to them (similar to an annual financial statement). At the same time, the managers of the enterprise needed to analyse the internal accounting information, which stimulated the development of management accounting.

In the early twentieth century Taylor's 'scientific management' system was applied extensively. In order for the system of scientific management to work properly it was necessary for existing accounting practices to be improved. Accordingly, special techniques in cost accounting, such as the standard costing system, budget control and differential analysis, were first introduced; and this in turn stimulated the development of formalized management accounting. After the 1950s, modern management accounting took shape and modern accounting divided into financial accounting and management accounting. During the wide application of accounting technology, not only were relevant standards set up in individual countries and internationally but also accounting and auditing departments were developed as a discipline.[9]

3. Patent Technology

It is commonly believed that owning a patent for a valuable technology may be a pathway to making a fortune. In his 1985 book *Japanese Technology or American Wisdom?,*[10] Kusaka Kimindo reiterated the observations of a professor from Harvard University that, during the 37 years following World War II, America transferred to Japan all the inventions of the past 200 years and charged Japan only about 40 billion US dollars for them. The average patent fee amounts to 3% of the sales income associated with its application. For instance, the royalty payment to MacDonald's from franchisees is 1% of sales and the '7-11' company requires payment of 3% to 4% of sales. The GDP of Japan at that time was 1,200 billion US dollars. Hence, if it paid the standard royalty fee of 3%, Japan should have paid 40 billion US dollars every year. It is evident that the many American inventions, or at least the many patents, that were supplied almost free of charge by the USA contributed much to the economic development of Japan after World War II.

Patent technology is employed by governments to encourage invention and to protect inventors and their intellectual property rights. A patent is essentially a government-enforced right given to an inventor, for a specified period of time, to prevent others from commercially exploiting his or her *bona fide* invention without formal permission. In other words, a patent is a state-granted monopoly right given to an inventor for specified time. If imitators enter the market rapidly and gain a substantial market share, although inventors or patentees receive compensation for their stolen ideas, such reparations generally cannot make up for the costs and risks of losing proprietary control of their of inventions. The patent system strengthened protection against competitors who would copy an invention and apply it in the market during the specified monopoly period. The reduced competition during the life of the patent helps inventors to avail themselves of the opportunity to earn monopoly rents, within proscribed time limits, as a reward for their inventiveness. The hope is that more people will thereby be encouraged to engage in invention and creation, activity that would not be accomplished through market forces alone. Therefore, patents function to ‘extend the interval between invention and imitation to encourage people to create’.[11] In addition, to patent protection also provide exclusive protection of copyrights, trademarks, trade names, artistic conceptions of fine arts and industry, as well as technological inventions.[12]

In short, patent refers to the right that a government confers on a certain invention for the inventors to make, use or sell the invention. The duration of a patent varies from country to country, with most countries prescribing a period of 16 to 20 years.[13]

A king of Athens in the fifth B.C. conferred the first patent on a cook for his innovative cookery; in 1236 King Henry III of England conferred on a citizen a 15-year monopoly to produce coloured fabric; and Edward III (1327-1377) gave a patent for weaving to John Kemp of Flanders. These were all primitive patents.[14]

The first recorded industrial patent was the one conferred by the Republic of Florence in 1421 on an architect and engineer by the name of Brunelleschi Filippo. The patent in question was applied to the manufacture of lifter-wheeled barges in the transportation of marble.[15]

The first patent law was passed in the Republic of Venice in 1474. Later, in 1624, Britain passed the Monopoly Law, granting owners of patents monopoly rights on the manufacture and use of inventions for a defined period. American and French patent laws were passed over a hundred years later, i.e. in 1790 and 1791 respectively.[16] Ever since then patent technology has been institutionalized in much of the world.

In Europe periodic resistance has arisen to patent laws. For example, the free trade movement in Britain and Germany from 1850 to 1873 promoted an anti-patent law campaign, probably in an effort to counter the overly coercive enforcement of patent laws. The government of the Netherlands even repealed its patent laws in 1869.[51] However, stimulated by the industrialization waves in various European countries in the nineteenth century , more countries introduced patent laws. For example, Austria adopted the patent system in 1810, Russia in 1812, Sweden in 1819, Spain in 1826, Brazil in 1859, Italy in 1859, Argentina in 1864, Canada in 1869, Germany in 1877 and Japan in 1885.[17]

Thanks to the tenacious efforts of advocates of the patent system, the *Industrial Ownership Protection Regulation* (Treaty of Paris) was adopted in 1883, a remarkable event that strengthened patent protection throughout the world and moved the international patent system substantially in the direction of standardization. Patent systems have continued developing throughout the world ever since. In 1900 there were only 45 countries that had established a patent system. By 1925 this had risen to 73, to 99 by 1958, to 120 by 1973, to 158 by 1980 and to about 180 countries and regions at present.[18]

The following analysis of the first and second industrial revolutions reveals how soft technologies, such as the institution of patents, has affected innovation in hard technology and its associated industries.

British industries, which depended mainly on the export of wool, lagged far behind continental countries during the sixteenth . This was partly due to the fact that Spain, Portugal and the Netherlands controlled marine transportation. The British royal family at the time did not have sufficient financial resources to address the problem, or did not have an apparent suitable strategy. Queen Elizabeth, the monarch of the day, adopted several economic policies aimed at improving Britain's position, including a policy that promoted technology and protected industries. Queen Elizabeth was in favour of this policy because by the end of the sixteenth the European continent was weary from the chaos of more than 30 years of war and the Britain attracted many foreign technologists, including glass-manufacturing experts from Italy and skilled craftsman who had been persecuted in the struggles between new and old denominations in France. These technologists contributed much to the prosperity of science and technology in Britain. In order to retain the skilled foreigners the Queen suggested granting monopoly rights to inventors and requested patentees to apply their patents in Britain within a certain period. In spite of strong resistance to the plan, the Queen's absolute authority overruled the resistance and the policy was put in place. Among the 55 charters granted 21 were conferred on foreign dwellers or inventors from abroad who were willing to transplant their technologies. This policy was repealed in 1599.[19]

In addition, the first monopoly law in the world was promulgated in Britain. The Royal Academy, established in Britain in 1662, promoted scientific and technological research for the entire nation. Many excellent scientists came to the fore under the leadership of Newton. Thus, Britain became the centre of the science and technology revolution in the seventeenth . Moreover, positive conditions were cultivated for Britain's industrial revolution.

The industrial revolution in Britain first began in the cotton textile industry. The competition between British and Indian textiles led to a series of technological inventions and innovations, such as the 'flying shuttle' invented by John Kay in 1733 and the 'spinning jenny' invented by James Hargreaves in 1765. Production and consumption accelerated but caused a great shortage of power and transportation supply. The invention of the steam engine by James Watt in 1769 satisfied these demands. The invention of the steam engine furthered the development of energy and transportation technologies, viz., the invention of steam trains, steamships and industrial steam power, facilitating the expansion of the industrial revolution into the fields of machinery and steel.

The elementary circulation network, which integrated the consumption market and the supply of raw materials, was first accomplished in Britain in the late eighteenth . This helped Britain efficiently import raw materials from other countries and export textile products to the entire world. Simultaneously Britain established the most advanced logistic system in the world to support international trade through advantages in marine transportation, international remittance and finance. For example, the first modern bank was the Bank of England, established in 1694, and the first bank laws were the 'charter law' and the 'royal charter' promulgated in 1694 by the British monarch.

Evidently, not only textile and steam engine technologies prompted the first industrial revolution. The global economic order that ensued under the auspices of the British Empire was made feasible because of the advantages enjoyed by Britain in its international physical distribution mechanism, circulation system, financial institutions and logistics systems. Patent technology, physical distribution technology, circulation technology, logistics technology and finance technology were the real forces behind the first industrial revolution.

Consider the contribution made by soft technology to the second industrial revolution. It is commonly believed that the revolutions in energy technology and transportation technology brought about the second industrial revolution focused on electricity, organic chemistry and the internal combustion engine. The second industrial revolution was not centred in Britain any longer. Commercial success resulting from a monopoly of direct trade with India gradually caused Britain to ignore science, technology and the patent system. The inventor of synthetic dye did not receive attention in Britain but was invited to establish a chemistry laboratory in Germany, which laid the foundation for the German chemistry industry that strengthened over time. In addition, during this period Britain did not consider advanced technologies in other countries as worthy investments. This was unfortunate for Britain because there were many excellent intellectuals who were enthusiastic about the financial industry and overseas securities investments. In this period, business was everything. However, in the meantime, Germany and America absorbed advanced technologies introduced from Britain and accelerated their speed of development. America and Germany surpassed Britain in the occupancy ratio of industry in 1881 and 1906.

The example of America is instructive. With rich natural resources and a small population, Americans paid more attention to soft technology in the hope that it would improve efficiency and tip the scale their direction. Taylor's production mode and Ford's batch production technology are examples of the approaches that ensued. Moreover, because America was essentially a set of British colonies until 1789, America's patent law imitated Britain's law. In 1836, subsequent to the establishment of the USA as a sovereign nation, America's patent laws underwent many changes. The United States established a formal patent bureau that examined inventions and issued patents. The patent inspection system first began in America. Further alterations to the patent system were made in 1870, greatly increasing the value of patents and making the patent system an astonishing facilitator of development in American science and technology. At the same time, many research institutes were established, increasing the quantity of technological inventions and the efficiency of technology transfer.

To summarize, it was mainly soft technologies, such as the patent system, physical distribution, logistics and financial technologies that caused the first industrial revolution while the second shifted to America, where modern management technology, the institutionalization of R&D, a flexible immigration policy, the reformation of the patent system, the new application of share technology (see stock and securities technology in this chapter) and rich natural resources were developed.

The patent system is certainly far from perfect, especially when considering the special role that patented technology plays in our economic development. In 1950 the United States Congress required that the patent, trademark and copyright subcommittee of the judicial committee of the United States Senate review the patent system. Under the leadership of John Stedman, the committee turned out 15 research reports, each from a different angle, between 1956 and 1958. Fritz Machlup issued the fifteenth report, 'The Economics of the Patent System', in 1958. In his report,Machlup pointed out that the patent system concealed profound economic contradictions from its very beginnings. In particular he was concerned about what he saw as the detached island of monopoly rights that is granted along with various forms of the patent. The preface by Stedman read as: 'In the free economy that is backed by competition, we should not only overcome the detached island of the monopoly that is restricted by various patent forms, but also encourage the patents. There are three million patents of this kind in American industrial history.'[20] The American publication *Business Week* recently published an article entitled 'Intellectual Property: A New Approach to a New Problem' that stated, 'For more than a , the protection system of intellectual property has helped nurture the creativity of artists and inventors. Now, this system is confronted with two global challenges: the Internet, which has been internationally heavily duplicated, and the global medical treatment crisis that results from the expensive patent on specific drugs for the undeveloped countries. It is time for us to have a new look at these problems and determine how intellectual property rights should function.'

Much of America's industrial competitiveness was lost during the 1970s. Many research funds did not earn efficient capital and this caused the discordant relationship between academic institutes and industries in the 1980s. Senators Robert Dole and Birch Bayh believed that the main problem was that the patent system at that time impeded competitiveness and obstructed the overall application of research achievements. The patent system's main problem was that because many products, including prescription drugs, were developed with government funding or as the result of research conducted in government laboratories, the government owned the titles to the patents. Although research projects funded by the government did indeed produce inventions, it was rare to find innovations that were applied successfully. Enterprises had to deal with the bureaucracy when using patents because the government owned them. Therefore, they were not active and most innovations owned by the government were put on the shelf. The new patent system of Bayh and Dole changed the technology-sharing relationship between academic institutes and industrial corporations.

The United States Congress adopted the Bayh-Dole Act and amended the Federal patent policy, thereby laying the foundation for successful technology transfer from universities (the recipients of much of the government research funding). The main points of the Bayh-Dole Act are listed below:

- Universities and small-sized enterprises can select their own research subjects and make innovations that will be funded by the federal government.
- Universities must apply for a patent for all their innovations.
- Researchers for universities must publicize their inventions immediately and apply for patents.
- Universities are encouraged to cooperate with the industrial sectors to accelerate the utilization of inventions funded by the federal government.
- Universities must share with other inventors the use of the charter charge.
- Universities are responsible for reporting to the financing institution the serving conditions of their inventions.
- Small-sized enterprises and the manufacturing industry are first to enjoy of the use the new inventions.
- The Government reserves the right to use all non-exclusive patents in the-world.

• The Government reserves the right to intervene.

The complicated history of the patent system mentioned above involves the process of the development of patents, the national and international institutionalization of the patent system, the acceleration of patent-assisted technological innovation during the industrial revolution and the subsequent reformation of the patent system. In the contemporary era of 'globalization' and 'informatization' the negative effects of patent technology have come more strongly in to view. This has created some challenges for the patent technology. The future patent system must protect not only the interests of artists and inventors but also the interests of the users of the inventions.

4. Logistics Technology

Logistic technology functions as the technology that supplies the necessary material, conditions and services to maintain a normal and efficient working environment for an organization. Logistics technology came about as a consequence of dealing with the challenges of fighting wars. Originally, the term 'logistics' was an abbreviation for the term 'logistic service in the rear' that was used by the army.

The early application of logistic theory and technology was evident in *Master Sun's Art of War*, written by Sunzi in 520 B.C.[21] Contents of military logistic theories could also be seen in *The Epic of Homer* and the West's earliest military work *The Anabasis.* Fixed logistic organizations were included among the troops of some European and American armies during the eighteenth .[22]

Most people knew almost nothing about logistic activities before World War II and few enterprises established logistics organizations. Towards the end of World War II American military departments, which at that stage were grappling with the challenges of guaranteeing ammunitions supplies for the war, developed formal plans using operations research and computer technology to organize expenses, purchases, transportation routes, weapons and storage. The resulting system for providing and maintaining military supplies came to be called 'logistics'. The demands of war furthered the development of military logistics technology. Logistics technology played an important role in both the European and Pacific battlefields.

As a result of the intensified competition of the world economy after the war, the West's large enterprises began applying military logistic theories and approaches to their production and management departments, thus reducing their logistics costs. However, enterprise logistics of that time emphasized mainly cost control of transportation and storage functions.

From 1960 to 1970 Professors Howard T. Lewis, James W. Culliton and Jack D. Steele of Harvard University introduced the concept of total costs to business-oriented logistics, thereby leading to the formal establishment of enterprise logistics as a field.

The period of 1970 to 1980 is generally considered to be the period in which enterprise logistics was formally institutionalized. Owing to the energy crisis and to hyperinflation in the American debt market, corporate revenues decreased greatly and economic competition was intensified, making it more difficult for companies to manage their businesses. These circumstances placed even more demands for results related to enterprise logistics functions. Thus, the standardization of logistics service and management for various organizations was promoted.[23]

The contents and requirements of technology, including logistics technology, change over time. Accordingly, at this juncture in business history the enterprise logistic systems appropriate to e-commerce differ greatly from those pertinent to the age of industrialization. As a consequence, the need for innovation in logistics technology is back on the agenda.

5. Advertising Technology

Advertising is a technique used to promote or publicize certain products, services and viewpoints and for catching the public's attention and tempting consumers into making some kind of response to the advertiser.[24] The term 'advertisement' comes from the Latin word *advertere*, meaning attention and temptation.

For a long time advertising has existed as a tool for spreading information. Advertisements written on papyrus appeared in Egypt in 1550 B.C. and in the ruins of Thebes in ancient Greece archaeologists have found a letter advertisement dating back 3,000 years. This advertisement offered a pure gold coin as reward for catching an escaped slave.

Among the earliest printed commercial advertisements in China are the steel plates of the Liu Furniture Canteen in Jinan (960-1127 A.D.). These plates are housed in the Shanghai Museum. In the centre of each plate is a painted depiction of a white rabbit pounding medicine in a mortar.

In 1450 Germany's Gutenberg invented the letterpress, making it possible to print numerous verbal advertisements quickly and at a low cost. British printer William

Caxton printed many advertisements on religious books and posted them on London streets, thereby initiating the use of printed advertising in the West.

The first newspaper advertisement appeared in Germany in 1525 and up to the 1800s the British newspaper *The Thames* carried a hundred advertisements every day.[25]

The earliest advertising agency was established in 1610 by two knights, courtesy of James I, the King of England.

Owing to the industrial revolution and batch production, advertising became an important sales technique in the nineteenth century . This period was considered the expansion period of commercial advertising. The first professionally managed advertising company was set up in London in 1812, followed by the first American advertising company, established in Philadelphia in 1841. In 1865 the wholesale advertising agency appeared. Following that it could be said that advertising had become a new industry. In 1868 the first modern advertising company - Ayer & Son - was established. Advertising companies receive commissions from newspapers and other organizations by acting as agents for their advertisements, while simultaneously establishing a clientele of produces wanting to advertise their products.

In the twentieth century broadcasting became a powerful means to occupy and control the market that provided extensive, rapid and betimes service. The United States was first to apply broadcasting to advertising. In 1902 the first licensed broadcasting station - the commercial broadcasting station of the Pittsburgh Westinghouse Electric Company - began broadcasting. Following success in America, broadcasting stations were soon established in other countries. Advertisements were broadcasted in commercial programmes. In 1903 the American psychologist Walter Dill Scott wrote *Advertisement Theories,* in which advertisements were first studied as a discipline of science.[26]

A Frenchman decorated the Paris Basilica with the first 'neon' sign. Neon signs were introduced to America in 1923 and became popular by 1930.[27]

Because television commercial advertisements integrate speech, music and visuals, television has become the ideal way to advertise and television commercial ads have furthered the advancement of advertising technology to a new level of development. The first television station was set up in Britain in 1936. Television stations were set up across America in 1939, and in 1941 commercial broadcasting on television began.

There are over 10,000 advertising companies in America, 3,000 in Japan, 2,500 in

France and 1,600 in Britain.[28] In 1976, 59.5 billion US dollars were used in advertisement throughout the world, 180 billion in 1986 and 291 billion in 1996.[29] The trading volume of advertising reached 10 billion US dollars in Shanghai in 2000.

The history of advertising proves that the integration of and interaction between soft technology and hard technology were key factors in the rapid development of advertising technology. Every new kind of hard technology, such as the letterpress, corporate systems, agent systems, broadcasting technology, neon technology, television technology and the Internet appear, without exception, to promote advertising technology. We can assume that there is still great potential for its future development.

6. Insurance System

Insurance technology is a complicated mechanism the establishment and maintenance of which requires great skill. Since the beginning of time, human beings have continuously been seeking ways to prevent disasters from occurring. Although it is impossible to prevent all catastrophes, human beings have found ways to make up for the losses they have to endure. Insurance is an established system that charges premiums, provides mathematical forecasting for unplanned calamities and transfers these risks from individuals in the form of a contract to an organization in which the members of the organization will fairly share the loss. The mechanism by which the majority will share the loss of the minority is not only an economic institution but also a form of legal regulation.[30]

The earliest form of insurance is the ship mortgage contract that was found in sphenogram[31] documents from the third B.C. It provided the ship owner with a loan that would be repaid if the voyage were safely completed. Later, the shipping mortgage developed into marine insurance. At the end of the Middle Ages, this kind of insurance was spread to the field of land transportation.

On 23 October 1347 Georgius Lecavellum, a Genoese merchant, created the earliest certificate of insurance known to man for the voyage of the Santa Clara ship. Marine loans and loss deposits developed into two exclusive businesses in 1400 and merchants specializing in marine insurance began to appear. Business insurance contracts became common with the rapid development of overseas trade in sixteenth .

The *Barcelona Royal Edict*, the earliest law relevant to insurance, was issued in 1435. Later, the *Venice Royal Edict* appeared. A relatively complete marine insurance regulation act was established in Florence in 1523, along with a standard insurance policy. The establishment of the insurance broker system originated from the insurance law that was enacted by Spanish King Philip II in 1556. British Queen Elizabeth I enacted the first marine insurance law in 1601.[32]

The inventive process of fire insurance added a great deal to soft technology innovation. Owing to a baking oven that overheated, the royal bakery caught fire on 2 September 1666. After spreading throughout London and burning for five days and nights, the fire caused great damage; 13,000 houses were burnt down leaving 200,000 citizens homeless. This fire made people aware of the importance of fire insurance. In 1667 Nicholas Barbon, a dentist, provided funds to establish the first fire insurance company in the world. In 1710 Britain's Charles Povey established the earliest fire insurance joint stock company, the Sun Insurance Corporation.

The development of demographics and statistics marked the beginning of fire and life insurance joint stock companies. The first life insurance company to embody the elements of the modern life insurance system was established in London in 1762.[33] The insurance premium was based on the theory of an average insurance premium determined according to a table of mortality and insured individuals who did not measure up to the policy's standards were charged a different special premium.

During the nineteenth century, insurance technology entered the modern period and the scope of the industry expanded to include property loss, death insurance, survival insurance, liability insurance, credit insurance and reinsurance. Now a complete body of insurance theory and a complete insurance technology system is in place.

According to statistics, there were only 1,200 insurance companies around the world at the beginning of the twentieth century and by 1982 there were 12,000. There were more than a 100,000 insurance companies throughout the world in the 1990s, among which over 500 were in London and over 300 were located in Hong Kong. The total profit of insurance premiums around the world in 1950 was 21 billion US dollars; in 1976 this was 250 billion US dollars and in 1985 it was 630.5 billion US dollars (the USSR, Eastern European countries and China were not included). A new record of 2,000 billion US dollars was set in 1995. Since 1986 the average rate of growth of insurance companies was 4.7% (the actual growth rate after adjusting for inflation and fluctuation in exchange rates), which surpassed the worldwide rate of GNP growth during the same period.[34] American profits from insurance premiums accounted for 47.69% of worldwide insurance profits and for 7.52% of the American GNP in 1985, while Ireland occupied first place in the world for the percentage (9.32%) of its GNP occupied by profits from insurance premiums.[35]

Thus, it is evident that the insurance industry reflects the economy and society of a country. China restored insurance in 1980. Despite the fact that the annual growth rate in total insurance profits has averaged 29% over the past ten years, there are still only 33 insurance companies, employing a total of 170,000 people, in China. In addition, the insurance income of China accounted for 1.63% of its GDP in 1999, while the average world percentage was 7.52 %. According to 'The Tenth Five-year Plan', China's proportion should reach 2.3% by 2005, which is close to the average for undeveloped countries.[36]

The development of insurance technology and its institution suggests that as human beings expand the range of their fields of activity, as complicated social relations increase and as economic intercourse rises, people's worries about risk and security also tend to rise, leading to the rapid development of the insurance industry. Soft technology and many relevant valuable economic and social institutions, have been created and designed as a consequence of such processes. The complete range of human wishes and problems pertaining to social and economic life is a rich source of soft technology.

7. Public Relations Technology

Public relations (PR) refer to the communication, or the extension of good will, of an organization that seeks to draw attention from a public that is already, or probably, interested in the institution.[37]

Modern PR originated in America at the end of the nineteenth century and the beginning of the twentieth century. American attorney Dorman Eaton gave a speech entitled 'Obligations of Public Relations and the Law Occupation' at Yale University in 1882 in which he applied the concept of modern PR for the first time. In addition, the term PR first appeared in 1897 with the publication of America's *The Yearbook of Railway Documents*.

In 1889 George Westinghouse, the owner of American George Westinghouse Electric Appliance Company, employed a reporter from Pittsburgh by the name of E. H. Heinrichs to help keep people from using direct current. This company was the first to use PR.

In 1903 Ivy L. Lee and George Michaels established the first PR consultation office in the world, in New York, and one year later, with George Parker as a new partner, they opened their second PR office in the same city.

In 1908 the official position of PR Manager was established at AT&T. T. N. Vail, an expert in news public relations, was the first holder of the position. AT&T used PR advertisements to promote the image of the company and the need for a full PR department was later established. Later, many other businesses in America followed AT&T's footsteps and established their own PR departments.

Crystallizing Public Opinion, the first PR magazine, appeared in 1923 by founder Edward L. Bernays. Dr Rex F. Harlow, a famous American PR scholar, opened the first PR course, in Stanford University in 1937. The first PR degree, bachelors or masters, was available through Boston University in 1947. In 1948 the PRSA (Public Relations Society of America) was founded, which established the regulations of association and rules for publicists.

PR spread to Britain in 1920 and by 1948 the Public Relations Association of Britain was established in London; since then it has grown considerably. Currently, London's Public Relations Association has more than 2,000 members in over 50 countries and regions and is the biggest professional PR organization in the world. PR spread to Canada in 1940 and by 1947 the first PR association was established there.

After World War II, PR made new progress in theory and practice with the recovery and improvement of the world economic order. Members of the war information office in the United States turned to business after the war and became active PR experts. Thus, PR experts began entering management positions in industry and the PR field became referred to as one of the four pillars of modern enterprise, together with funds, equipment and talents. PR experts participated in building relationships between America and other countries. Furthermore, PR now plays a role in politics and domestic presidential elections.

In 1955 the International Public Relations Association (IPRA) was established in London. More than 60 countries have become active members.[38] In 1965 the participating members, signalling that public relations technology had begun to institutionalize internationally, adopted the Athens Regulations on PR.

PR activities began to appear in the coastal regions of South China in 1982.[39]

According to the statistics provided by the American *Fortune* magazine in 1980, 436 out of the 500 largest enterprises had established special PR organizations. America's PR field contains over 2,000 PR advisors, 20,000 PR managers and 140,000 employees.[40] Over 300 universities in America have added PR courses to their curricula.

Carl Byior and Associates was established in 1930 in New York and is still the largest multinational PR company in the world. In 1997 Byior provided a new definition of PR:[41] 'PR technology is in fact perception management; through managing the public views of things, enterprises and individuals, PR changes the public's behaviours and decisions and is finally gaining acknowledgement.' Many large enterprises established high-level PR positions, such as CPO (Chief Perception Officer), after established CIOs (Chief Information Officers) and CFOs (Chief Financial Officers).

To sum up, PR has evolved into a special discipline and a special technology. It is applicable in many fields, ranging from business enterprise to the political life of a country and from international commercial activities to international political relations. PR technology can be summarized as 'the means and approaches of changing human behaviours through influencing and affecting their psychologies', including sales promotion technology (sales promotion of products, services, people and policies) and lobbying techniques in politics. According to an investigation of the world PR industry in the early 1990s, the business volume of the global PR industry had an average annual growth rate of 20%, while Europe experienced a 35% growth rate and some Asian countries and regions even surpassed growth rates of 100 %. China experienced a growth rate of more than 50%.[42]

8. Modern Management Technology

Management has been treated as a discipline of science and technology since early in the twentieth century. In the early stages of commercial and industrial history, when ownership was not yet separated from management, enterprise management relied mainly on the individual experiences of practising managers. For a long time managers had no sources of formal knowledge to which they could turn for insight; learning took place mainly through informal communication with friends, colleagues and associates in similar or related fields of business.

However, as industrial development and the division of labour became more specific, managerial problems became more complex. Gradually, managers came to realize that managers in quite different industries, such as textiles and railroads, confront many similar issues. Charles Babbage's work on *The Economy of Machinery and Manufactures,* published in 1832, discussed these common issues, paying particular attention to such problems as calculating costs and establishing incentive systems.

General ideas about management, conducive to the formulation of theory, were brought forward and put into practice in the 1850s by some excellent American railroad managers, such as Daniel C. McCallum, Albert Fink and J. Edgar Thomson. American engineers and manufacturers, such as Henry R. Towne, Henry Metcalfe and Frederick A. Halsey, started a movement in the late nineteenth century, now called 'systems management', which initiated the development of modern management technology and laid the foundation for Taylor's approach scientific management.[43] At the end of nineteenth century, with the transition from laissez-faire capitalism to monopolistic capitalism, the scale of industrial activity increased continuously and the capitalist economy entered a new development period, with competition between enterprises intensifying. Therefore, in order to win over both the indigenous and international markets, proprietors needed special technologies and experts to perform management 'scientifically', to improve production efficiency and reduce costs, which gradually brought about the separation of management and ownership. Frederick W. Taylor, the 'Father of Scientific Management', was the first person to consider management consulting to be a social occupation. Although Taylor continued to be an outstanding inventor (he possessed more than 40 patents), in 1890 he also established an independent consulting business under the rubric of 'an engineer of efficiency'. He thus became the founder of the management consulting industry. Taylor contributed much to the idea that management development is a special discipline of science and technology. In 1911 Taylor published *Principles of Scientific Management,*[44] which marked a milestone in the history of management theory and practice.

The development of business education played an important role in the systematic development and diffusion of management technology. In 1881 the University of Pennsylvania attempted to initiate business education in America. In 1898 the University of Chicago and the University of California both created colleges of business. In 1908 Harvard University established a graduate programme in business, heralding the formal entry into universities of management as a discipline.

The twentieth century was an age in which management giants came forward in large numbers with plenty of innovation in managerial practice and management theory.

Henry Ford incorporated Taylor's scientific management principles into his factories and designed a production line for mass production in 1910, thereby influencing mass production in industry for the entire twentieth century. Not inconsequential for his time, Ford turned out one million cars by 1915.

However, neither Taylor nor Ford attached much importance to the organizational problem. In the 1920s, A.P. Sloan came up with the concept of 'Division Management in Organization Research'. This concept greatly influenced the organizational innovations of large enterprises. American companies, such as Dupont and GM, accordingly adopted this organizational mechanism to fulfil the demands of business diversification and cross-regional management of their products. The mechanism of division management was extensively applied throughout the world by the 1960s.

Harvard University applied the well-known 'Hawthorne Effect' to one factory belonging to Westinghouse Electronic in the middle of the 1920s. This application provided theories on respecting interpersonal relations and human emotions and attaching importance to informal organizational functions.

Marketing development also emerged during the 1920s. Since the second industrial revolution, enterprises generally emphasized production and finance. The distribution of commodities was left to wholesalers. After World War I, American enterprises turned increasingly to their domestic markets and gradually began acquiring market shares and controlling the markets that they served. With respect to competitive strategy, after learning the lessons of focusing on pure price competition, enterprises began to pursue other systematic approaches centring on non-price competition. For instance, they began to use packages, advertisements and trademarks as weapons for controlling the market.

The early twentieth century signalled the beginning of marketing as a field. In 1910 R.S. Butler first introduced the term 'marketing'. In 1912 A.W. Shaw explained his marketing theory for the first time in *Some Problems in Market Distribution*. Following the end of World War I and the reduction of overseas demand for American products in the 1920s, the US government became actively engaged in the promotion of industrial efficiency, the application of standardized products and the mass production system. However, enterprises subsequently had to face serious business challenges, such as how to develop markets and how to promote the products they were now mass-producing. Consequently, the 1920s were years of high-pressure marketing.

This high-pressure marketing period suddenly downshifted in 1929, when the world economic depression occurred. In order to sustain market share, enterprises performed promotional activities, such as market research focusing on the attitudes of consumers. They also emphasized customer service, thereby promoting the notion that 'consumers are God'. The 1930s was the beginning of the downshifted, low-pressure marketing period (Robert Bartels, Robert Keith and Robert L. King are the source of this review of the history the marketing development divided into the above phases).[45] After World War II, competition between enterprises focused on technology innovations and new products. The priority for competitors was comprehensive market management under an overall strategic framework. This, in turn, promoted the use of the marketing agent.

Modern management reached another milestone in the 1950s. Around that time American troops introduced many 'business and management technologies of American style' into Japan. [46] In addition, quality management theories initiated and developed by American land forces during World War II evolved further in Japan as Japanese managers applied these theories, together with W. E. Deming's theories, during the 1950s. Later, these theories became the basis for the distinctive characteristics of Japanese's enterprise management. During the 1950s the Management Science Association (1953) was established and the journal *Management Science* began publication in America, Maslow Abraham published his *On Stages of Demands* (1954) and Douglas McGregor proclaimed his X and Y theories, which provided the theoretical foundation for respecting people and paying attention to interpersonal relationships in enterprise management.

In the 1950s America began applying 'strategy', originally a military term, to enterprise management. During the 1960s, a number of relatively mature publications on the theory and practice of managerial strategy appeared one after the other. These included . *Strategy and structure* by Chandler Alfred in 1962, *The Creative Manager* by Peter Drucker in 1964, *Corporate Strategy* by Igor Ansoff in 1965 and *Top Management Planning* by Steiner in 1969.[47]

In the 1970s the quality of enterprise leaders and how they functioned as managers became important issues in management theory. In particular, great emphasis was placed on the essential issue of helping enterprises improve management levels and succeed. Henry Mintzberg's path-finding book, *The Nature of Managerial Work* (published in 1973), is an example of a highly influential piece in this genre.

The 1980s was an era of total quality control. The 'economic miracle' that Japan achieved during the 30 years after World War II and the many Japanese products that occupied the international market shocked the developed countries, especially the United States. Before Japan's economic breakthrough, American enterprise had created the microelectronic industry and all the scientific and technological resources that had assisted in the development of this industry, such as the transistor, the semiconductor chip and large and small computers, were invented in America. But Japan's companies drove the large American enterprises and companies that had previously controlled this industry out of the market. America's Xerox Company invented modern duplicators but Japanese counterparts conquered this market in 1979.

The history of the consumer electronics industry involves a continuous retreat of American companies from the market. For example, in 1955, 95% of all radios sold in America were American-made but in 1975 there were no American-made radios sold in America. At its peak the total amount of sales of the American TV industry equalled six billion US dollars and this amount accounted for 22% of the entire consumer electronic products market. However, in 1987 there was only one American TV manufacturer (Zenith), whose sales accounted for 15% of the total sales in the TV market. Video recorders made in Japan defeated the original American patent holders. The mass production of automobiles was invented in America but European and Japanese manufacturers eventually mesmerized American consumers with their high-grade and low-price automobiles, frustrating their American counterparts. This experience proved that even the best product concepts, technologies and patents might not be translated into commercial success if companies are not managed well.

In 1980 a programme called *It Worked in Japan, Why it Did Not Work Here with Us?* was broadcast on America's NBC television network. This stimulated a new wave of research and inquiry into the nature of Japanese management theories and managerial practices. In the meanwhile, *TQC* by Deming was publicized around the world.

Rapid development of the technology of 'competitive advantage' occurred during the 1970s and 1980s. Typical of that period were publications such as Michael Porter's *Competitive Strategy: Techniques for Analyzing Industries and Competitors, Competitive Advantage: Creating and Sustaining Superior Performance* and *The Competitive Advantage of Nations*.[48] In addition, business philosophy and enterprise cultural theory fully evolved during this period. Many successful enterprises committed themselves to forming common values inside their companies and strengthened their competitiveness by encouraging the enthusiasm and creativity of their employees.

In the 1990s, the established management mode and management theories faced serious challenges with the new application of information technology and economic globalization. Enterprises put forward various new management concepts and technologies in an attempt to adjust to the new management context of the twenty-first century. In 1993 typical works, such as *Reengineering the Corporation* by James Champy and Michael Hammer and *Fifth Generation Management: Integrating Enterprises through Human Networking* by Charles M. Savage were produced.[49]

Tremendous progress in science and technology was made in the twentieth century. A large number of achievements and inventions from the past several hundred years were applied to industry only in that century. The reason why they were not applied earlier may be attributed to the emergence in the twentieth century of what I call 'management technology'. The Japanese scholar Kishimoto Yoshituki encapsulated the significance of management technology during the last hundred years of innovation by calling the twentieth century the 'Management Century'.[50]

In the twentieth century much of the attention in management focused on human creativity. Some management theorists advocated that management should shift from 'substance-centred' management (which is treats people as 'economic beings') to 'human-centred' management (which treats people as 'social beings') and towards 'ability-centred' management (which treats people as 'able humans'). This theoretical perspective requires that emphasis should be placed on how to create a proper environment and how to train and develop human intelligence and creativity.

9. Stocks and Securities Technology

Stock technology is a form of economic organization in which various people pool their funds by purchasing shares in a business as a whole, becoming entitled to dividends or bonuses according to the proportion of shares they hold. The stock system in enterprise only emerges when the economy has developed to an appropriate level. Its historical development has been long and gradual.

The stock system and its organizational form came from a European company during the Middle Ages. At the beginning of the twelfth century there were many enterprises owned by a single investor or partnership enterprises.

During the sixteenth and seventeenth centuries the growth of large-scale industrialized production created the need for a great deal of investment capital in order to purchase the large quantity of machines and equipment required but the funds available from family, friends and relatives were far from sufficient. Under these circumstances, stock technology was invented to extend the range of sources in society from where investment funds could be raised and the stock enterprise mechanism was established to systematically manage the funds of many shareholders.

Britain established the first joint-stock company in 1553. It was a chartered overseas trade company and its shareholders were all aristocrats, landlords, dukes, high ministers, merchants and churches. The first genuine British stock company, the Turkey Company, was an overseas trading company established in 1581. Two hundred and forty-two people bought shares in this company and it raised its capital by floating shares in the form of open stock.[51] Another stock company, the East India Company (at that time it sold special local products purchased in the Orient to the countries of Europe), was established in Holland in 1602.[52] Later, stock companies began developing rapidly in the banking, transportation, mineral, public services and manufacturing industries. At the end of eighteenth century, stock companies replaced almost all the partnership enterprises and enterprises owned by single investors.

In the late nineteenth century traditional industries in Britain slowed down, while those in Germany and America accelerated. At that time, the events that promoted the industrial change in the German and American economies stemmed from the shift from competition between the small internally-financed enterprises towards cooperation in establishing large-scale stock companies. These eventually developed into the gigantic monopolies that were the hallmark of the early years of the new century. What was so fascinating about this age was that most chemistry and electronic industries were supported by scientists, while many strong industrialists were involved in the metal and machine industry. Kelvin, Edison, Simons Brothers and Brunel all shifted away from being primarily scientists towards being industrialists. By using the stock market, large-scale enterprises raised a large amount of funds required for their development. Sufficient funds promoted the extensive application of science and technology, including combustion engine technology and transportation technology that had stimulated the transportation revolution. Another feature of this period was the extensive application of science and technology to war: submarines, torpedoes, high quality explosives, canons and the mechanization of war further promoted the development of technology.[53]

At the beginning of the twentieth century stock companies contained one-fourth to one-third of the national wealth of Britain, America, Germany and France, thus occupying the prevailing position in the economies of these countries.[54] By the 1980s stock companies played an even more important role in the market. For example, there were 2,710,000 stock companies in America, representing 16% of all the enterprises but their assets made up 85% of the total; sales made up 89% and 80% of net income came from such companies. At present, 18.5% of all American companies are stock companies, accounting for 90% of the total sales.[55] In Japan 53.5% of ordinary corporations are stock companies but almost all of those enterprises with capital funds greater than one hundred million yen were stock companies in 1984.[56]

The invention and skilful design of securities technology provided an excellent resource for the development and application of stock technology. In fact, stocks are just one type of security. Securities technology is the most successful 'technology' in raising, using, appreciating and managing property. Securities are legally 'pieces of paper recording rights and obligations of property' and can be divided into evidence securities that are simply used to prove a certain fact and negotiable securities that are used to explain the conditions for the transfer of rights and obligations. From the point of view of rights and obligations, negotiable securities can be further divided into commodity securities, monetary securities and capital securities.[57] Fund-raisers issue capital securities in order to raise funds from providers based upon equal conditioning. On one hand, small sums of money that are held by individuals in society can be gathered together through the issue of securities to ensure the larger amount of funds the raiser needs for a certain purpose. On the other hand, from the perspective of providers, they can expect to receive a relevant reward after purchasing the securities with money that is temporarily left unused for various reasons but is gathered by the raiser for something significant. Capital securities can be divided, according to the nature of their

Table 5: Global top securities exchanges and their establishment year[58]

income, into bonds and stocks. Stocks are a means of raising capital to fund the development of enterprises; hence, they are a type of revenue security and they also provide various rights for the shareholders.

With the prosperity of stock companies, stock merchants in Amsterdam established a stock exchange in 1613. In 1657 a relatively well-organized and stable stock exchange appeared in Britain.[59] The securities market was extensively developed in industrial countries and regions by the end of nineteenth century. The establishing years of the top ten securities markets in the world today are shown in table 5. At present the securities market can be divided into several markets, such as bonds, stocks, issues, circulation, exchange and over-the-counter markets.

The securities market became increasingly important to the capital market in the twentieth century. In order to minimize risks in the securities market, listing standards became much stricter, which made it almost impossible for small enterprises, especially small scientific companies with relatively great risks, to list their stocks. For the purpose of establishing capital markets to support SMEs (small and medium-sized enterprises), high-tech companies and other relatively risky enterprises, many countries around the world began to establish a 'second market' for high-risk securities. In 1971 a brand-new stock market - Nasdaq - was established in the United States. The Nasdaq was an innovation in both financing techniques and operational mechanisms for venture capital. These innovations created the conditions for small enterprises to list their stocks. Since 1992 the funds requirements for listing enterprises has been reduced and the condition that the listed enterprises must make profits for three consecutive years has also been repealed. These innovations in the securities markets not only lowered the requirement of listing but also initiated the competitive system of the market maker. It is evident that stock market innovations provided SMEs, especially high-tech enterprises, with a quite favourable environment for raising capital. Each country with a formalized securities market has customized its design to take into account the special circumstances of the domestic economy.

By the end of 1999, 4,829 companies had been listed on Nasdaq, among which there were almost 2,000 science and technology companies and Internet enterprises. Today, this kind of market has developed greatly in 12 European countries (1996) and also in Japan (1991). Modelled on Nasdaq, securities markets in the service of small-size scientific enterprises were established in Asian's newly rising countries and regions, such as Singapore (1987), Malaysia (1997), South Korea (1996), Thailand (1999) and Taiwan (1994).[60] Hong Kong established a second market in November 1999 but the listing regulations were changed in 2001 to embody much tougher standards. The innovative points are as follows: the listing difficulties for SMEs have been lessened through attaching importance to the listed enterprises' future (rather than its past record), reducing listing standards, advancing the market broker in the stock market, reducing business costs and improving efficiency and transparency by the application of e-commerce. Today, 260,000 terminals have been established in 55 countries and regions and Nasdaq has become an incubator for start-up enterprises.

With the development of the securities market, various crimes centred on the stock exchange have emerged, which has required a new wave of innovations for the securities market institutions. China, for example, is now developing securities technology. This is a great attempt at institutional innovation and such efforts are far from perfect, especially when listed companies violate laws and regulations. This has prompted the Chinese Securities Control Committee to set up an investigation bureau for securities crimes.

The above analysis demonstrates that the technology of stocks and the securities market play indispensable roles in the production, commercialization and industrialization of hard technology. Meanwhile, just as is the case with other technologies, securities technologies also need constant innovation.

10. Merger and Purchasing Technology

The enterprise merger is another type of organizational technology. One enterprise buys the property of another (acquisition) or combines with other enterprises under single ownership (merger) to seek common development. The stimulus of this merger may be to strengthen market control ability, extend technological scale economies or economic scale economies, reduce business costs or disperse risks. All of these purposes centre on the larger goal of intensifying competitive power. The enterprise merger, an example of annexation, is a method of external growth for enterprises. Annexation includes mergers, acquisitions, consolidations, amalgamations and takeovers.

In order to understand the function of merger technology and to analyse the relationship between soft technology and institutional innovation through the example of annexation-technology history, let us analyse the four annexation waves in American industry.[61]

The first merger wave in the United States occurred during 1898 and 1902. After the civil war, owing to the establishment of the railroad system and the introduction of new production technologies, the general trend amongst American enterprises was to shift their focus from serving local and regional markets towards serving the national market. Those enterprises with the production capability to meet the demands of the entire nation, especially enterprises in the petroleum, tobacco and steel industries, avoided competition, improved efficiency and enjoyed monopoly profits through horizontal mergers. For instance, the American Standard Oil company, whose petroleum production made up 90% of the production for the entire country in 1878, became an exceptionally large monopoly group whose petroleum production made up 2/5 of the entire world in 1880 through mergers with other enterprises in the same industry. However, there were some consequences of market power that brought the giant monopolies, such as Standard Oil, under intense public scrutiny; and in an effort to regulate the behaviours of these monopolies, the US government promulgated new laws to curb what was seen as the extreme power of the corporations. The new laws, passed in 1914, were known as the Antitrust Act, reflecting the fact that the Trust was the preferred legal form of organization adopted by the monopolies.

The second merger wave took place between 1925 and 1929. By then the horizontal merger had become greatly restricted owing to various anti-monopoly laws. However, managers and owners increasingly discovered the value of vertical mergers as a vehicle to enlarge the scale of their enterprises and vertical mergers became widespread. In 1929, before the world economic depression, stock investments and the second merger movement became popular in American business. The primary purpose of this merger wave was to expand markets and to reduce costs through the creation of monopoly markets and through internal economies of scope and scale. Once again, the US government felt the need to curb what was perceived as the excessive power of this new kind of giant enterprise through the imposition of new regulations. As a consequence, in 1933 Congress passed a set of laws, the Stock Act, forcing companies to become far more transparent to public scrutiny about their financial affairs. These regulations were reinforced further in 1934 by the passing of the Stock Exchange Act.

From 1966 to 1968, the third merger wave reached its peak against a background of economic prosperity and continuing enthusiasm for investment in the stock market. In order to get around the strictures of the Antitrust Act, companies found new forms of merger pathways through which they could grow. The new approach involved creating business conglomerates through the merger of large multi-plant corporations aiming to expand the market or diversify business through large mergers with companies that may not have been related to the core enterprise's business, horizontally or vertically. At that time there were a number of loopholes in corporate law, particularly in the area of corporate taxation, that were exploited by companies as they pursued stock exchanges through non-taxation mergers. Under this kind of acquisition strategy, many companies also engaged in highly dubious financial tricks, involving large and complicated merger patterns, often designed to hide tax liabilities and other financial obligations. This wave of corporate behaviour led to the US Congress passing the Williams Bill in 1968 and to new taxation reforms in 1969.

The merger fever that appeared from the middle of the 1970s to the 1980s could be considered the fourth merger tide. Though the number of the companies merging was small compared to the previous wave, most of them were very large in scale, exerting a great influence upon the industries involved. Some commentators called the mergers of this period 'Mega-mergers'.

In the decade leading up to the 1990s, the distinguishing feature of enterprise mergers was the rapid increase in transnational mergers. The techniques of merger and acquisition had existed in the developed countries of the West since the beginning of the nineteenth century but as vehicles for extending domestic enterprises, the transnational merger as a business mode did not fully emerge until World War II, along with the increase of direct transnational investment. The transnational merger and acquisition process began to rise in 1993 after being at low ebb during the period of 1991 to 1992. Up to 1995, the trade volume of the world transnational acquisition and merger reached 229.3 billion US dollars, which was twice as much as that of 1988; it was 334 billion US dollars in 1997, which increased 45% from 1996 and accounted for 58% of the world's direct foreign investment;[62] in 1998, it reached 604.6 billion US dollars. From above we can see that the transnational merger technique is not only a force that has promoted the development of the world economy and increased direct foreign investment but it is also an important symbol of economic globalization.

The fever of international enterprise annexation and acquisition has not yet cooled down and shows no sign of doing so. It is reported that the worldwide volume of trade for which companies involved in international acquisitions and mergers are responsible has now reached a total of 3,300 billion US dollars (among which the transnational purchase and annexation amount totalled 862.7 billion US dollars). This is far more than the equivalent amount of 2,600 billion US dollars in 1998, which exceeded the total amount for the six years from 1990 to 1995. The amount for the telecommunications industry, 561 billion US dollars, was the highest and the banking industry was second, with 297 billion US dollars. With 45 exchanges totalling 13 billion US dollars, Microsoft was responsible for the largest number of trades. Intel came in second with 35 exchanges totalling five billion US dollars.[63]

Within a hundred years, the merger technique has developed from that of the horizontal merger and then the vertical merger, through a series of new forms, including downstream combinations, upstream combinations and the mixed mergers of the conglomerates and finally to the transnational merger. Mergers can take place between alliance partners and also between competitors including both cooperative annexations, as well as annexations with competitors. The history of the enterprise merger indicates that the wise use of the merger technique can be a favourable means of improving competitiveness. The development of the merger technique has also promoted institutional innovations relevant to enterprise competitiveness, such as the Antitrust Act, the Securities Exchange Act and various taxation laws. One important lesson that may be garnered from the history of the corporate merger (as an example of soft technology) is that institutional innovation must keep pace with the application and development of new soft technology.

11. Risk Investment Technology

'Risk investments' refers to investments projects which may have high risks by normal business standards but which are likely to yield high profits or high business growth rates sufficiently large to offset the high risk. These investments are sometimes also known as 'venture investments' or simply as 'ventures'.

The earliest investment company known to have been created specifically for risk investments (i.e. a proto venture capital company), ICFC, was founded in Britain in 1945. The American Research and Development Corporation (ARD), founded in the USA in 1946, was the first formalized risk investment company engaged in public exchange and managed by a financier.

In 1946 J. H. Whitey founded the first private risk investment company, with a starting capital of 10,000 US dollars, inventing the new term 'venture capital'. In addition, Whitey was the first one to make a risk investment by way of stock sharing.

In 1952 Canada's first venture capital company was established. In 1958 the US Congress promulgated the Small-size Enterprises Investment Act. Many investment companies devoted to small enterprises emerged in the wake of the creation of this Act and became the main source of venture capital for American firms at that time.

The Draper & Johnson Investment Co., founded in 1962, pioneered the administrative mode of the venture capital fund that is still widely used today.

In 1973 the National Venture Capital Association (NVCA) was founded, indicating that the venture capital industry had become a new American industry in its own right.[64] In 1983, 40 European venture capital foundations were set up, including the European Venture Capital Association (EVCA).

The level of development of a country's venture capital industry is a reflection of the level and prospect of its high-tech and related industries. For example, although the British venture capital industry started very early, it developed at a slow pace. It did not improve until the 1980s after the British government adopted a series of policies and measures - such as tax privileges, a loan guarantee programme and an enterprise expansion programme - that encouraged the use of venture capital. According to the BVCA statistics, British venture capital totalled 0.8 billion pounds in 1979 and nearly 2.5 billion pounds in 1995, which was 0.4% of the British GNP.[65]

America, with the highest rate of development of high technology and the strongest technological competitive power in the world, is also home to the premier venture capital industry. The first peak in the history of American venture capital appeared in the 1950s and 1960s. According to the *American Venture Capital* magazine, more than 13,000 high-tech companies supported by venture capital were established from 1970 to 1979. The 1980s trends in the venture capital industry were stimulated by the tax reform system and by the rapid development of high-tech companies; this increased the amount of venture capital invested from 1.4 billion US dollars in 1975 to 11.5 billion US dollars in 1985 and 40 billion US dollars in 1995. By 1998 there were nearly 2,000 venture capital funds in America, totalling more than 60 billion US dollars in investments. Venture capital supports about 10,000 high-tech projects every year and about 80% of high-tech companies in America have developed with the help of venture capital.[66]

Since the beginning of the 1990s, the venture capital industry has progressed impressively throughout the world. According to an OECD estimate, the total amount of venture capital sum invested worldwide in 1996 reached 100 billion US dollars. Countries such as France, Germany, Australia, India and Israel all initiated formal programmes and policies aimed at promoting the development of the risk investment industry. In order to encourage venture capital, the French government instituted a number of loose taxation policies and corporate institutions. For example, founders were allowed to keep their preferential shares for up to 15 years after the new company was established (prior to that the limit was only seven years). The French government also introduced a number of improvements to the securities system that required greater transparency in arrangements for preference shares, together with a requirement that 5% of the stocks invested by life insurance companies must take the form of venture capital. In Germany, venture capitalists investing in high-tech companies received tax exemptions on shareholder gains since April 1997; in addition, two high-tech enterprise stock exchange markets - Frankfurt Neuermarket and EASDAQ - were established. The larger, established German technology-oriented enterprises, such as Siemens, Deutsch Telecom and Daimler-Benz, also all became involved in the high-tech venture capital industry.[67]

Venture capital technology (i.e. the technology of venture capital, as opposed to the technologies into which venture capital is often invested) is undergoing continuous innovation, in both theory and practice. For example, as venture capital investment techniques have begun to mature, a series of theories and conventions about raising venture capital, arranging investment systems, establishing operating mechanisms and administrating venture capital companies and support systems have taken shape. Most countries have now worked out laws, regulations, financing systems (including the stock market), policies and corporate institutions relevant to venture capital. However, the concept of venture capital has changed. It now covers now all stock rights and financing activities aimed at private stock-holding companies. Meanwhile, many new trends have appeared during the development of venture capital. These include the globalization of venture capital, annexations and acquisitions among the venture capital companies, the increasing involvement of securities in entry and exit mechanisms of venture capital, the increased public regulation of venture capital management and an increase in the diversity of sources for venture capital.

12. Physical Distribution Technology

At its core the history of physical distribution technology is as long as human history itself. Physical distribution technology developed along with the birth and development of human civilization. As far back as the appearance of the circulation of commodities, the movement of labour tools from one place to another by the human body is a nascent form of what we now call physical distribution. With the arrival of commodity production, however, consumption activities and production activities gradually separated from each other. This created the need for linking production and consumption and the need to develop physical distribution techniques that involved managing the interspaces between commercial exchange activities and the activities of transporting goods.

As we mentioned earlier, in the late eighteenth century Britain had established an international distribution and circulation network that linked producer markets and consumer markets into an organic whole. These developments made an indelible contribution to Britain becoming the centre of the first industrial revolution. Yet it was not until the publication in 1912 of A. W. Shaw's book, *Some Problems in Market Distribution*, that the term 'physical distribution' appeared formally for the first time. Shaw stated, 'Goods and materials will have additional value due to their transfer through time or space.' Here I am using the term 'physical distribution' to refer to what Shaw described as the transfer through time and space of goods and materials.

In 1918, during the First World War, the Instant Delivery Co. Ltd. was founded in Britain, the purpose of which was to deliver goods to retailers, wholesalers and consumers in a timely fashion.

In 1935 the American Marketing Association established the earliest definition of physical distribution as the service activities that take place as goods and materials circulate between the place of production and the place of consumption.

In 1964 Japanese organizations began using the formal concept of physical distribution. In the *Physical Distribution Handbook* compiled by the Japanese Comprehensive Institute, physical distribution referred to 'the physical movement of materials from providers to demanders and the economic activity of the creation of time value and place value. Physical distribution includes such activities as packing, loading and unloading, storage, stock management, circulation processing, transportation and distribution according to a plan.'[68]

In China, the term 'physical distribution' began to be used when the Chinese Material Workers Delegation went to Japan to attend the third international physical distribution conference in 1979.

Today, physical distribution has developed into a discipline of science and technology. The concept of physical distribution, apart from the fact that it begins once the products leave the factory, includes a series of such activities that occur in the physical circulation process, such as the purchase of raw materials, processing and manufacturing, sales of products, post-servicing and recycling. Owing to the great profits produced by reasonable physical distribution, the physical distribution field has been praised as 'the third profit source' after natural resources, such as raw material, fuel and human resources. Physical distribution is predicted by some commentators to become the largest industry in the twenty-first century because of the increasing difficulties of extracting profits from the other two sources.

Time-honoured physical distribution technologies are being transformed thanks to the widening of commercial opportunities created by the rise of e-business. For instance, great changes have taken place in the American physical distribution trade in recent years, e.g. e-commerce (the physical distribution in e-commerce trade now has a turnover of more than eight billion US dollars), software integration of supply chains and third party physical distribution (as intermediate markets) have rapidly developed. The level of development of physical distribution systems will become a fundamental determinant of commercial advancement in every country or region. Now that China has entered the World Trade Organization, its physical distribution capabilities are rapidly becoming a key factor affecting the competitiveness of its enterprises involved in transnational physical distribution activity.

13. Virtual Technology

The term 'virtual' is derived from the notions of the virtual machine and the virtual address that are widely used in the field of computing. The concept of 'virtual' was not applied to the production and organization of enterprises until 1988 when Englishman David J. Skyrme described the necessity of 'virtual working' in modern societies. [69]

In 1991 Dr. K. Preiss, Steven Goldman and Roger Nagel produced a report entitled, *21st* Century Manufacturing Enterprise Study: An Industry-led View, in which the concept of the virtual organization was proposed. The 1992 monograph by William Davidow and Michael Malone, entitled *The Virtual Corporation,* further enriched our understanding of virtual corporations. In their March 1994 essay, *Welcome to the Virtual Corporation Era,* the same authors discussed the development of virtual technology in the following terms: 'a mere theory on a piece of scrap paper three years ago, has now become a common phrase in the daily business life ... corporations ... are joining together and forming meta-enterprises and manufacturers, suppliers, distributors and even customers are linking together in an enduring relationship built on mutual trust ... The virtual revolution is the defining business transformation of our generation.'[70]

Virtual technology is, in fact, an organizational technology; and the development and application of virtual technology has paved the way for optimizing combinations of resources by corporations. Virtual cooperation is a kind of technology that breaks the boundaries of traditional enterprises and makes use of the external resources of the enterprise and even resources abroad. By virtualizing the functions or resources that it does not possess, or in which it has few advantages, a corporation is able to generate additional competitive advantage for itself. Virtualization may be a vehicle for liberating enterprises from the pressures of becoming too large and it may empower small enterprises to compete more effectively with large enterprises by making available to them the resources and capabilities of others. It may be wise for small and medium-sized enterprises, with weak R&D capabilities, to take advantage of virtual research institutes, virtual manufacturing systems and global manufacturing networks.

Virtual technology is now one of the most extensively and successfully used organizational technologies. The rapid development of information technology and the trend towards economic globalization both presage a bright future for virtual technology. For example, virtual enterprises, virtual research institutes,[71] virtual banks, virtual offices, virtual stores, virtual manufacturing systems, virtual purchasing, virtual universities and virtual scientific parks, etc. are just some of the possibilities. The essay 'Organization Innovation and Virtual Institute', included later in this book, will further enrich our understanding of virtual technology.

14. Incubator Technology

Incubator technology emerged through the process of providing systematic support services for the early stages of the development of small and medium-sized enterprises. The original meaning of business incubation derives from the analogy of a bird brooding - or incubating - its eggs. Incubator technology can provide new companies with the appropriate knowledge needed to improve their chances of survival.

The vigorous support of incubator technology symbolizes the commitment of a country towards enhancing its prosperity and the development of its economy. This is because promoting the growth of small and medium-sized enterprises is an important means of maintaining the vitality and innovative ability of any county and of adjusting its economic structure. If the incubators are successful, they facilitate the creation of high-value added business activities and knowledge-intensive enterprises that play a key role in leading the transformation of the economy to meet the conditions of the information age.

An American, Joseph Mancuso, first conceived the concept of the enterprise incubator. He also founded the first incubator - the Batavia Industrial Center (BIC) - in Batavia, New York in 1956. By 1995 a total of 750 incubators, exhibiting different ownership structures (government, academic institutes, private and joint state-private ownership), different management goals and different configurations of services, were operating in the United States. The incubator has been popularized in 42 states in America and the content of services include office space, office services, commercial planning, assistance with raising money, training and education, employment and administrative support. The National Business Incubator Association (NBIA) was founded in the United States and the members include the owners and administrators of incubators, incubator founders, economic development experts, elected officials, real estate developers, venture capitalists and investors and enterprise consultants, among others.[72]

Besides helping draft the business plan and providing advice on commercial strategies, most incubators also help businesses with their finances and assist in selecting outside experts, because obtaining appropriate talent and funding are fundamentally important when starting up a company.

Through abundant research and practice, America's Laura Akilcrease of Triton Ventures divided incubators into five groups: open-type commercialized incubators, company-style incubators, private-type incubators, risk investment incubators and virtual incubators.[73] Some other commentators have classified incubators according to other criteria, such as their business domains and the degree of support provided to incubator tenants.

Today, incubator technology has spread from incubator enterprises to incubator entrepreneurs and from incubator professionalism to incubator globalization. About one thousand incubators have been established all over the world. In 1987 the first Chinese incubator was established at the Wu Han East Lake Founder Centre. By the end of the year 2000, 110 incubators existed in China, with 1,785 enterprises incubated and more than 5,000 enterprises in the process of becoming incubated.

15. A Brief Summary

This section ends with an attempt to summarize concisely the history of our commercial technology.

The first period in the commercial technology development lasted until the end of the eighteenth century. During this period such commercial technologies as accounting technology, banking technology, stock technology, logistic technology, physical distribution technology and patent technology had been developed and it was these technologies that facilitated the birth of the first industrial revolution.

The second period in the development of commercial technology occurred at the end of the nineteenth century and the beginning of the twentieth. This was the period of the institutionalization phase of commercial technology. It was also the period in which the reformation of patent technology, R&D institutes, scientific management methods, mass production technology, securities market popularization, monopoly concerns, horizontal annexation techniques and the Antitrust regulations developed.

The third period in commercial technology development took place in the 1950s and 1960s. During this period venture capital, modern management accounting, various management technologies, social technology and mega-merger techniques, among others, were developed. In addition, a variety of remarkable institutional innovations came into effect in a large number of countries during this period.

As the world entered the information era, in 1980s and 1990s, the scope of markets surpassed traditional limitations of time and space, current transaction modes were transformed and commercial technology began experiencing its fourth climax. This period was an age of overall innovation of soft technology. The emergence of global management, total quality management, innovations in the stock market, transnational mergers, virtual organizational technology, e-business, incubator technology and modern physical distribution technology, etc. helped promote the third industrial revolution at the end of twentieth century, as well as facilitate the age of the intellectual service economy (see table 2.)

B. A Retrospective of Social Technology Development in the Twentieth Century

1. Research about Relevant Social Problems in Industrial Countries

After World War II the economies of western capitalist countries rapidly progressed. However, together with material abundance, various social problems became more prevalent and even overwhelming. Take the United States as an example. Since the end of the 1960s American society has been plagued by problems, such as inflation, unemployment and the social effects of pollution. A variety of experiments in social policy have emerged in an attempt to address these and other social problems.

For a long time, American science and technology has been conducted in the traditional government-dominated mode. For instance, a number of projects have been implemented by the US government as national plans, with the simultaneous goals of pursuing general American social ideals and building up the national reputation. Examples include the TVA (Tennessee Valley Authority) Plan in the 1930s, the Manhattan Project in the 1940s, the Defensive Weapon Development Plan in the 1950s and the Apollo Plan in the 1960s. The achievements of these plans did have significant influences on industry, provided many employment opportunities and promoted the progress of America's basic science and engineering.

However, many people observed that the efficiency with which the great technological achievements of the public sector were transferred to civilian applications was low. In particular, the 'systems technology' developed by the Apollo Plan, which lasted from May 1961 to July 1969 and which cost the American taxpayers 24 billion US dollars, did not achieve the expected results vis-à-vis transfer to civilian enterprises. This caused many people to seriously rethink their previous opinions regarding the purported 'trickle-down' effects of the enormously expensive military and space technology programmes; rather, it was felt that in the new economic and social environment, science and technology should be targeted more directly towards the multiple needs of consumers, with less burden placed on tax payers. The challenge of how national projects that are directly applicable to the needs and demands of consumers may be developed was added to the policy agenda of the United States. In addition, enterprises that were perceived by the public as too being ruthless in the pursuit of profit, to the neglect of social needs, became the targets for increasing public criticism.

At around the same period a new international debate ensued, encapsulated by the claims published by the Club of Rome in its wave-making *The Limits To Growth - A Report for the Club of Rome's Project on the Predicament of Mankind*.[74] This best-selling book observed that the economies of the developed countries were encountering a new class of problems, while the developing countries were developing rapidly in the resource-consuming mode previously followed by the now developed countries. Various conflicts of interest and conflicts of values now faced the world, centred on issues such as the speeding-up of industrialization, population growth, mode of economic development and the progress of science and technology development goals, on one hand, and the constraints of natural resources and the environment, on the other.

Against this backdrop of the 1950s and 1960s, the United States began to invest in basic research aimed at solving social problems. The so-called 'intelligence technologies' needed for solving social problems - such as forecasting, evaluation and planning techniques - developed rapidly. In some academic circles this new field, focused on the analysis of policy issues associated social problems and social demands, was called 'policy science'.[75] Researchers and analysts in the US stressed the importance of interdisciplinary and interdepartmental research and focused attention on comprehensive inquiries at the interfaces of science and technology, the social economic system, the cultural system and the environment system, placing special attention on the interactions of these domains.

This new approach to inquiry required considerable restructuring of research institutions and organizations. For example, the so-called interdisciplinary and interdepartmental research are forms of cooperative research conducted across the boundaries of traditional academic divisions, such as physics, science and engineering, biology, social science and new types of science but they left the actual boundaries of traditional disciplines essentially intact. However, in order to solve the social problems at the centre of the new research we now know that the coordination of research needs to go beyond the now established interdisciplinary modes; it must enable the conduct of research from completely new fields and allow established disciplines to move beyond the constraints of their orthodox viewpoints and paradigms. The kind of research needed to address major contemporary social issues tends to undermine the old university research system based mainly on the division of departments and disciplines and to stimulate the gradual establishment of interdisciplinary and inter-field education and research systems.

Some representative organizations that have moved in this direction are the Research and Development Corp. (1948), the Battelle Memorial Institute (BMI, 1955), the Stanford Research Institute (the Behavior Science Advanced Research Center was set up in 1952 by Stanford University) and the Technical Military Programming Organization (TEMPO). These organizations have completed numerous effective research and development studies regarding national defence planning technology, management technology, systems development, communication systems that supported the Apollo Plan, management technology in the diplomacy field, the redevelopment of cities and many other topics. Consequently, these organizations have strongly furthered the reformation of research in the education system and increased the value of generalist and theme-specific boundary-spanning experts in interdisciplinary studies.

The policy sciences that developed in the 1960s and 1970s are divided into two categories: first, R&D for the so-called intelligence technologies, such as technology foresight, evaluation and planning, aimed at improving the efficiency of science and technology; and, second, research on the influence of progress in science and technology (hard technology) on human life, human emotions and inquiries into methods of solving social problems related to science and technology. A report of the US Senate entitled 'Applying Systems Analysis and Computer

Technology to Social Science and Social Problems' was an example. It listed some major projects on foresight, evaluation and planning that reflected the understanding of social technology prevalent at that time in America:[76]

1) The Public Opinion Inquiry technology and online Delphi project located at the RAD Institute and MIT. MIT was also the location for the development of the 'Technology for Groups Dialogue and Social Choice' theory.

2) The Parallel and Sequential R&D Strategy project, based on the publication by Professor William Abanasie, of Stanford University, of the 'Parallel and Sequential R&D Model'.

3) The New System of Social Development Plan managed by Stanford University's Professor Bruce B. Lusignan, who was also responsible for the implementation of Stanford's Interdisciplinary Engineering Course.

4) The Problem Solving course, which was the responsibility of Moshe B. Rubinstein, of the University of California at Los Angeles.

5) The Survey Research Center, of the University of California at Berkeley.

6) The ICPR - Inter-University Consortium for Political Research - the development of which was led by the University of Michigan.

7) Others.

During this period the application of social technology to solving domestic and international political, economic and social problems was emphasized worldwide and various modern 'think tanks' were born. An example of this phenomenon was the birth of the Club of Rome in 1968 and its research plan regarding the human crisis. The Club of Rome, which is still active today, gathers together many famous economists, politicians, environmentalists, natural scientists and social activists to form a comprehensive research institute that addresses important international issues and global development strategies. In addition, the International Institute for Applied Systems Analysis (IIASA) was founded in December 1972 in Austria, with funds from 12 countries. Its research covers a range of issues associated with the entire human race, resources on the Earth, human resources, human society and economic technology methodology. The London Strategy Institute - another example - was founded in 1958 in the United Kingdom, changed its name in 1971 to the International Institute for Strategy Studies (IISS) and became a branch of the International Relations and Security Network (ISN). The main business of this network is to formulate explicit judgements on various international political, economic and social problems. Roland Berger & Partner GmbH International Management Consultants, with its headquarter in Munich, is a global advanced management consulting service company that was founded in 1967. Further examples, from the orient, are the Nomura Comprehensive Institute founded in 1965 and the Mitsubishi Research Institute (MRI) founded in 1970; these are both famous intellectual centres and research institutes in Japan.

2. Soft Science in Japan

With the continuous high-speed development of its economy since World War II, Japan is now facing many of the social tensions and problems that are now common in western countries. Americans are using terms such as 'intelligence technology' and 'policy science' in their research; however, Japan instead invented the concept of 'soft science' and has conducted centralized research on social problems within the framework of soft science.

The Soft Science Seminar set up by the Planning Bureau of the Science and Technology Agency (STA) in 1970 is the starting point for the development of soft science in Japan.[77] The seminar's report points out that the 'research object of soft science is not limited to natural phenomena and technology and it includes activities pertaining to the human race, social affairs and knowledge. Therefore, soft science advocates the application of natural science methods, such as systems theory and information processing, in the solution of the above mentioned widespread comprehensive problems.' After the 1971 Soft Science Seminar (of the STA) the Institute of Future Technology was entrusted to conduct specialized research (1971—3) on 'the science and technology policy and the research and development system of Japanese characteristics'.

Researchers from the Institute of Future Technology travelled to the United State in 1971 to investigate the research on social problems. As a result, the Institute published a series of research reports, entitled *Basic Design of Japanese Type Science and Technology Development System*, pointing out that soft science is the new trend in science and technology development. If soft science is not properly developed 'in the near future, the gap between Japan and the United States in soft science will result in major social problems'. The Institute's reports also stressed the urgency of developing soft science in Japan. Firstly, it argued that Japan needed a different and more comprehensive scientific method if it wanted to solve the complex social problems associated with the environment, energy, regions, cities and transportation; secondly, it showed that developed industrial countries had already conducted research, development and application in this field; and thirdly, it concluded that 60% of enterprises in Japan had already applied methods that could be considered soft science in these fields but that the gap between Japan and advanced countries such as the United States was still large.

After the report from the Institute of Future Technology was examined and discussed at the Fifth Meeting of the Council for Science and Technology, high-level experts from all fields were required to conduct centralized research on the concept of soft science, its necessity, its characteristics and the fields requiring research and basic knowledge from the vantage point of soft science.

From 1971 to 1987, the STA treated the 'promotion of soft science' as an important R&D field and listed it in its *White Paper on Science and Technology* each year. To further promote soft science and training in the national think tanks, STA listed it as a specific topic in the R&D plan and the Economic Planning Agency and Ministry of International Trade and Industry (MITI).[78]

The Comprehensive Research and Development Organization was set up in Japan in 1974 to enable research in soft science to be combined with analysis of various policy problems. The basic understanding of soft science that prevailed at that time was as follows: soft science is a science based on information science, behaviour science, systems engineering and social engineering; the means for solving problems of soft science are mainly foresight, planning, management and evaluation, etc. The primary characteristics of soft science were considered to be that: 1) its research objects were not only natural phenomena (the traditional objects of science and technology) but also issues that contained human and social factors; 2) that understanding the above issues from a systematic viewpoint and putting the emphasis of research on soft intelligence technologies, could help solve real problems; 3) that soft science organically combines a wide range of fields of knowledge and systematically synthesizes theories and methods that can contribute to the solving of different problems; and 4) that the basis and background of the discipline is information science, systems engineering, management science, behaviour science and social science.

The classification of soft science provided in the report *Basic Design of Japanese Type Science and Technology Development System* reflects the understanding of soft science that eventually dominated Japanese academic circles. The ten categories proposed in the report were: 'general' soft science, information soft science, energy soft science, material soft science, system soft science, environment soft science, behaviour soft science, policy soft science, life soft science and others.[79] Explanations of the above ten categories are below:

- *'General'* refers to general questions pertaining to soft science.

- *Information soft science* is divided into information patterns, information media, information processing, information theory (including semiotics theory), signal theory, forecasting theory, signal detection theory, automatic machine theory, learning theory and decision-making theory, etc.

- *Energy soft sciences* conduct research on energy in four areas: energy of the Earth, biology, technology and society.

- *Material soft sciences* research materials within a social economic system, e.g. social economic problems, such as population problems, employment forecasting, family and consumption forecasting, urban planning, the development of the Earth and industrialization; technology economic problems, such as industrial forecasting, technological forecasting, products planning and market forecasting, as well as operational research.

- *System soft science* includes the research, design and application of systems.

- *Environment soft science* divides the environment into the physical,technological, economic and social environments.

- *Behaviour soft science* examines and deals with human beings as energy systems, which have the following basic characteristics: (human body) structure characteristics, (human) function characteristics and (human and environment relations) environment characteristics.

- *Policy soft science* is based on social engineering, management engineering and futures engineering. It also applies to various methods that are beneficial to the understanding of phenomena, planning and control.

- *Life soft science* mainly addresses the problems of biological science, ecological science, medicine and pharmacology, etc.

- *'Others'* refers to other soft science problems not included in the above nine categories.

This report also listed major soft science R&D problems, such as the social effects of pollution countermeasures, urban problems, disaster prevention, transportation and communication, medical treatment, precautionary public security and consumer protection.

In 1977 the dominant understanding of soft science in Japan evolved. Soft science came to be viewed as comprehensive science and technology whose principal aim was to develop and apply theories, methods and tools that can explain and solve various complex problems we are facing and further help decision-making processes become scientific.[80] Under this view, soft science would research and synthesize dynamic analytical frameworks, methodologies and skills in the fields of information science, systems engineering and management science, as well as the new theoretical models or knowledge in behaviour science and social science. Compared with the 1971 perspective, this definition removed the limitation of 'solving policy problems' and changed the framework from 'applying natural science methodology in human beings and the social system' to 'synthesize various achievements and knowledge in natural science, humanities and social science'.

3. Soft Series of Science and Technology in Japan

In the 1980s the general rubric under which research on soft science in Japan was conducted was transferred to the Soft Series of Science and Technology (SSST). The main idea behind this shift was reflected in two reports entitled *A Survey on the Present Situation and Future Trend of R&D in the Series of Soft Science and Technology* reported by NISTEP (National Institute of Science and Technology Policy, under the auspices of STA) In 1988 and 1989[81],[82] the reports elaborated on the notion of SSST, its technical applications, the scientific fields it supported and its research system. It pointed out that the 'soft series of science and technology' is the corresponding notion of the 'hard series of science and technology', which was developed as natural science and engineering. The research on SSST enlarged the notion of science and technology, which in turn enabled the systematic study in this innovative field and new methodological groups with practical significance.

The major themes discussed in the reports are described below:

1) Science and technology include natural science and technology, humanities and the social sciences and technology.

2) The basic disciplines of the soft series of science and technology are systems theory, information processing, cognitive science, behaviour science, organization science, management science and policy science, etc.

3) The relevant disciplines include all fields of humanities and the social sciences and natural science.

4) Soft industries that can be developed include the talent industry, information industry, education industry, the intellectual and consultation industries, etc.

5) The hardness of technology means that it has the physical world as its operational object, which includes natural systems and man-made physical systems (like machinery), while the softness means that its operational object is the

visualized world presented by the psychological activities, thinking and actions of human beings, which includes the man-made abstract system (objects abstracted by the human psychological activity process, such as information, knowledge, system, mode and notions) and the system of human activities (behaviours realized by internal processes rooted in human self-consciousness, such as service).[83]

In 1990 Japan's SSST investigation committee newly defined the soft series of science and technology as a new field of science and technology with the aim of clarifying human knowledge activities such as cognition, thought, reasoning, judgement, innovation and the corresponding motivation mechanisms (the part of science); handling and operating the means that support or partially replace those activities and the information and experiences produced by them (the part of technology).

SSST can be divided into hardware, human-ware and other new fields according to the characteristics of their research objects. Those, in turn, can be divided into *basic fields* (cognitive science, psychology, thinking psychology, behaviour science, economics, politics, system theory, mathematical science, linguistics and organization science, etc.) and *application fields* (value engineering, social engineering, software engineering, policy engineering, systems engineering, management science and engineering and urban engineering, etc.) according to their conjunction with the previously accepted fields of science and technology.

Two particular facts signalled the prominence and respect that the soft series of science and technology had garnered within Japanese society by the 1980s. In 1992 a report entitled *Soft Series of Science and Technology Research and Development Basic Plan* was submitted to the Council for Science and Technology under the name of the Prime Minister (Miyazawa Kiichi, who was then Chairman of the Council).[84] In addition, the *White Paper on Science and Technology*, published annually by the STA, listed soft series science and technology - alongside the fields of information science, materials science, life science, space science, ocean science, geosciences and cutting edge technologies - as one of the eight major R&D fields, every year during the decade from 1988 to 1998.[85]

Further insight as to the meaning of the soft series of science and technology in Japan during that period may be found from four angles:

1) Projects

Reviews of the major research projects listed in *White Paper on Science and Technology* in 1998, as follows:

- *STA*: investigation of science, technology and human and social issues; study on R&D management (NISTEP); study on the thinking function (Institute of Physical and Research); and study on human features (Japan Atomic Energy Research Institute).

- *Environment Agency*: comprehensive research on the management and maintenance of the natural environment; research on Earth environment issues from the human and social perspective (comprehensive Earth environment research promotion expense).

- *Ministry of Finance*: research on 'sensory measurement' techniques for evaluation of wine quality; research on the improvement of wine production techniques (Research Institute for Brewing).

- *Monbusho*: software composition principles that are essential for development organizations (relevant universities).

- *Ministry of Agriculture, Forestry and Fisheries*: comprehensive research on the development of basic technology for suitable light labour agricultural practice (crops related research); evaluation technique and adaptive technology development for the health of agricultural, forest and aquatic products; the quantitative evaluation of the rural living environment; and development of host technology (National Research Institute of Agricultural Engineering).

- *Ministry of International Trade and Industry*: human media (industrial science and technology R&D); environmental system technology (institution) suited to human behaviour; measurement and evaluation technology for the care and behavioural characteristics of the aged (Research Institute of Life Engineering and Industrial Technology).

- *Ministry of Posts and Telecommunication*: research on the 'friendly communication society' (Communications Research Laboratory, communication and broadcasting organization).

- *Ministry of Transportation*: physiological aspects of human beings driving automobiles; the technology of preventing man-made mistakes; physical distribution structure analysis; and information systems for the new Physical Distribution systems (Ship Technical Research Institute).

2) Fields and Issues

Reviews and forecasts of fields and issues considered to be at the forefront of research (which are listed in the reports *A Survey on Present Situation and*

Future Trend of R&D of Series of Soft Science and Technology in 1988 and 1989). These reports divided the development of SSST into three stages. The first stage of the development of SSST took place before 1960, the second was from the 1960s to the first half of the 1980s and the third began with the second half of 1980s.

- The representative fields at the forefront of research in the first stage focused on large-scale systems development (like the Apollo Plan), the second stage focused on research about resource and environment issues and the third stage focused research on creative behaviour itself and the development of knowledge resources.

- The primary research objects for the first stage were complex technology and man-made systems that the aim of research is clear from the beginning. The primary research object of the second stage was the complex ecological environment system. The primary objects of research during the third stage were creative activities and complex self-organizing systems.

- The development goal for the first stage was the choice of tactics, e.g. the optimization of management skills aimed at improving efficiency (minimize resource input). The second stage was the choice of system, e.g. system adjustment through planning, forecasting and evaluation technology based on systems models. The development goal of the third stage was the choice of strategy, e.g. organizing the economic factor structure according to strategic goals.

- Computing was seen as a basic field of technology, underlying all other fields, during all three stages. During the first phase the emphasis was on basic practice in computing. During the second phase the emphasis was placed on the shift from batch processing to online processing and from centralized processing to decentralized processing. During the third stage the emphasis was placed on compound batch processing and knowledge information processing, with terminal users as the locus of attention.

- Notable achievements during the first stage were found in the fields of operational research, industrial engineering, brain-storming methods, the Delphi method, relevance tree methods, matrix methods, network methods, scenario analysis, creative techniques, linear programming, dynamic programming, game theory and factor analysis methods, etc. The second stage's primary achievements took place in systems analysis, systems methods, decision support systems, value analysis, graph theory and systems dynamics. The representative achievements of the third stage were found in the comprehensive soft series of science and technology itself, such as social engineering, policy science, strategy information system, the ABC science (artificial, brain and cognitive science), knowledge and creative engineering.

3) Research Institutes

The same report, *A Survey on Present Situation and Future Trend of R&D of Series of Soft Science and Technology*, also listed those National Institutes that conducted researched on SSST and their major projects:

- *Research Institute of the Population Ministry of Health and Welfare*: demographic research.

- *Institute of Statistical Mathematics of Monbusho*: investigations and research in the field of forecast and control.

- *Construction Research Institute of the Construction Ministry*: residence environment, city planning, construction and infrastructure structure.

- *National Research Institute for Agricultural Economics of the Ministry of Agriculture, Forestry and Fisheries*: agricultural economic problems.

- *National Institute for Educational Research of Monbusho*: research on educational practices and basic theory.

- *Economics Research Institute of Economic Planning Agency*: investigation and research on the structure of the economy.

- *Research and Training Institute of the Ministry of Justice*: research on criminal policy.

- *National Institute for Environment Studies of the Environment Agency*: research on the prevention of the social effects of pollution.

- *Institute of Financial and Monetary in the Ministry of Finance*: domestic and foreign finance and economics.

- *Institute of Posts and Telecommunications Policy in the Ministry of Posts and Telecommunications*: utilization, storing, insurance and the information research of telecommunication matters.

- *NISTEP of STA*: research on science and technology policy.

4) Fields of Study

The application fields of SSST during this phase were divided into the fields of policy, management and administration, society, family and individual life and the general field of knowledge activities, such as R&D.

The above lists of research fields, classifications, major practice projects in SSST and its history force us to conclude that the real emphasis of SSST was on the application of natural (conventional, physical) science and technology and the methods of systems science towards the solution of social problems. Although SSST was defined to include not only social technology but also other kinds of soft technology, it did not in fact properly embrace the full scope of soft technology.

Actually, national level support in Japan for research on SSST has basically stopped since the 1990s. For instance, in the *Science and Technology Basic Plan* that was submitted by the Science and Technology Policy Bureau to the Science and Technology Convention on 26 December 2000, SSST was not included as a field. The field of basic social infrastructure, which mainly included disaster prevention technology, crisis management technology and technologies concerning basic humans livelihood, etc., replaced the SSST field.

Nonetheless, the research and practice of SSST in Japan bears significance for the R&D history of soft technology. Firstly, the understanding of technology in SSST, broadly defined, and the discussion within SSST of the soft nature of technology were pioneering contributions to the field. Secondly, no matter what labels were used, it was particularly meaningful for research to have been conducted on a type of technology, including SSST, which is different from traditional technology and for this to have been listed in the Japanese *White Paper on Science and Technology* for a number of years. Finally, the fact that soft science, or the SSST (depending on the label you prefer), has now disappeared from the front stage of the drama of Japanese science and technology is a matter worthy of reflection and further attention.

4. Soft Science, Soft Series of Science and Technology and Soft Technology

Soft science had not broken out of the initial framework of American intelligence engineering and policy science since it was introduced 30 years ago. Firstly, the focus of its application was still limited to the decision-making field. Secondly, the focus of the research was still on the methodology for applying natural science and technology and systems science to solving social problems but it was not integrated with the development and application of social resources.

In China, in July 1986, the State Science and Technology Committee hosted a forum on national soft science research.[86] After that forum the development of soft science and the need to conduct systematic research on the meaning, objects, relevant disciplines and methodologies of soft science were promoted. For example, the theoretical method of soft science was divided into general theory (systems theory, information theory, cybernetics, dissipative structure theory, synergetics, mutations, indistinct mathematics, 'scienology' (the science of sciences), behaviour science, etc.), the methodology of systems science, planning and optimization methods, forecast and evaluation methods, management and decision-making methods, simulation method, econometric methods and others. Particularly, Gu Jifa and Zhu Zhichang developed a series of oriental systems methodologies, such as the Comprehensive Integrated System Methodology put forward by Qian Xuesen, the Processional Triangle Cycle of System Engineering proposed by Wang Huanchen and the System Methodology of Wuli-Shili-Renli.[87] At the same time, there were corresponding soft science institutes established at both the local and national levels, ranging from government agencies to specialized institutes. The National Soft Science Research Planning Projects fund was set up to encourage relevant research by the Ministry of Science and Technology. All these have contributed significantly to research on the economic and social development of China during the past ten years.

However, the focus of soft science research and application in China is still on the methodology of social science and on decision-making methods. *Soft Science in China,* from the Chinese soft-science book series, reflects China's focus:

> There are two main threads in soft science, one is the quantitative analysis and research containing Operational Research, systems engineering and techno-economics at the centre, the other is the study of the development strategy and the policy and management methods that are centred on scienology and futurology, etc. The characteristics of this science are that it follows systems thought and makes the decision-making method more scientific and democratic by integrating social science with natural science, quantitative analysis with qualitative analysis, working experience and technique with scientific method and means and researchers with decision-makers.[88]

In other words, the goal of soft science research is to make decision-making more scientific and democratic and to refocus its main content, centring it on strategies, the decision-making method and the methods of policy-making and management.

Japan's SSST is similar in many respects to soft technology as portrayed in this book, including its understanding of the importance of the soft dimensions of science and technology and basic fields of knowledge. However, there are also significant differences between the two with regard to some basic concepts, connotations, features, research directions, research aims and composition of research fields. For example:

1) SSST has included relatively thorough study of the soft nature of technology but the above mentioned research priorities and research field of Japanese SSST indicate that it actually stresses social technology and the softened part of hard technology, rather than soft technology as such.

2) The application fields of SSST are mainly focused on using natural science and technology and systems technology in solving social problems but it does not exhibit adequate applications in business activity, cultural activity and indigenous technology activities.

3) The activity of SSST mainly addresses decision-making methods and does not exhibit adequate understanding of its functions of technological innovation and institutional innovation, broadly defined. SSST only considers that aspect of the intellectual service industry that is concerned with industrial innovation.

5. What is Social Technology?

Earlier in this chapter it was pointed out that social technology should not simply be summarized as the application of the technology of social science. Proper consensus on the meaning of social technology, as understood by its advocates, observers and commentators, has still not occurred and, in any case, after half a century of development its meaning continues to evolve.

In *An Introduction to Social Technology - Group Discussion* written by Misumi Jyuji in Japan in 1955, the technologies that control human relationships and spiritual phenomena in a society are described in general as social technology.[89] Jyuji also conducted research on the two themes of social science and social engineering, based on the concept of group dynamics put forward by K. Lewin in the 1940s. Lewin labelled the application of group dynamics and group engineering as social technology and social engineering and discussed the application of various meetings, including the formal meeting, the informal meeting, the small-scale meeting and large-scale public meetings. Lewin also discussed the functions of group and individual discussions, types of problem-solving functions and the process management function of group meetings and so on.

In 1966 the American scholars Olaf Helmer, Bernice Brown and Theodore Gordon co-authored the book *Social Technology*.[90] The authors believed that social technology is a form of social science methodology, which mostly includes the methods of operational research, the Delphi method and Experts System, etc. They described how to apply these techniques to long-term foresight in the research report *Long-Range Forecasting Study* sponsored by the RAND.

Erich Jantsch, the OECD Adviser, quoted Olaf Helmer's concept of social technology in 1967, supporting the idea that social technology is the generalization of technologies that are essential to society and which are based mainly on social inventions. 'Social inventions' refers to inventions that exert a strong impact on the social system and on social technology transfer; 'social engineering' refers to human activities that are effective and directive in the transfer of social technology.[91]

Dong Guangbi, a Chinese scholar, also discussed social technology in a 1989 article entitled *On Social Technology*.[92] Guangbi stated that social technological knowledge is solidified in social organizations in a way similar to how natural technological knowledge is materialized in tools, mechanics and equipment. Political organizations (governments, congresses and courts, etc.), economic organizations (factories, farms, stores, banks, insurance companies, etc.) and cultural organizations (schools, hospitals, etc.) are all transporters of social technology. The operating process of various social organizations is social technological knowledge, namely, operable social knowledge.

When the Japanese Monbusho (the Japanese government's Ministry of Education) approved the research project entitled 'Social Technology in 2000', an explanation of social technology was added:[93] 'Social technologies are technologies that comprehensively apply natural science and social science to the construction of a society and which make people feel at ease and substantial.' Saikawa Hiroyuki, chairman of the Japanese Theory Convention, believes that the object of social technology is the nature or behaviour of individuals or groups. Therefore, the significance of social technology R&D lies in 'coordinating science and technology and society by applying humanities and social science knowledge'. Monbusho started the research project entitled 'Social Technology' in April 2001 and the budget for the year 2001 was 1.5 billion Japanese yen. The first group of projects may focus on the design of the accident prevention system of atomic energy equipment.

Therefore, we can see that although the same term is used, the understanding and explanations of social technology differ greatly.

I believe that social technology can be summarized as the process, method, procedure and system by which various social resources are developed and applied and as the value (wealth-creating) system where social resources are created or embodied.

As to social resources, many western scholars conduct research from the perspective of social capital: Pierre Bourdieu's, *Le capital social,*[94] James Coleman's *Social Capital in the Creation of Human Capital,*[95] Robert Putnam's Bowling Alone,[96] etc. The book *Knowledge and Social Capital* compiled by Eric L.

Lesser in 2000 reviews and summarizes the research achievements of typical contemporary social capital.[97] Lesser indicates that, according to the Merriam-Webster Dictionary, the term 'capital' refers to 'accumulated wealth especially as used to produce more wealth', hence the notion of social capital is maintained.

However, there is a confusing array of definitions of social capital in political science, sociology and economic development literature. For instance, after analysing the definitions of 18 scholars, Paul S. Adler states, 'social capital is a resource for individual and collective actors created by the configuration and content of the network of their more or less durable social relations'. Lesser, on the other hand, believes the following:

> Social capital is the benefits or wealth that exists because of an individual's social relationships. Within those social relationships, there are three primary dimensions that influence the development of those mutual benefits: the structure of the relationships, the interpersonal dynamics that exist within the structure and the common context and language held by individuals in the structure.

Regarding the resource of social capital, there is considerable confusion between the sociological literature, the political science literature, the development economics literature and the organizational research literature. For instance, experts in organizational science believe that social capital is composed of three dimensions: 'under the structural dimension, they list network ties, network configuration and appropriable organization; the cognitive dimension includes shared codes, language and narratives; the relational dimension includes trust, norms, obligations and identification'.[98]

According to the definition provided in this book and also for the convenience of researching social industries, I will examine social technology from the perspective of social resources, which is divided roughly into two domains: internal and external.

Since the essence of social resources is the various personal and collective relations and the various networks among individuals, groups and social organizations, these are to be treated as external social resources. These resources include schools, social groups, communities, associations, chambers of commerce, academies, hospitals, political organizations (governments, congresses and courts, etc.), NGOs (non-governmental organizations), families and public resources, e.g. public facilities, social relations and personal relations.

Internal social resources are generated by internal factors that, in turn, make it possible for social networks and organizations to be maintained. For example, internal factors such as trust between people are the basis for the formation of all kinds of social organizational activities and networks. It is the same with common beliefs and values. Therefore, the following are treated as internal social resources: institutions (including social standards and laws), beliefs, values, views, morality, customs, all kinds of desires of people (the desire to work, the fulfilment of their ideals or dreams, the enjoyment of life, a high quality of life, peace, security, trust and an environment that is stable and friendly, etc.) and human emotions.

Because social resources cannot create value automatically, only the application of social technology can make social resources create or embody value and solve social problems. Social technology therefore involves two interrelated and interactive dimensions.

The first dimension is the process and mode by which technology develops social resources. This generally refers to the social activities of various organizations, such as meeting technology, discussion technology, education technology, training technology, learning technology, coordinating technology, alliance and cooperation technology, public relations technology, human relation technology, organization technology, service exchange technology, communication technology, complementary currency technology, operational mode and mechanisms of social groups and communities, etc.

The other dimension is the methodology of solving social issues and handling social affairs, including all types of systems technology methodology, planning technology, evaluation technology, foresight technology, decision-making technology, strategy choosing technology, policy design and analysis and institutional innovation techniques, etc. Today, many soft science methodologies mostly belong to social technology from the perspective of soft technology and they mostly provide services for decision-makers at different organizational levels. The social technologies of Olaf Helmer and Theodore Gordon start with the methodology of solving social problems.

From the perspective of methodology, there are two ways to solve problems. The first is by stressing each social problem and to develop and search for a corresponding technology (hard technology) appropriate to solving that problem; the other is by conducting an overall design and planning process according to space and region limits while ignoring individual problems and looking for solutions for the effective operation of an entire system. The former belongs to the hard-tech application in social development, which has been our usual way for hundreds of years - and, strictly speaking, it is not social technology. The latter is the methodology of social technology. It involves first of all searching for solutions from the level of the totality or the 'whole' and then at the level of the part. The answers to the questions about what kind of hard technology may or not be appropriate and whether or not it is even appropriate at all to use high technology depend on the need of how the technology might fit within the larger solution. This approach captures the charm of social technological innovation. Ecological planning technology is an example. Stemming from its basic purposes, the development and application of social technology must stick to the principle of balancing technological, economic and social development in a sustainable manner.

Here, we should pay attention to the dualism of social resources, to the balance and harmony of the two sides: to restrict the darker side of social resources development and to expand the positive side will be one of the main tasks of social technology.

Today, social technology is facing the arduous challenge of moving from being a noble idea towards becoming a workable method. For example, until now formal decision-making technologies tended to be comparatively 'hard', with many emphasizing the analysis of objective factors only; and often the more quantitative format was considered to be the more scientific approach ... even though it produces erroneous results because it ignores essential subjective factors.

This issue is elaborated upon further by Theodore Gordon in a letter wrote to me:[99]

> The decision-making process should be improved throughout the whole world in order to solve problems at present and in the future. I wrote about this in the 1997 State of the Future report. Today, decision-making technology is taught from the standpoint of economics using techniques like cost benefit analysis and min-max theorems. However, in the future, I think, good decision-making will go well beyond economics. A course of decision-making in the future might include, for example, the role of human intuition, risk taking propensity, values (consideration of what is the right thing to do and models for seeking the right decision) and the consideration of how the mind works in the process of making decisions, particularly how the mind can distort data and information and reach for decisions that are illogical and inconsistent. The field of cognitive science will also have a role by showing how the mind creates models of outcomes, small and fast scenarios that are accepted or rejected when arriving at a decision.

As to the role of psychology and the significance of subjective factors in the decision-making process, Kusaka Kimindo has noticed that the high-speed growth of the Japanese economy since 1963 has much to do with people's confidence in the national economy at that time. Kimindo remarks that 'although high speed economic growth is an economic term, the key is whether it is believed or not. Many Japanese managers at that time invested in equipment with their personal property as guarantee. They did this without any hesitation for the belief in the return of investment.'[100]

In the subsequent sections of this book, the significance of the development of soft technology will be discussed from the perspectives of technological innovation, institutional innovation, industrial innovation, technology competitiveness, the gap between developed and developing countries, technological foresight and soft technology education.

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Chapter 3: The Characteristics and Classifications of Soft Technology

A. What is Soft Technology?

As traditionally understood, 'technology' describes an operable knowledge system that is mainly derived from the knowledge of natural science. In this book, this is referred to as 'hard technology', namely, the skills, tools and rules that are employed by humans to alter, accommodate (humans can only accommodate nature, not control it) and manage nature for human survival and development.

Operable knowledge systems derived from social sciences, non-natural sciences and non-scientific (traditional) knowledge aimed at solving various practical problems also belong to the category of 'technology'. This class of technology is referred to in this book as 'soft technology'. Soft technology comes about through the conscious use of common laws or experiences in economic, social and humanistic activities; soft technology then shapes the rules, mechanisms, means, institutions, methods and procedures that contribute to the improvement, adaptation or control of the subjective and objective world.

Therefore, in general, technology is composed of hard and soft technology. As economies develop and as technology changes, the boundary between hard and soft technology blurs. However, in general, we can say that hard technology is manifested mainly through material forms, while soft technology is manifested mainly through human psychology and behaviour. Here, 'hard' refers to the physical entities through which operations are conducted. 'Soft' refers to entities without physical form. In other words, 'hard' refers to tangible phenomena, while 'soft' refers to intangible phenomena.

Soft technology must, by definition, exhibit two general sets of characteristics: it must be *technological* and it must also be *soft*.

From the vantage point of its *technological characteristics* we may say the following things about soft technology:

- It should be an operable knowledge system of tools, procedures and rules for the solution of problems.

- It should be directed towards practices for providing ‘service’ for social change and economic development.

From the vantage point of its *softness characteristics* we may say the following things about soft technology (for details see table 6):

- Its operational knowledge is deeply rooted in internal human conscious operational activities.

- Its operating fields include the processes of human psychology and human social activity systems. The latter comprises those human behaviours controlled by and embodying human psychological activities related to perceptions, emotions and values. The various psychological, social and cultural factors are therefore the distinguishing parameters of soft technology.

- The way in which soft technology provides *service*, besides tangible products, is mostly through intangible modes such as services, procedures, rules and institutions.

- The meaning, functions and characteristics of soft technologies can be presented, formed, modified and expressed in ways that accommodate distinctive features of the psychological activities and social environments in which they operate.

- Soft technology can also affect our level of understanding the subjective and objective world around us.

In short, soft technology is the intellectual technology of creation and innovation centred in human thought, ideology, emotion, values, world views, individual and organizational behaviours, as well as in human society.

I have chosen to use the phrase ‘soft technology’ to distinguish the primary subject matter of this book from that of traditional hard technology.[1] The reasons are that, on one hand, the term ‘soft science’ has entered into international usage, perhaps making it easier for people to accept the term ‘soft technology’ rather than some other term that I may have chosen to coin; and on the other hand, I wish to emphasize the distinction between what I call soft technology and the concept of ‘social and humanistic technology’ that is discussed in some literature.[2] So that we may gain a deeper understanding of soft technology, I will devote some time to discussing its basic characteristics before I proceed to discuss its classification from a variety of perspectives.

B. The Characteristics of Soft Technology

Hard technologies and soft technologies, since they are both technologies, have many attributes in common. From the perspective of their intrinsic nature as *technology* they both exhibit the following features:

- They take the form of means, skills, tool, rules, mechanisms, methodologies or processes for the solution of problems
- They are intended to provide 'service' for social progress and economic development.

However, as we can see from table 6, when compared with hard technology, soft technology is a completely new technological paradigm.

In general, soft technology contains the following characteristics when compared with hard technology:

1) Soft technology exhibits a closer relationship with humanity and culture. Soft technology takes the internal psychological activities and the external behaviours of human beings as its operational object and its content and levels are determined by its focus on the ways of thinking and action modes of human beings. Its application and popularization are directly related to local morality for particular times, cultural backgrounds, habits and knowledge levels, etc. At the same time, during the process of the operation of soft technology, different features are formed according to different operational objects. We can say that human factors and the social environment control the formation, presentation, moulding and innovation of soft technology. Therefore, soft technology is a technology that contains human thoughts, viewpoints and strong individuality and it controls the direction of hard technology applications.

2) Soft technology embodies distinctive concepts of humanity and human factors. The concept of man in soft technology is different from that in hard technology where the object is 'outside the human body'. Although the human body is the operational object in western medical science and life science, it is treated as a 'physical' object or a complexity of cells and can be duplicated and cloned in the scientific sense; whereas in soft technology, the human body is regarded as an organic whole with consciousness, feelings, thoughts and values.

   Hard technology also stresses these human factors but is more concerned with human reaction and capacity towards the 'outside' and 'substance', while soft technology pays more attention to human psychological activities, such as sense, feeling, mood, thought, thinking patterns, values, traditions, habit, personality and the ability to control psychological activities. Therefore, the main parameters of soft technology are various psychological, social and cultural factors.

3) Soft technology is rooted in the spiritual world. The so-called spiritual world includes the abstract world (the object that is conceptualized through those actions processed in the immanent consciousness), the visual world (the reappearance of images of events through memory and the mind's eye) and the presentational world (the reflection of sensory experience, emotion/mood and action, e.g., heartache, dread, enjoyment, etc.) [3] Whereas abstract thinking operates concepts, visual thinking operates images and presentational thinking operates the consciousness itself. The concept of the presentational world has already been applied in arts circles, which can be further divided into three branches, namely, emotional thinking, sense thinking and action thinking.

   The physical world, in which hard technological operation is conducted, includes natural and artificial fields. The spiritual world, in which soft technological operation is conducted, includes an inner orchestration action system and an outer behaviour system. The former includes the abstract field (concepts, modes, systems) and the consciousness field (sensation, emotion and mood/feeling). The latter includes the social behaviour field (performance is dominated by inner orchestration action and value view, world view, ethics/morals, sentiments, etc.).

4) Soft technology is not neutral. Soft technology is fundamentally dualistic. The dualism of soft technology stems from its dualistic functions, in that it simultaneously manifests both productive forces and the relations of production (for further explanation see the section entitled 'The Functions of Soft Technology' in chapter 4).

   For a long time, profit-oriented technology development and its unethical application have caused numerous disasters for humanity. Besides facing ecological damage to the external ecological environment, human beings have also faced technology-induced threats to their interior nature and to the social world. Examples include the issues associated with the Y2K threat, which brought about a 'global earthquake' during 1999. Countless observations may be found in the scholarly literature and in the popular news media about the negative effects of almost every kind of technology, such as atomic technology, genetic technology, nanometer technology and the technology of high-energy physics.

   However, it is unfair to blame technology for all these disasters. The responsibility for the defects of technology, the so-called menace of technology and for the direction in which the application of these hard technologies has moved lies completely in the hands of the operator of the technology - people. Moreover, we need to continuously invent and develop new technologies to meet human demands, to deepen our understanding of nature and to serve the needs of society for solving many problems that are brought about by hard technology industrialization.

Hard technology is 'neutral' in the sense that it is controlled by people and contains no moral bias in itself. Soft technology therefore needs to be designed to provide effective control and the right direction for hard technology, e.g. soft technology is a tool of innovation, which has, as one of its purposes, the manipulation of innovation in hard technology.

From this perspective, soft technology is imbued with human thought and human biases and hence soft technology is influenced by morality, values and world views. Therefore, soft technology has both positive and negative effects, just as a coin has two sides. That is why governmental and social intererventions are necessary in the application and promotion of soft technology and its activities must be encouraged and regulated and sometimes even prohibited or censured by institutions, laws, standards and policies.

5) Soft technology is resistant to standardization. The fact that soft technology embodies psychological, social and cultural factors creates severe obstacles to its standardization. On the other hand, soft technology includes explicit and tacit technologies.[4] The former can be presented by words, data, standardized procedures and general principles that are disseminated and shared by way of books, lectures and training; whereas the latter, which includes thinking technology and LPFE technology, cannot be properly be presented in the form of written documents and formal languages. Because it is difficult (by its very nature and by definition) to articulate tacit technology in a formal manner, it becomes difficult to communicate and share in a standardized manner. This is due to what Ikujiro Nonaka refers to as implicit knowledge embodied in technological phenomena.

6) Soft technology has imprecise boundaries. Since all soft technologies are closely related to human factors, the boundaries between science and technology, technology and associated knowledge and different types of soft technologies are very vague and each influences and infiltrates the other. Although soft technology can be systematically categorized, as we shall see below, it is nevertheless much more difficult to place precise conceptual boundaries around the various dimensions of soft technology than it is for hard technology.

Table 6: Differences between soft technology and hard technology

7) It may not be necessary to convert all soft technologies into products and services. A great number of soft technologies, just like hard technologies, can form the basis of industries and can be used to provide products and services, e.g. financial derivative tools, various kinds of incubators, cultural products and so on. However, most soft technologies are much more suitable for producing intangible processes, services, experiences, results, mechanisms and institutions than they are for producing products (as products are conventionally understood).

8) Innovation in soft technology has distinctive causes. The reason for the obsolescence of hard technologies is usually the emergence of new - normally superior - inventions to replace the old technology. This process is what 'technological progress' is generally understood to be all about. Innovation and renewal of soft technology, however, is more often caused by the changes in peoples' lifestyles, values, levels of demands and thinking patterns than it is by direct competition from other technologies.

   Innovation in soft technology is differentiated by the fact that it is more strongly limited by relevant institutions, systems, laws, regulations and policies than is innovation in hard technology. Hence, the creative destruction of old institutions and laws should take place to enable soft technology innovation. This process usually follows this pattern: designing the system/method (implementing the operating system/method (providing concrete services (the process of operating or implementing is the process of providing customers with services) (developing criteria to form institutions and organizations to facilitate promotion, popularization and application (creative destruction of institutions (operation in the new institutional environment (the next round of innovation.

9) Soft technologies have to be combined or integrated in practice. The implementation and success of soft technology requires a comprehensive and holistic approach to its application. As was mentioned above, hard technologies have to be integrated with soft technologies so that their social and economic value may be realized (for more details see the chapter 'Technology Innovation'). The primary criterion for judging the success of the commercialization and industrialization of hard technologies is whether they integrate well with continuously advancing soft technologies. On the other hand, soft technology will only succeed if it is combined comprehensively with other relevant soft technologies, modified according to the different conditions of local geographic and socio-political circumstances and according to the demands that stem from ostensible design goals. Similarly, integration with continuously advancing hard technologies is necessary for the promotion of soft-tech innovation and to ensure higher quality soft technology.

10) The characteristics of soft technology must accommodate distinctive regional conditions. Differences in soft technology will be produced by differences in cultures, economic levels, lifestyles, habits and thinking modes of communities. Hence, a soft technology developed in one region will always have to be redeveloped to suit the conditions in another if it is to function optimally in that other region. It is imperative to the basic success of their operation that soft technologies embrace the distinctive characteristics of different regions, communities and cultures where they are applied.

11) The relationship between soft technology and institutions is close. The dualism of soft technology means that it is, by nature, entwined and infused with institutions. In the case of hard technology, institutions are part of the environment and conditions for innovation. In the case of soft technology, however, institutions are not only part of the environment of technological innovation. Soft technology itself forms the foundation and content of innovation in relevant institutions, systems, law, regulations and policies. On the other hand, the invention, dissemination and application of many soft technologies are restricted by relevant institutions, systems, laws, regulations and policies.

12) Soft technology requires special talents. Hard technology requires specialists in particular technical fields but soft technology requires people with talents derived from interdisciplinary and cross-sector knowledge and experience.

C. Soft Technology Trends

Soft technology is one of the most important trends in technology development worldwide. At present, its development exhibits the following characteristics.

1. Soft Technology is Transforming Hard Technology

The rapid development of technologies, such as software technology, Internet technology, bio-information-technology, gene technology and artificial intelligence and their industries can be attributed to their softening. These technologies have all contained 'soft' features from their origins. As these technologies mature and generate products, their 'soft' side is subject to constant innovation, which enables the products to adapt to the ever-changing marketplace, and becomes the main source for providing added-value. Take the mobile phone industry as an example. A recent model of a Panasonic mobile telephone had a listed sales price as a stand-alone product in France of 1,400 Francs(one Euro is about 6.56 Francs); but its price at a French supermarket was set at only one Franc. The purpose of this artificially low sales price was to attract new customers, lock customers into a particular telecom network and, above all, to induce customers to purchase a complementary service through the supermarket, i.e. a subscription to a particular wireless telecommunications service.

Accordingly, as noted by the French weekly magazine the *New Observer*, the first of the ten keys to success of the new economy is that the best way to sell service is to give away equipment free of charge. In Japan, for example, many mobile phones can be bought for only one hundred yen or are even free of charge. The aim here is to attract customers of cellular phones to eventually become permanent customers of the communications network and associated services. The selling of mobile phones is no longer the core feature of mobile phone transactions. The profits of the mobile phone industry derive mainly from services so the mobile phone industry has actually become a service industry rather than a manufacturing one. As a further example, the well-known premier supplier of virtual Internet services in China, Sinonet (www.sinonets.net.cn), declared recently that its Zhongguancun branch will give medium and small enterprises in Zhongguancun 'one thousand sets of free website building options'.

Recently, firms in a variety of industries, such as education and training, physical fitness, business, intelligent services, culture and art, have begun to make heavy use of Internet services as a vehicle to promote and extend their businesses. This illustrates that non-tangible services can add real value to established enterprises. Service-oriented business strategies of established enterprises (including those in the equipment industry) - including increasing the service component of products, emphasizing services in the branding of firms and adding humorous, entertaining and human-performance dimensions to products - can become the primary means for attracting customers, creating markets and increasing added-value.

2. Soft Technologies are Creating New Industries

The most familiar soft technology industries are those that specialize in management technology. Examples include the activities of finance companies, logistics companies and technology assessment companies. Businesses based on training and education programmes are becoming widespread and, even if they do not use the term 'soft technology' to describe their work, it could be argued that the majority of their programmes and curricula are constituted from soft technology.

A current trend in the intelligent services industries is towards specialization. Each specialized professional/intelligent service business (e.g. a management consulting company), most of which provide services to organizations in traditional industries, has some kind of soft technology at its core. Soft technologies are therefore rapidly becoming core technologies for established industries (see details in chapter 5) and are facilitating the creation of new industries at a rapid pace, thereby accelerating the transition from the industrial economy to an intellective service economy.

3. The Rapid Rise of New Soft Technology Fields

Since the 1980s new soft technologies have emerged in an endless stream along with the trend of economic globalization and the economic 'informatization'. For example, in the field of business technology, new technologies, such as e-commerce technology, incubator technology, virtual technology and modern finance technology, have emerged. Furthermore, this process by which intellectual service industries grow rapidly propels the upgrading of traditional soft technologies and contributes to the development of new stages in the evolution of soft technology. The emergence of Nasdaq, multinational mergers, venture capital mergers and new business models are examples.

As business technology has leapt forward, other types of soft technologies, such as social technologies, have begun to gain or regain attention. Innovations in culture technology including entertainment technology also continue. Furthermore, humanity is finding new theoretical perspectives through which to look at itself, such as being part of the ecological systems of nature, information-processing systems, information sources, information receptors, energy sources and life sources. Psychological science and psychological technologies are assuming a more important position in fields such as decision-making and health. Research into traditional Chinese medical science and technologies is progressing, the humanistic ecological view of man-nature harmony is being more widely embraced and current social trends are stimulating the development and application of new types of soft technology.

4. The Further Integration of Soft Technology and Hard Technology

High technology does not belong solely to the domain of hard technology. High technology can also be found in soft technology. The extensive integration of soft technology and hard technology is creating immense business opportunity, which at the same time increases the intelligence content of soft technology. In short, soft technologies are increasingly becoming exemplars of high technology. For example, in the field of product design, especially in applications such as computer software, advertising, movies, television, fashion and environmental management, etc., high technology is gradually merging with culture, art and aesthetics. The need to link 'technology' with 'content' is illustrated by the fact that a Japanese electronics company such as Sony has become a major player in the American and international movie-making, music, broadcasting and entertainment businesses; or that America On-Line has merged with Time Warner to become one of the most influential players in the publishing industry.

Since its birth 50 years ago, the credit card industry has progressed from being one kind of simple paper-based credit issued on trust by a barbecue restaurant, through being no more than 200 cards issued on trust by the Diner's Club for use in a group of restaurants, to its present status as a substitute currency embodied in more than a hundred types of credit card that are widely used throughout the world. The credit card industry is now big business. In developed countries, almost everyone has credit cards and some people even possess seven or eight different cards. The credit card industry is also developing rapidly in undeveloped countries. Credit cards began as paper cards with a personal signature on them and have now developed into smart cards that incorporate a large amount of information and a plethora of functions. Today, many credit cards contain large-scale IC chips; new applications of the IC chips are infiltrating all aspects of modern life. Even the credit card system, which from its beginning has been a prime example of soft technology, has evolved to incorporate complete subsystems of hard technology thereby becoming a pre-eminent form of high technology. Credit cards and the whole credit card system are an example of high technology that manifests the comprehensive fusion of soft technology. It represents only the 'tip of the iceberg' of high-tech in the soft technology field.

E-commerce technology is also an example from high-tech industry. E-commerce is an electronic mode for conducting commercial transactions through a network where the processes of advertising, ordering, making payments, sending out goods and delivery are all conducted through the exchange of digital information (or 'e-data'). E-commerce aims to reduce the cost of the transactions, reduce the use of paper documents, improve efficiency and make the whole transactional process transparent. On the other hand, the application of electronic transaction tools may make many traditional transaction modes and their associated technologies obsolete. For example, paper receipts for financial transactions may disappear. It also creates new modes of commerce, such as attracting new customers through digital networks. In short, e-commerce technology transforms traditional transaction modes into intelligence-intensive transaction modes. E-commerce is high-tech transactional technology.

Other obvious examples of soft and hard technology integration, beside e-commerce, include modern music technology, the Internet, software and modern physical distribution systems.

5. Intellectual Property, Copyright and Soft Technology

How might more incentives be generated for innovation in soft technology? Along with the development of service economy, service innovation and mechanisms that will encourage service innovation have been added to the agenda. However, we still face the problem of a lack of research on the essence of service itself. I do believe that the various methodologies and means of services are, essentially, expressions soft technology and that soft technology is the fundamental technology of a service industry. From this perspective, there is no doubt that intellectual property protection, including copyright protection, is needed to protect soft technology innovation and to help innovators to appropriate the returns of their activities; and there is no doubt that continuing innovation within firms will depend on such forms for encouragement.

A particularly instructive example of the revolution that is currently taking place in the institutionalization of soft technology may be found in a recent development in the patent system in the United States. Within the last several years the US Patent and Trademark Office has been granting patents for business methods. The US Patent and Trademark Office received 7,800 business methods patent applications during 2000 and during that same period it issued 899 business methods patents. Citibank has filed applications for 19 financial product patents in China since 1996.

In other words, the US government now issues patents for soft technology! This action of the USPTO has generated quite a lot of controversy but, given that until recently patents were largely restricted to hard technology, it is a landmark event in the international history of soft technology institutions.

A revolution in the field of managing patents and copyrights is required in today's knowledge society. The challenge is to find ways in which the intellectual property that is the common wealth of humanity may be shared with the general public, while maintaining the incentives for innovation provided by a strong intellectual property regime, especially in fields of soft technology. Namely, both the social contributions and economic benefits of intellectual property regimes should be considered. From this point of view, traditional patent systems and institutions are inadequate, or even inappropriate, for the field of soft technology. Addressing this issue is one of the biggest challenges for the development of soft technology.

D. The Classifications of Soft Technology

There is a number of ways, using a wide variety of criteria, for classifying hard technologies. For example, in terms of research objects, they may be classified as information technology, material technology, bio-technology, energy technology, ocean technology and space technology, etc.; in terms of function, they may be classified as automatic technology, environmental protection technology, sense technology, remote sense technology and so on; in terms of their disciplinary structure, they may be classified as specialized technology, general technology and fundamental technology; and, in terms of industry, they may be classified with such categories as oil exploitation technology, textile technology, coal technology, etc.

It is more difficult, however, to classify soft technologies. First, analysing the sources of soft technologies is difficult. In the case of natural science and hard technology, the physical world is the object of cognition and operation. For non-natural science and soft technology, however, what needs to be 'cognized' and operated are cognition and operation themselves. Furthermore, since all soft technologies have human factors as their carrier, they bear profound relationships with each other.

Second, when we analyse the applicable characteristics of soft technology, we see that it is difficult to draw a strict line between business technology and other kinds of soft technology. For example, culture technology is developing with the commercialization of cultural resources.

Third, it is even more difficult to classify soft technology in terms of function. Owing to the intersection and merging of functions, the boundaries between technologies such as organizational technology, property-valuation technology, communications technology, transactional technology and management technology is rather vague. For the sake of further study on soft technology and the conscious creation, development and application of soft technologies, it is nevertheless necessary to develop reasonably good categories for classifying soft technology. This book provides a first attempt to take up this challenge. We will begin by classifying soft technology according to the sources from which its constituent knowledge is derived.

1. Sources of Knowledge

In light of our understanding of technology as an operable knowledge system, we may say that different types of knowledge form the basis for different kinds of soft technologies, each with distinctive characteristics related to its respective knowledge source.

Category 1. Technology originating from the knowledge of social sciences. Examples include: transaction technology, management technology, consulting technology, social technology, design technology, organizational technology, tools derived from finance, incubator technology, systems technology and all other types of business technology.

Category 2. Technology originating from the knowledge of the natural sciences with 'soft' features. Examples include: network technology, software technology, biotechnology, environmental protection technology, artificial intelligence technology, etc. All of these technologies are rooted in natural science knowledge but the addition of 'soft' features as they are transformed into products and services is the central determinant of their added value.

Category 3. Technology originating from the knowledge of oriental medical science and culture. Examples include: telepathy technology of humans for environmental change, Chinese traditional diagnostic and therapeutic technology, the three regulating technologies of breathing, heart and body in Qigong,[5] longevity extension technology and the diagnostic technology of ethnic minorities, e.g. Tibetan medical therapeutic technology.

Category 4. Technology originating from the knowledge of thinking science. Examples include: psychological training techniques, spiritual health technology, decision-making technology, systems technology and thinking technology, etc.

Category 5. Technology originating from non-traditional scientific knowledge. Examples include the knowledge of language, literature, philosophy, law, art, religion and special environment, including culture technology, entertainment technology, leisure technology and indigenous technologies.

Category 6. Technology originating from the intersection of the above fields of knowledge. These technologies are the most abundant examples of soft technology with the greatest potential.

2. Fields of Application

Based on our understanding that technology offers a means for providing services for social and economic progress, with practice as its aim, the following classification system for soft technology is appropriate.

Category 1. Commercial technology. Commercial technology is the process technology of creative human economic activity. It can also be thought of as technology to improve the efficiency of economic activities and to realize the economic value of technologies (both hard and soft technologies). Various technologies, such as exchange technology, currency technology, patent technology, accounting technology, stock technology, advertising technology, management technology, finance technology and incubator technology, etc., are cases in point.

Category 2. Social technology. Social technology is technology directed towards social activities and the social relations of human beings, who create value by exploiting and making use of social resources.

Category 3. Cultural technology. Cultural technology is directed towards human spiritual life and is a kind of innovative activity associated with culture. Distinctive technologies are involved in the process of creating, producing, managing and marketing cultures and also in the process of providing services to customers. Cultural technology can be divided into designing technology, producing technology, marketing technology and consumer technology. Examples of design and production technology, within the larger category of cultural technology, are music-producing technology, programme-producing technology, movie and television technology, sports performance, beautification technology, fashion technology, publishing technology, game technology, amusement technology, drawing technology, performance art technology, cooking technology, various 'chess art' activities and image design, etc. Marketing technology and consumer technology include cultural brokerage systems, advertising technology and organization and management technology in the fields of culture, art and sports and so on.

Category 4. LPFE technology. LPFE technology is the technology of 'learning through personal feeling and experience'. Examples include telepathy technology and dialectical therapeutic technology in traditional oriental medicines, such as the diagnostic technology that applies the skills of 'looking, hearing, asking and feeling'; therapeutic technology in traditional Chinese medicines; and the medicine of ethnic minorities, including Tibetan medicine.

Category 5. Soft-life technology. Soft-life technology is the technology of harmonizing physical health and spiritual health. For instance, longevity extension technology, health care technology, health technology and other examples of the ancient Chinese healing arts have been developed and applied to the human body in the sense of soft technology (see table 6). Soft-life technology is quite different from hard-life technology, such as gene technology or regenerative medical technology.

Category 6. Soft-engineering technology. Soft-engineering technology is technology for simulating and manipulating human systems and social systems within the framework of natural and artificial systems. Examples include software technology, network technology, artificial intelligence technology, ecological technology, environmental protection technology and social engineering, etc.

Category 7. Military-soft technology. Military-soft technology consists of military strategies and tactics.

Category 8. Political technology. The systematic organized behaviours of governments, political parties, social groups and individuals involved in domestic political affairs and international relations[6] - such as diplomatic technology or the activities of managing international, domestic and communal public affairs[7]- may be called 'political technology'.

3. Functions of Soft Technology

Having provided some working classifications of soft technology - based upon its sources of knowledge and its fields of application - we are now in a position to more systemically discuss the functions of soft technology. In particular, we may ask, 'In what ways does soft technology facilitate the provision of valuable services?'

1) Technology of intellectual development

Technology of intellectual development is used to improve and develop human intelligence and abilities, for example, education technology (providing and implementing the methods, concepts and content of education), learning technology and R&D technology. For instance, R&D technology is the technology that produces sources for technology. R&D includes the methods, means and processes of providing research results, new products, new services, new methods, new tools and new conceptions that have market value. It also includes the methods, means and processes of providing new systems, institutions, organization and management methods for research and development itself.

2) Technology of intellectual supply

The technology of intellectual supply is used to help people improve their problem-solving abilities and judgement by providing improved techniques for gaining and organizing knowledge, judgement, insight and experience - in a manner similar to that in which expert consultants and think tanks conduct their work, involving enterprise diagnoses, psychological consulting and health consulting.

3) Management technology

Management technology aims at improving people's ability to coordinate, balance and control the things for which they are responsible. Management technology covers a wide range of topics and a wide scope of organizational domains, from state affairs and international relations to industries, enterprises, families and individuals.

4) Organizational technology

Organizational technology refers to the means and methods by which organizational resources may be restructured and resource allocation may be optimized. It is also technology for improving efficiency in resource allocation within organizations. Enterprise merger techniques and virtual technologies are examples of organizational technologies. A merger is an external organizational technology that reorganizes the structure of enterprises vis-à-vis their external relations. Organizational modes, such as the straight-line organization, functional organization, straight-line plus staff organization, project organization, matrix organization, network organization and fishing net organizations are well-known types of internal organizational technologies. The joint-stock company is an example of organizational innovation which in many instances replaces partnership companies and sole proprietorship companies.

The mechanisms by which research institutes conduct their work are successful examples of R&D organizational technology. Before the nineteenth century, scientific research was the personal behaviour of scientists based on the interest of the nobles; therefore, R&D always depended on independent personal conception and invention. In 1863 Alfred Krupp, the German steel magnate, set up the first chemistry lab in the world. In 1876 Edison set up his lab and decreased the habit of scientists engaging in research all alone, organized a group of specialized talents, allocated tasks himself and devoted the group to one invention collaboratively, which helped him to obtain the patent rights of 1,093 inventions.[8] This ushered in the new age for scientific research.

At the end of the nineteenth century and the beginning of the twentieth, big companies in Europe established a number of industrial R&D laboratories (e.g. the Siemens Company, in Germany) fashioned after the practice of Edison. Later on the Dupont Company, AT&T, Westinghouse, Kodak and Standard Oil set up R&D institutes. In fact, the research institutes that appeared in industrial companies came about as a result of the growth of the above companies' personal workshops and testing places after inventors like Siemens and Edison became industrialists. Industrial research in the strict sense began after the 1920s. Between 1920 and 1960 research results from industries in industrial developed countries increased nearly a hundred times, 80% of the industrial scientific technologies were controlled by research departments of the above monopolized enterprises and most researchers belonged in the research institutes associated with the industrial and military sectors.[9]

As science and technology was increasingly used for military purposes, governments of various countries invested more in science and technology and interfered more directly in the conduct of science and technology research and this was one of the reasons why national research institutes were established. German physical engineering institutes were the first national research institutes to be established, commencing in 1887. After they were established, many governments worldwide set up a number of state-sponsored research institutes based on variants of the German model.

Research institute mechanisms helped build the interaction of science and technology and social development, which has played a key role in the industrialization of the great results of scientific and technology achievements in the twentieth century, thereby speeding up the process of economic development in those countries involved in the game.

5) Asset accumulation technology

The technology of asset accumulation provides ways of managing property and the incremental accumulation of property. To put it simply, it means the technology of how to make money and it includes various kinds of financial instruments, finance technology, share technology, venture capital technology, transaction technology, stock technology and trading technology. These technologies, together, are sometimes also referred to as 'financial engineering'.

The Japanese *Economic News Agency* published 'A General Guide for Financial Products' in November 1987, which summarized 107 kinds of financial products, including 26 used in banks, 10 in trust banks, 23 for stock exchanges, 8 for banks and stock exchanges, 11 for post offices, 9 for life insurance companies, 6 for insurance companies that deal with loss and damage, 2 for agriculture associations, 5 for other organizations and 7 for loan products. The financial products listed here serve as excellent examples of what we may refer to as the technology for the incremental accumulation of financial capital.

6) Technology of coordination and cooperation

The technology of coordination and cooperation is a set of methods for coordination, cooperation and regulation of the conduct of people in social and organizational activities based on behaviour science and economic principles. Examples include commercial contracts, information agreements, cooperation agreements and alliance contracts.

Cooperation agreements and alliances are effective means for modern enterprises to maintain or improve competitiveness and such arrangements often even extend to cooperation with current or past competitors. Larraine Segil, of the Lared Group in the United States, has proposed the idea of 'Intelligent Business Alliances'. In her work, she discusses at length the significance of alliance technology from many perspectives, such as the establishment of a pyramid of strategic relationships, value transfer in alliances, alliance competency and the mind-shift approach. [10]

Inter-organizational cooperation and alliances are a growing phenomenon in modern society. According to the results of a survey carried out by RAND,[11] pertaining to the field of academic cooperation, 33% of all the papers published in 1981 had more than one author and papers involving international or transnational cooperation accounted for 17 %. The two figures increased to 50% and 29% respectively in 1995. In other words, academic work - as one example of a field of cooperative activity- has increased in the degree to which it is carried out across organizational boundaries and international boundaries in particular.

7) Relationship technology

'Relationship technology' - the best known example of which is public relations technology - regularizes, channels and deals with all kinds of relationships and provides the norms that guide the relations between technology and technology, equipment and people and people and people. It incorporates the norms of international relations, interpersonal relations, diplomatic relations, family relations, conjugal relations, etc. All these technologies are directly related to morality, social ethos, cultural background, habits and knowledge levels and they are therefore regionally specific. Among relationship technology, public relations technology has already become a kind of discipline theory, specialized technology and industry.

8) Technology of propagandizing and inducement

The technologies of propaganda and inducement are technologies that are implemented with the expectation of influencing and manipulating the mode of conduct of human beings (involving decision-making at all levels) by promulgating new information, new ways of thinking and new lifestyles. For example, advertising technology is a technology that is employed with the expectation of inducing and changing the behaviour of consumers by promoting product-related or service-related ideas and concepts through media such as newspapers, broadcasts, mail and television.

9) Marketing technology

Marketing technology is a technology for analysing and generating new demands and consumption patterns. It is aimed at the development of new markets, new clients and new market channels based on research about the behaviour and psychology of customers. For example, client technology offers means for attracting customers, creating markets for customers and developing products and services while, at the same time, it may also provide ways of keeping customers and satisfying them. Sometimes customers are even incorporated into the enterprise as partners, trade agents or product agents (as in the case of what has come to be known as 'relationship marketing' or 'pyramid sales').

10) Design technology

Design technologies are technologies that convert new concepts, ideals and goals into operable plans or projects. Design technologies describe the pathway by which goals may be achieved. They can be categorized according to the different goals, objects and standards (economic, social, artistic, aesthetic, national and international, etc.) that they address: industrial design, enterprise design, product design, enterprise image design, construction design, image design for human beings, advertising design, fashion design, environment design, plot design, etc. Since ancient times, any successful construction design - i.e., architecture - has been seen as the quintessential embodiment of culture, art and technology, as well as strongly reflecting the cultural and economic background of that time.

11) Environmental innovation technology

Environmental innovation technology provides the content and basis for environmental innovations, consisting of the hard environment (material) dimensions and the soft environment (non-material) dimensions (see chapter 6 for details). Here, we refer mainly to the soft dimensions of the environment. Innovation in the soft environment means constantly creating and improving environments that are favourable to the realization of new concepts and initiatives, the speeding up of technology transfer for the realization of social and market value and efforts to help check those unfavourable, unjust and unfair behaviours that affect the environment. The most common expressions of soft environmental innovation take the form of tools, regulations, mechanisms, institutions, laws and policies.

12) Social technology

Social technologies are used to develop and make use of social resources that solve social problems. For more information, see the section about social technology in chapter 2 and social industries in chapter 5.

13) Cultural technology

Cultural technologies are used to enrich spiritual life and purify the soul. For further information, see the section about cultural technology in chapter 2 and cultural industries in chapter 5.

14) Beautification technology

Beautification technology is a technology that beautifies living conditions and life. It combines aesthetic standards, culture quality, morality and habits (towards beauty) with the psychological pursuit of beauty in human beings and makes full use of all the conditions that result from the modern hard technological achievement. It involves pursuing beauty, presenting and embodying personality, peculiarity and self-confidence for the satisfaction of spiritual demands. The fashion industry, the decoration industry and the beautification industry are all developed centred around beautification technologies.

15) Technology of personal independent creative space

This technology provides space for a wide range of personal independent creativity and provides opportunities for people to create freelance careers as, for example, musical producers, image designers, programme producers and hosts, independent film producers, all kinds of agents (technological projects, culture, sports, etc.), photographers and freelance writers. Nowadays, many young people prefer to set up their own companies rather than stay in big companies awaiting promotion. The enticing image of new millionaires emerging in new companies in Silicon Valley and also in some of the high-tech companies in China and elsewhere has played a role in the value shift that is taking place.

It is reported that since 1983 the number of new companies set up yearly in the US has never been lower than 600,000. Since 1986 the number of self-employed workers has increased by nearly one million. It is estimated there will be 12 million self-employed workers by 2010.[12] With the development of the market economy in China, this trend is also clearly apparent. Individual managers in cities and towns increased by 6.71 million in 1990 to more than 62 million in 1999.

16) Information service technology

The provision of valuable information to enterprises, individuals and society at large is the primary purpose of information service technology. Media technology is a way of changing the views and concepts of the public and guiding public behaviour by using all kinds of information-conveying means, such as news, broadcasting and television to transmit and explain the content of publicity. Modern information service technologies generally make full use of modern exchange facilities, means and tools, such as publishing, books, periodicals, newspapers, movies, broadcasting, television, telephone, telegraph and the postal service. The higher the technological content of these means, the better that hard means are integrated with soft ideas and the more advanced the information service and exchange technology is, the higher the benefits will be.

17) Physical distribution technology

Physical distribution technology creates benefits during the process of getting materials and products flowing, circulating and distributed through the economy.

The classification of the technologies mentioned above, according to their functions, is also portrayed in figure 5 as intellectual service technology, environmental innovation technology and spiritual life enriching technology.

4. Objects of Service

Service is the activity or function that can bring an individual or an organization certain conveniences and can be traded in the market. In other words, the service component in economic activities can, in themselves, be the object of transactions in the market for valuable productive activities.[13] Here the object of transaction is stressed for the reason that there are many service activities that cannot be the objects of transactions and, conversely, not all value productive activities ought to be thought of as service. For example, the domestic chores that belong to each member of a household cannot normally be traded on the market. However, if these activities are taken to a market to sell, they become service activities.

Now, we can try to cognize service from the soft technology perspective. For a long time, although people everywhere enjoy services, although service creates added-value over 60% of the world GDP, service is still the 'assistant sector activator' of primary and secondary industry for many people. This comes from a lack of understanding about the nature of service: service is not a technology and there is no core technology in the service industry.

'Service' is a process by which the demands of the one who accepts the service are satisfied through the necessary tools and means. Depending upon the definition of soft technology, the essence of service is soft technology and as one of the process technologies, the aim is to satisfy human demands: substantial demands, spiritual and mental demands, as well as the demand to promote the ability to problem-solve. Service is no longer a non-technological factor.

Therefore, service belongs to category of soft technology. It can be classified (according to the objects of service) into: service for organizations, service for enterprises, service for groups, service for individuals and service for society at large.

1) Individual service technology

Individual service technology focuses on services provided directly to end-consumers in the market. They can be further classified into: 1) technologies providing visuals (drawing, carving, dancing, etc.), auditory (music), sensational (limit sports, leisure, visionary environment and other feeling and experiencing activities) and audio-visual (movie, television) enjoyment; 2) technologies providing valuable methods or skills of spiritual enjoyment, such as art, music and fine arts; 3) technologies providing methods of how to spend time and improve the quality of life, leisure and resting times, methods and technique of games and the choice of mode of transportation; 4) technologies providing guidance for health, psychological consultation, etc.; and 5) technologies providing services that provide direct convenience to individuals.

2) Enterprises service technology

Enterprises diagnosing technology[14] and intermediary technology are enterprise service technologies with a long history. With the development of service technologies, service itself is constantly producing new service technologies until it becomes more specialized and elaborately divided. Logistics technology, incubator technology, all types of consultation technology, design technology, etc. are all service technologies.

3) Social service technology

Social technologies and culture technologies are examples of social service technology. With the coming of the information age, even time will become an expensive commodity and the development of computers, e-mail and Internet technology intensifies this trend. Hence, the value of service will rise constantly and more service technologies that have never been imagined will be developed.

With the development of intellectual services and the transmission of service to industries including manufacturing, the concept of service already transcends its traditional sense and the term 'service technology' is no longer adequate to convey the meaning needed to study the new concept of service and service innovation. Hence, I have not used the 'service technology' in this book.

5. Management Levels

Management technologies and all the soft technologies closely related to management can be classified as micro, media and macro levels and in terms of management levels, there are individual, enterprise, industry and state levels.

Management technology is one of the areas of soft technology that was developed earlier and is a special kind of soft technology. First, management technology infiltrates into and covers all fields of economy, society, organization and technology - similar to the way in which behavioural science has reached into all fields of the social sciences. In the final analysis, the object of management is humanity. Management is therefore not only a technology but is also an art, closely related to personal factors, such as judgement, insight and charm, moral character and human endowments.

Secondly, management technology is a kind of soft technology but not all soft technologies belong to the category of management technology. For example, education technology, design technology, culture technology, social technology and many of the business technologies are not a part of management. Even if some technologies closely related to management - such as organizational technology, market technology and corporate merger technology - were developed to adapt to

Figure 5: Categories of Soft Technology

- Soft technology
  - Intellectual service technology (broadly defined)
    - Intellectual development tech
    - Intellectual supply tech
    - Management tech
    - Organizational tech
    - Property increment tech
    - Coordination and cooperation tech
    - Relationship tech
    - Propaganda and inducement tech
    - Marketing tech
    - Design tech
    - Information service tech
    - Personal independent creativity space tech
    - Physical distribution tech
    - Social tech
    - LPFE tech
  - Environmental innovation technology
    - System
    - Mechanism
    - Institution
    - Policy
    - Law
    - Regulation
  - Spiritual life enriching tech technology
    - Beautification tech
    - Art
    - Entertainment tech
    - Sports
    - Media tech
    - Leisure tech

the ever-changing competitive environments surrounding enterprises, they still should not be thought of as part of management as such. Nowadays, many influential environmental factors cannot be controlled or 'managed' by enterprises and hence they should not be considered to fall within the domains of management and management technology.

It is predictable that the existing soft-technology field will further expand, divide and become further elaborated over time, in accordance with social and economic development.

Notes

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Chapter 4: Soft Technology and Innovation

In this book the functions of soft technology are classified into three categories, as summarized in table 7.

Tool of innovation. The first function of soft technology is to act as the process technology for technology transfer, technology commercialization and industrialization. In this sense, soft technology can be seen as a servant of the transfer, and even industrialization, of other technologies. Therefore, soft technology is both the tool and the content of technological innovation in general.

Key technology for independent industries. The second function of soft technology is to act as the core technology to create independent industries. An industry is an enterprise cluster that engages and links identical or similar businesses. If there is a technology that underlies and links the enterprises cluster, thereby adding value to their business, that technology may be considered to be a core technology of that industry. The core technology acts as a facilitator of industrial innovation.

Content and basis of institutional innovation. The third function of soft technology is to create an environment that is favourable for innovation in both hard technology and soft technology. As such, soft technology is the basis and content for the institutional innovation that accompanies industrial innovation and technological innovation.

Looking at the functions of soft technology in this way reveals the fundamental duality of its nature more clearly. Using the language of political-economy we may say that soft technology involves both the forces of production and the relations of production.

On one hand, because of its technological attributes, soft technology not only generates added-value and stimulates the formation of new industries but also provides directions, tools and means for innovation in hard technology (part of the *forces of production*).

On the other hand, owing to its 'soft' attributes, soft technology plays a critical role in determining the substance and content of new institutions. Hence it may also form the basis of institutional reforms, thereby assisting with decisions associated with adjusting the benefits distributional system and with changing, restraining and regulating various relationships in economic and social activities including the interest relationship (belonging to the *relations of production*).

Table 7: Functions of Soft Technology

A. Soft Technology and Technological Innovation

1. The Essence of Innovation is Soft Technology

According to Joseph Schumpeter, the path-setting economist who pioneered the development of innovation theory, innovation is about establishing new production functions; namely, it is about introducing a new combination of production factors and production conditions into the production system. The new combination, as described by Schumpeter, includes the following five cases:[1]

1) The introduction of a new good - that is, one with which consumers are not yet familiar - or of a new quality of a good.

2) The introduction of a new method of production - that is, one not yet tested by experience in the branch of manufacture concerned. This need not be founded upon a scientifically new discovery and can also be a new way of handling a commodity commercially.

3) The opening of a new market - that is a market into which the country in question has not previously entered, whether or not this market has existed before.

4) The procuring of a new source of supply of raw materials or half-manufactured goods, again irrespective of whether this source already exists or whether it has first to be created.

5) The creation of a new organization in any industry, such as the creation of a monopoly position (for example by setting up a trust) or the breaking up of a monopoly position.

Schumpeter also referred to these 'new combinations' - or innovations - as 'economic development'.

David Sawers further stated that technological innovation is 'the application of new technology to some practical purpose, or the new application of the existing technology for some practical purpose ... Innovation is characterized by its variety ... Innovation is a technological process, as well as a commercial process, military process, or social process.' [2]

Alexander King has defined innovation as 'the first successful application of science and technology in commerce and military affairs'. [3] He divided technology development into three stages: invention, innovation and dissemination. Invention is the emergence of a new concept and the application of science and technology to a particular purpose; innovation is the process in which invention is transferred to commodities and services; dissemination is applying innovation widely to an industry, or worldwide, thus contributing to the growth of industrial productivity.

The innovation process, as enumerated by Schumpeter, could be interpreted in soft technology 'language' to involving the following elements: 1) operating a variety of tools for technology transfer, such as productive technology, management technology and organizing technology; 2) the technology of creating markets; 3) the creation of new market channels or physical circulation and distribution systems around raw materials and products; and, 4) organizational innovation inside and outside of enterprises. From the view of soft technology, the above elements of innovation are part of soft technology activity. David Sawers emphasizes that innovation is process technology; Alexander King stresses that technology innovation comprises both technological activities and commercial activities and that the commercial activities constitute the technology transfer process of hard technology. King's definition of innovation comes closer to the definition of soft technology in this book. And the technology that can be transferred and transformed into commodities and services includes not only hard technology but also soft technology. There is no doubt that *the essence of innovation is the process of invention, innovation and dissemination of soft technology - in other words, it is the new application of soft technology*.

Therefore, the concept of innovation should be expanded from focusing on the material sectors of the production economy to include the non-material sectors of the production economy, from economic activities to social activities, from innovation aimed solely at economic benefits to innovation under the social and economic framework of sustainable development, from hard-technology innovation to soft technology innovation, including service innovation, institutional innovation and the integrated innovation of both hard technology and soft technology. That is to say, innovation theory should be endowed with a deeper and broader meaning than has typically been the case up until now.

Following Alexander King, we also need to recognize that invention and innovation are not the same thing; they are two stages of technology development. Invention is the emergence of a concept, thought or idea of some new (useful) technology; while innovation is the process through which end-users utilize new technology. In the case of soft technology, however, the boundaries between invention and innovation are very blurred, since soft technology itself is both the means and the content of innovation.

The following is an analysis of the relationship between soft technology and innovation from two perspectives. From the first perspective, soft technology may be seen as the tools and means of technological innovation. Each country and region faces the challenge of how to develop soft technology in line with its own distinctive characteristics. According to this perspective soft technology is a tool for innovation in hard technology. From the second perspective, soft technology forms an expanded innovational space in which integrated innovation in both hard technology and soft technology may occur.

2. Soft Technology Enables Innovation in Hard Technology

It is common for experts in the field of technological innovation to comment that technology from one context should not normally be copied ‘mechanically’ or applied indiscriminately in other contexts. Hard technology, however, can actually be ‘copied’ and it should be standardized. It is soft technology that cannot be applied ‘mechanically’. The most difficult challenges in applying advanced industrial and enterprise technology from foreign sources (including ‘foreign’ sources from both the home country and abroad) lie with soft technology, not with hard technology.

It is widely understood that technical knowledge may only be converted into actual products and services through the medium of technology. In order to insert technology into products, to expand the presence of products in the market and to enable enterprises to make profits, another series of 'technologies' is needed - to act as tools, or means, to insert and expand technologies into products and industrial processes. These technologies include the technology for protecting the inventor's interests, the technology of fund raising for high-tech industries, the technology for improving of the efficiency of transferring hard technology, the technology for improving customer service and for continuously improving goods and services (for the experience of customers). Only when the above 'intermediate' technologies are actively applied is it possible to commercialize technology rapidly and competitively. That is the reason why managerial innovation and technological innovation are often mentioned in the same breath, even though it is not appropriate to describe the above soft technologies as 'management'. We could say, in short, that soft technology provides the means and tools for a traditional sense of innovation. Soft technologies also act as the bridge for adapting hard technologies to contemporary circumstances. In order for a community to improve its overall ability in technology innovation, it must grasp and take full advantage of soft technology.

Soft technology is, in fact, a vehicle for moving technology from the outside to the inside of an enterprise or industry. In other words, it is the means for conducting technology transfer. Thus, soft technology is the tool for innovation.

An example from China - Zhongguancun, the High-Technology Development Zone, in Beijing - serves as an excellent illustration of the above principles. For some time arguments have raged about whether or not the development of Zhongguancun during the last decade was really based on technology, let alone high technology. Some say that it developed, instead, through '*trade(manufacturing)technology*.' Some people even say that Zhongguancun's 'electronic street' is a 'cheater's camp'. However, from the soft-tech perspective, trade is a process of utilizing commodity exchange technology and market technology to create benefits; manufacturing is a process of utilizing manufacturing technologies, organization technologies and management technologies comprehensively. Trade and manufacturing in Zhongguancun during the last decade has primarily been about applying soft technology processes in a special environment within China.

Before China's reform and opening up, Zhongguancun had already become a well-known educational centre and a national venue for research in natural sciences. With 68 universities and over 200 research institutes, over 30% of the academicians of the Chinese Academy of Science and Chinese Academy of Engineering are gathered in this region of Beijing. However, after 1979, especially during the past ten years, this region was no longer a pure research centre. It became a centre of a new type of economy, an incubator of high-tech industries and a centre for the commercialization of knowledge and technology in China, as well as a pilot and demonstration base for new things. The Zhongguancun's unique charm helps it attract many talented people from across the country and from abroad. Since 1990, the number of registered Zhongguancun residents has increased by 37% annually and by the end of 1998 Zhongguancun (the experimental zone of Hai Dian) had a registered workforce of 138,546, among which 8.27% had Ph.D.s and M.A.s, 36.8% were university graduates, 19.31% were college graduates and 12.95% were technical secondary school graduates. This zone contains nearly 9,000 enterprises of considerable economic scale, which are founded by Chinese science and technology entrepreneurs (over 900 of which were foreign-funded enterprises, joint ventures and cooperative enterprises). The growth rate of these enterprises is significantly greater than that of the national average: from 1988 to 1998 the total technical, industrial and trade income of the zone recorded an annual growth rate of 42.58% and the industrial output value of 48.66%; in 2000, the total technical, industrial and trade income amounted to 154.03 billion yen, increasing 46.8% compared to the same period in the previous year. For years, the average age of employees in scientific enterprises in the zone has been 30 and many bosses of small companies are only in their 20s.[4] Now the zone is full of change and vitality.

The reason why even greater, more fundamental, changes did not occur in Zhongguancun during the past decade is partly due to the lack of deeper links between trading and manufacturing. Under the planned economy, most enterprises had less inner demand for technology progress and they were weak in technology-transfer ability. In a sense, there were enterprises but no entrepreneurs. Those who mastered natural science knowledge and technology could not raise funds to transfer knowledge and technology to products or to endow them with market value because of the limitations of the environment. Nor could they turn products into commodities (in the market) or accumulate money for further innovations.

Therefore, during the era of reform and opening up in China, the road of *trade*(*manufacturing*(*technology* has been the common solution for people who have had no market economic knowledge and experience under the planned economic system. This gave them the opportunity to experience the economic laws of the market for themselves through the processes of trading, acting as agents, conducting assembly activities, copying and imitating... for the purpose of innovation. In this way, they became familiar with markets and by following these steps they carried out the design and production of their own products. In other words, they learned soft technology. If a sound macro environment for exploring and doing business did not exist, or there were no masters of soft technology available, innovation surely would not have advanced. The achievements of science and technology would have been doomed to remain as samples and as display items in a showroom.

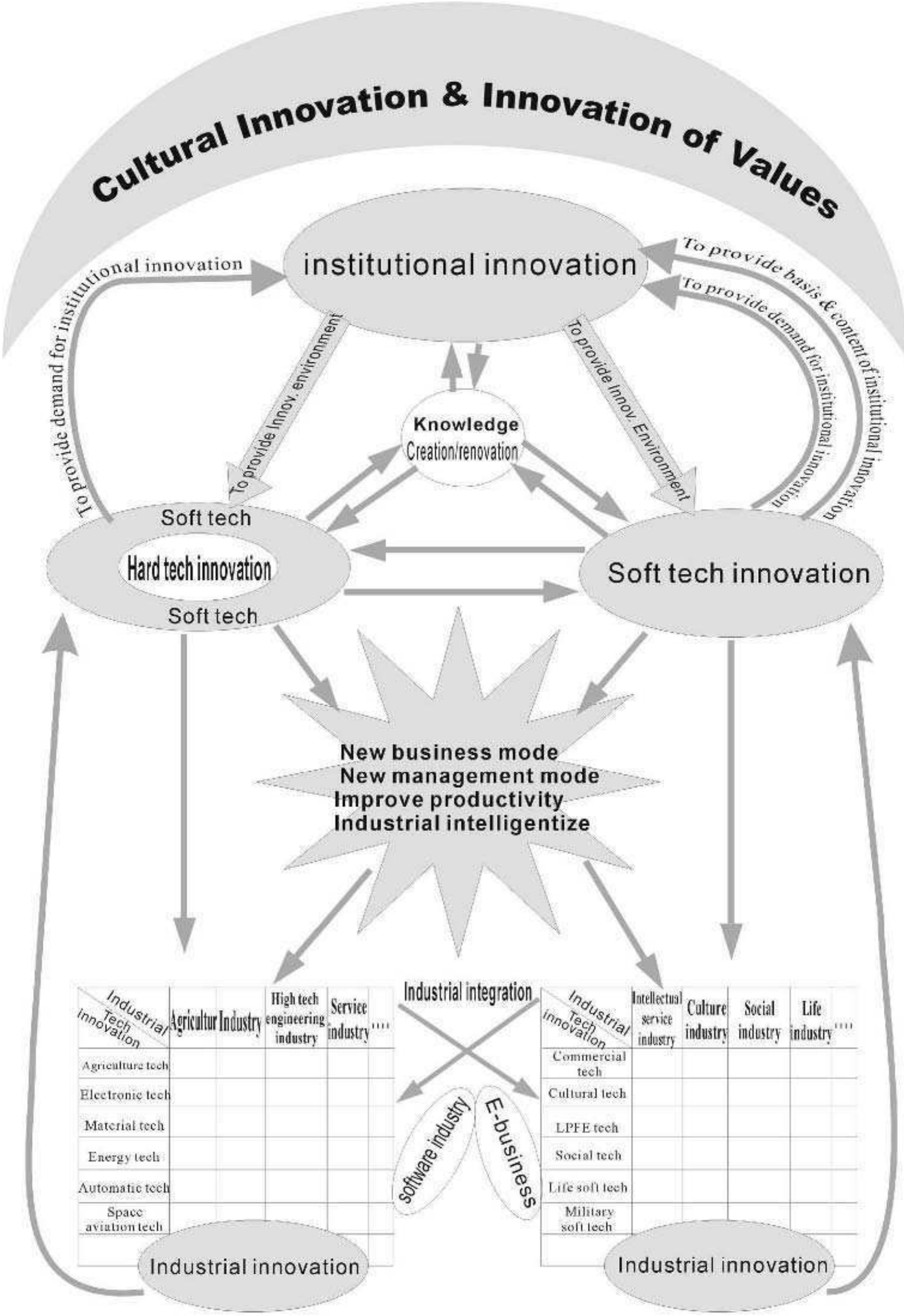
Thus, we can now understand that the past ten years in Zhongguancun have involved the process of Chinese scientists and engineers mastering and making use of soft technology to foster innovation capability under the new environment presented by Chinese government policy reforms. This capability could not grow from textbook knowledge. It had to be learned the hard way. Who can seriously claim that during the past ten years Zhongguancun has not created technology of its own?

3. Soft Technology and Innovative Space

From the perspective of soft technology, technological innovation should be viewed broadly. If there is a total of at least five approaches, in all, for innovation in hard technology, there will be a wider range for soft technology. Innovation in hard technology and soft technology is analogous to the development of the right brain and left brain in humans - they are the two essential wheels of technology innovation and neither side should be neglected. It is common for people to talk about technological innovation, managerial innovation and institutional innovation as if they were three discrete phenomena. In talking this way, however, they do not quite understand the essence and content of institutional innovation; and, in another sense, it is a misunderstanding of soft technology to simply classify it in the category of management. Moreover, the innovation about which they talk is aimed mainly at hard technology.

The success of Silicon Valley, in California, demonstrates that the integration and interaction of hard and soft technology innovation are keys to its success as a high-tech development zone. The University of California's Professor Martin Kenney points out in his *Institutions for New Firm Formation in Silicon Valley* that the Silicon Valley has the ability to periodically generate new industries and clusters. [5] This is the point where Silicon Valley differs from ordinary industrial clusters and cannot be explained by common industrial-cluster theories. Silicon Valley is 'not only a productive site for the creation of new firms, technologies and industries, but it also has fostered the development of innovative, new business models', some of which have been successfully used throughout the world. To be regarded as an electronic industrial cluster is just part of the picture of Silicon Valley; its key to success lies in the 'emergence of those non-technical institutions'. Martin Kenney believes that two kinds of economies exist in the Silicon Valley. The first economy consists of those 'firms, corporate research laboratories and universities that are the constituents of the existing economy, which are not unusual for any industrial cluster'. Their goals are, 'in the case of private firms, profitability and growth; in

Figure 6: Innovation System and Structure



the case of universities and non-profit research institutions success is measured in terms of research and education'.

In addition, there are a series of organizations in Silicon Valley that constitute the second economy, which set Silicon Valley apart from most other regional clusters and which are combined to create an 'economy' that is 'predicated on facilitating entrepreneurs in the creation of new firms'. Those organizations are engaged mainly in 'nurturing new firms and the transformation of quite informal business arrangements into institutions specialized in the delivery of specific services for new firms'. This is the reason why the second economy is so attractive for entrepreneurs and entire start-up companies from regions around the world locate in Silicon Valley. In fact, the second economy is generated from those organizations whose nature is institutional rather than corporate or whose nature belongs to what we might call 'social industry'.

Though the firms and universities that belong to the first economy do also initiate new independent firms or act as a source of entrepreneurs, in themselves these kinds of activities tend to lack continuity and are prone to miss opportunities since they tend to be rather fixed in the set of businesses and clients with which they deal. In Silicon Valley, venture capital investors, investment agencies, venture banks, recruitment companies, law offices, accounting offices and sales companies combine to form a strong network for the second economy. Of course, it is difficult to distinguish clearly between the first and second economies because they are interdependent and interwoven. Nevertheless, for second economy organizations, entrepreneurs are the initial and essential investment (their ideas and contributions) and venture capital is the second most important investment, as well as the main source of capital.

The process by which the second economy has emerged, as proposed by Martin Kenney, is actually the process of forming soft-tech industry. Kenney's second economy is the intellectual service industry and those activities that create new business models and new firms are the innovational activities of soft technology. Now Zhongguancun has also begun to form a second economy but soft-tech industries have not been consciously promoted and developed and the interdependent organic ecosystem has not been properly formed in Zhongguancun owing to a lack of understanding of soft technology.

Therefore, an understanding of soft technology will greatly enlarge technological innovation space. As is shown in figure 6, technological innovation space, in general, may be divided into hard-technology innovation, soft-technology innovation, industrial innovation, institutional innovation, business model innovation and the integrated innovation of soft and hard technologies, together with the updating and creation of knowledge. Since people are more familiar with hard technology, the following discussion is mainly about soft-technology innovation.

1) Innovation in soft and hard technology. In our classification system enumerated earlier, 17 major functions of soft technology were identified. Each category of soft technology is a domain in which new technologies, new products and new markets may continuously be developed. What needs to be emphasized is that hard technology innovation cannot be separated from soft technology and cannot exists on its own, in isolation. That is to say, hard technology innovation must depend on soft technology as its means.

2) Industrial innovation. Industrial innovation here refers to the formation of a new industry or to the reform and upgrading of an old one. Increasingly, soft technologies function in a manner similar to that of many hard technologies, as core technologies in the formation of new industries. Especially with the coming of the information era, cultural industries and social industries have been formed, in addition to the various intellectual-service industries that are now well recognized. Soft technology has also integrated with high technology to form industries such as the Internet industry, the software industry and various ecological industries, etc. In the same way, innovation in hard-tech industry may not happen without soft technology because the process of the formation of new industries, in which hard technology is the core, is actually the process of applying soft technology.

3) Knowledge creation and updating. In the previous section, I enumerated six sources of knowledge. The continuous process of creation, production and updating of knowledge will constantly generate new technologies and the invention of new technology and technological innovation in turn will enrich humanity's knowledge.

4) Institutional innovation. Institutional innovation means substituting new institutions for the old ones or the process of establishing new institutions according to the requirements of social development and technological progress (for details, refer to the later part of the chapter on institutional innovation). Technological progress and the application of new technology constantly generate the need for institutional innovation, and institutional innovation, in turn, generates an environment for technological innovation. The basis and content of institutional innovation are provided by the constant development of soft technology.

5) New business models and soft technology. New business models, which result from the interaction of different innovations, will directly change the pattern in which the economy operates. It is generally recognized that the core of compe-

tition between enterprises is technological innovation (usually thought of as hard technology innovation) and the development of new products. However, this is only a partial view of competition. The basis of competitive advantage may be found in the operating mode of an enterprise and in whether or not it adapts to new business models. If the social, economic and cultural environments change, enterprises will need access to new business channels and to new ways of doing business; a new regulatory environment for firms will also be needed. If the benefits of adopting such innovations are better than sticking with the old situation, they will be adopted by most enterprises; and they will be regularized and improved incrementally, thereby establishing a new business model. Meanwhile, the development of hard technology, such as electronic technology and communications technology, provides opportunities for new business models, e.g. e-commerce. Strictly speaking, e-commerce is also a kind of institution or the integration of new institutions that is supported by relevant soft technology innovations but it does not have as much constraining force as normal institutions, nor does it need government approval. However, it does involve a wide range of commercial technologies.

6) Soft technology innovation and hard technology innovation provide innovation tools for each other. Every field and function of soft technology generates new objectives, new meaning and new space for innovation, resulting in the endless generation of new technologies, industries and jobs that may act as sources for economic and social development. Many Chinese companies suffer from the 'disease of project famine' - their growth is retarded by the outdated thinking of their managers who believe that hard technology projects (hopefully 'high technology') are the only way to make profits.

7) Culture innovation and innovation of values. See details in 'Cultural Innovation' in section C of chapter 6.

B. Soft Technology and Institutional Innovation

For a long time, economists, scientists and sociologists have studied the institution from a variety of perspectives. The subject of institutional economics was very popular in the US during the 1920s and 1930s. New institutional economics emerged in the 1970s, causing economists to study the contribution of institutions to the development of the economy from different points of view, such as property rights theories, transaction costs, trust agents and contract theories. For example, Douglass North believed that a series of institutional changes paved the road for the industrial revolution, a fundamental change for human society. Institutions are also studied in science and technology fields because they are among the most significant driving forces of technology: they not only set the basic conditions of technological innovation but they also determine the allocation mechanisms of the income generated through innovation. History is replete with evidence that the social and economic development of nations involves continuous reformation and that institutional innovation is at the core of social and economic reformation.

David S. Landes discusses the importance of institutions in his book *The Wealth and Poverty of Nations* in which he analyses the resistance to technological progress that has been observable in China and other ancient civilized countries.[6] He points out that this resistance comes not from lack of innovation but from institutional ossification.

What, then, is an institution? What is the essence of institutional innovation? It is important that we understand the contrasts between different categories of institutions, especially as they affect innovation.

The *Comprehensive Dictionary of Chinese Language* offers three dimensions of explanations for institutions: 1) rules requiring all members of a community or organization to stand by and do things according to certain procedures; 2) political, economic and cultural systems that are formed under certain historical conditions; and 3) large scale of moral standards in the political sense.[7]

From the perspective of institutional economics, Douglass North, the primary representative of the new institutional economics school of thought, proposes that institutions are a series of formulated rules, law-abiding procedures and moral criteria of conduct, which aim to restrain the behaviours of individuals and are directed towards seeking aggregate social welfare or the greatest marginal benefit,[8] and that institutions are the games rules of a society.[9] V.W. Ruttan,[10] another representative of the school of new institutional economics, points out that an institution is a code of conduct that is used to control a particular behaviour pattern and mutual relationship. Wolfgang Kasper and Manfred E. Streit of Germany think that an institution is a code of conduct and that it thus becomes a means to guide people's behaviours. [11] It usually excludes some behaviours and limits possible reactions. Therefore, institutions make people's actions foreseeable. Institutions are regulations made by people, that restrain random and opportunist actions in interpersonal relationships. Institutions decide to a large extent how people should realize their goals and whether or not they can realize their basic values.

To summarize, an institution is a complex system of a series of codes of conduct and standards, which is used to limit and regulate people's mutual behaviours.

As institutions establish the behaviour rules of people, they can be classified according to what behaviours these rules concern (encourage or restrict) into religious institutions, political institutions, social institutions, economic institutions, technological institutions and others.

Religious institutions restrict people's behaviour regarding religion and they offer rules that restrict people's beliefs; political institutions are the rules that govern political authority and the allocation of social resources and income; social institutions restrict and formalize people's behaviours in social activities and social lives; economic institutions restrict and formalize all kinds of relations in economic activities, including property rights delimitation, relations of business and competitions, economic organization and property allocation, etc.; technological institutions encourage or restrict all kinds of behaviours in scientific research, technological invention, technological innovation and technology expansion.

This book focuses on economic and technological institutions. It analyses how institutions come into being, what the content of institutions is and what the relationship is between institutional innovation and technological innovation from the perspective of a broad understanding of technology.

Familiar behavioural rules include regulations, mechanisms, institutions, policies and all kinds of standards. Generally speaking, laws are behaviour rules made by legislative bodies that are guaranteed to be carried out by state power; policies are the regulated criteria for making decisions about actions and are established by government for accomplishing tasks in a certain historical period. There are a variety of types of regulations but regulations normally refer to 'the government behaviour of controlling the actions of citizens, juridical persons and subordinate organizations of the government'.[12] Some commentators also portray regulations as rules authorized by law through government administrative organizations that restrict and supervise behaviours of enterprises active in the market. Generally, systems are created from a set of institutions that exhibit special relations among themselves.

It is obvious that different kinds of institutions interlink and overlap and it is difficult to distinguish among them. The main body through which an institution is established may be either a governmental or non-governmental organization, according to the situation.

For convenience, the term 'institution' will be used here to cover regulations, institutional mechanisms, institutions, policies, the rule of law, laws and standards, etc.

1. Institutions are a Means of Regulating Soft Technology

From the point of view of soft technology, when people's behaviours in the process of soft technology development (including invention, application, creation, added value and appropriating benefits) are regularized, routinized and made into publicly recognized rules of behaviour and social rules, then the corresponding institutions or institutional mechanisms have been formed.

Institutional innovation means changing or creating new work routines or behaviour rules to replace the old ones according to the requirements of the application of new soft technology. It may involve new application requirements of existing soft technology and may incorporate international, national and local conditions. International circumstances, economic and technological levels of development, values, ethnic morality, social norms, religious beliefs, language, culture, social organizations, administrative systems, the role of the government and the natural environment are all important factors for institutional innovation.

Through the above vehicles (the relationships between soft technology and institutions), the second attribute (the relations of production) of soft technology is manifested. Conversely, institutions (the relations of production) are dualistic. They have two basic technological attributes (the forces of production): first, institutions are not goals in themselves, they are only means to dominate given behaviour modes, to restrict interactive behaviour and to realize basic values; second, they provide service of many kinds, in the economy, in politics, in society and in technology; and, as such, they are therefore a dimension of technology, broadly defined. We can say that the institution is the operational regulation of soft technology and a kind of 'product' of soft technology.

Institutions serve economic activities. Such institutions include market economy institutions, proprietary institutions, enterprise institutions, accounting institutions, interior bylaws and regulations of enterprises. Institutions also serve societies, e.g. various kinds of social security institutions, the laws of leagues, association institutions, the laws of non-profit organizations, the laws of publications, etc.

However, we should distinguish between institutions and soft technology because institutions are the operating rules of soft technology. In other words, they are the control 'technology' of soft technology - the 'technology' of technology.

Soft technology is in fact a 'game', in economic terms, i.e. soft technology is technology making 'games'. The invention and creation of new soft technology is therefore the invention and development of new 'games' and institutions are the game rules that correspond to the operation rules or procedures of soft technology.

Now let us review the correlation between soft technology innovation and institutional innovation.

For the purpose of inventing or 'producing' soft technology, a concept or an idea is first needed. However, the idea or the concept is not actually soft technology because it is not, in itself, operable in a practical sense. If, however, through experimentation or experience, a way is found to convert the concept or idea into a practical operational system (or operational mode, operational procedures) for solving problems, then we may legitimately say that soft technology has been created.

Soft technology can provide the means for encouraging innovation, thereby increasing productivity; it can connect hard technology with products, thereby realizing its value; and it can help products to gain market value and large-scale implementation. These outcomes can be accomplished, for instance, through such means as exchange technology, trade technology, management technology, organizational technology, accumulation technology of human resources, competition technology, cooperation technology and patent technology.

As soft technology becomes popularized and implemented on a broad scale in society, it is necessary for institutional innovation to take place. This is because soft technology always involves the three variables of human factors, social factors and cultural factors. Owing to these factors, any changes in soft technology always require changes in organizational structure, patterns of economic operation, modes of social activity, values and the relative roles, positions and interests of individuals and groups in the community.

For instance, the application of commercial technology is usually accompanied by competition in the market. To become more competitive companies rely not only on improving the performance of their enterprise internally (e.g. by increasing efficiency, improving the quality of products and services, or acquiring new knowledge and talent). They also employ new external means to improve competitiveness (e.g. adopting new corporate strategies, employing competitive intelligence or pursuing merger techniques, virtual organizational structures, advertising technology and public relations, or even using head-hunters to 'steal' talent from rivals).

Competition can be an effective way to promote industrial development but sometimes companies engage in immoral, divisive or criminal tactics as part of competition (e.g. the dishonest financial reporting or accounting scandals, as recently revealed in the cases of Enron, Arthur Anderson, WorldCom and others in the United States), thereby damaging normal market order. If free competition is not restrained, unscrupulous application of soft technology may lead to widespread damage to the market economy and to the suffering of innocent people and organizations as collateral for competitive advantage of the minority.

Figure 7: Institutional innovation and the procedure of soft technology innovation

Hence, when new soft technology is disseminated, it becomes necessary to establish certain relevant institutions or abolish others. For example, the Antitrust Act was established in the USA in 1914 to address the need to standardize merger technology; and in 1933 and 1934, the Stock Act and the Stock Exchange Act were established to address the need for standardizing stock technology and the stock market at the climax of enterprise mergers during that period.

It is important for the relative merits of alternative institutional designs to be properly evaluated. Common evaluation principles include whether or not the institution favours creativity and invention, supports strongly defined property rights, improves cooperative or competitive relationships among individuals and groups or facilitates income growth by positively affecting economic size and the reduction of transaction costs. If the rate of returns and net efficiency with the new institution supported by new soft technologies will be higher than it was with the old, then institutional innovation is feasible and appropriate. In a healthy innovative environment, an endless cycle of soft technology innovation will take place: soft technology invention (innovation (diffusion (application (regularization (institutional-change(breaking with the old. Within a healthy innovative milieu soft technologies and relevant institutions will always be subject to change.

To keep fair, equitable and healthy competition going, government, social organizations and industrial organizations must positively enact implementation rules and game rules of soft technology to encourage or constrain some organizational and individual behaviours according to the international, national and local situations and according to the particular purposes or affected range of the institution. In this sense, institutions are a technology for controlling and managing technology.

There are two opposite schools of thought in the field of institutional economics:[13] one emphasizes that institutional change relies on technological change, while the other emphasizes that technological change relies on institutional change. The opposition of these two points of view is an artificial dichotomy. Without soft technology, innovation in technology (understood here as hard technology) is impossible to realize. Hard technology cannot automatically add value in the economy. When the need for the application of new hard technology arises, or the need for new applications of existing hard technology arises, then the need for invention and creation of soft technology will also arise; and questions will also arise about how those existing soft technologies should be applied in new fields. Continuous R&D and innovation in soft technology result in the necessity of constant institutional innovation. In this way, new technology, or the new application of existing technology, provides bases and content for the birth of new institutions. Soft technology innovation is therefore the ball and chain between institutional innovation and hard technology innovation.

The debate in institutional economics may be resolved in this way: innovation in hard technology relies on innovation in soft technology, while institutional innovation relies on soft technology innovation. Figures 7 and 9 illustrate the mutual relationships of these phenomena. The study of the process of soft technology innovation and institutional innovation also clarifies what institutional economists have said regarding the correlation between technological change and institutional change.

We may quote V.W. Ruttan, as follows: 'The conversion of supply for technological change and institutional change is formed by a similar force, the progress of science and technology knowledge lowers the cost of the new income flow caused by technological change, the progress of social science and related professional knowledge lowers the cost of the new income flow caused by institutional efficiency income (including improved skill in settling conflicts).' 'The social science and related professional knowledge' that he mentions here is, in fact, a part of soft technology progress.

In conclusion, the application and diffusion of soft technology to a wide variety of organizations, regions or domains, is generally concomitant with the regularization of soft technology. Namely, the application of new soft technologies, or the new application of existing soft technology, creates pressure for new institutions to emerge. This is why we can say that soft technology innovation is the basis and content of institutional innovation.

2. Enhancing Research and Innovation in Technological Institutions

Owing to the lack of interdisciplinary cooperation between experts in the social sciences and experts in the natural sciences, scholars who have studied institutions have neglected technological institutions. Once the concept of soft technology has been understood, however, it is possible and necessary to conceptually separate technological institutions from economic ones. This, in turn, makes it possible to conduct systematic research on the design of optimal technological institutions (including system of laws, standards and policies that pertain to technology) for the purpose of further promoting technological innovation, in the broad sense.

While it may be difficult to distinguish between technological institutions and economic institutions, the two types of institutions nevertheless differ quite significantly. Furthermore, with the rapid development of technology, the systematic study of technological institutions bears more and more significance.

Technological research and development activities have become increasingly linked to scientific research activities and are difficult to differentiate from those activities. Scientific research activities themselves also face institutional requirements when their results are applied in practice - in other words, as they get translated into technology. However, some contemporary scientific fields, such as genetics, are perceived as having potentially significant implications for the structure of society, morality and ethics, lifestyles and human civilization, even before they reach the stage of applied technology. Laws are therefore needed to direct and control such research from its beginnings and sometimes such laws even need to be international in scope (e.g. the strict prohibition of experiments involving cloning of human beings by all countries). In such cases, institutions need to be developed earlier than is normal in natural science research.

Although technological activities differ from scientific research activities in the sense that they are intended to directly contribute to economic and social development, they are nevertheless not, strictly speaking, economic activities themselves. The motivations of a great many scientists and technologists are not primarily economic in nature. They are often more about gaining a sense of achievement by way of invention and innovation, about self-fulfilment and social fame, or even simply about personal interests, namely, non-economic motivations. As a consequence, the normal kinds of economic institutions may not be very suitable for controlling the behaviours of scientists and technologists.

As the influence of technology in society has increased, normal people have become more aware of the significance of research and development. The era when large-scale technological research and development projects were controlled and funded mainly by governments has passed. The widespread contemporary interest in seeking business success through technology has increased the role and influence of private enterprises, private individuals and non-government organizations investing in technological research, technological innovation and technology commercialization. This, in turn, has increased the importance of strengthening (or relaxing) the regulations pertaining to science and technology.

The Japanese Trade Promotion Committee, asked by the Japanese Academy of Industrial Technology, has conducted research on the institutional requirements of science and technology by surveying many institutions that influence science and technology activity.[14] Take the United States as an example:

Institutions influencing R&D activities and the development of infrastructure:

- Regulations concerning research projects (related to political purposes, environmental pollution, economic profits and moral values);

- Regulations concerning methods and agreements of research (related to human health and security, protection of animals used in experiments and environmental protection);

- Regulations concerning the spread of scientific knowledge (keeping certain levels or fields of science available, protecting economic interests, personal health, privacy and security and national military and economic security).

Institutions that indirectly restrict R&D activities:

- Regulations for federal research organizations and their research activities (the restriction on individual researchers, such as incentives and payments and restrictions on federal researchers, restrictions on research organizations of the federal government or those funded by the federal government);

- Regulations for cooperative research and development (related R&D laws including Steven-Wydler Technology Innovation Act of 1980, Federal Technology Transfer Act of 1986, National Competitiveness Technology Transfer Act of 1989, Bayh-Dole Act of 1980, policies and Anti-monopolization Law pertaining to cooperative development);

- Regulations for technology transfer and intellectual property rights (intellectual property rights for the inventions of federal employees, property rights of patents owned by the federal government, central management of the supply of patents and property rights, cooperative development agreements and technology commercialization, etc.);

- Privatization of public research organizations.

Other institutions and regulations that influence R&D activities.

In modern society, new hard technologies are emerging every day and soft technologies are also changing quickly. The rapid pace of technological innovation is creating pressure for research on technological institutions and also on innovation in technological institutions. People are aware that technology can bring human beings blessings as well as various disasters. For example, nuclear technology can provide efficient and clean energy as well as the most dreadful weapons of mass destruction. However, as discussed earlier under the heading of 'Characteristics of Soft Technology', it is unfair to blame 'technology' for all these situations. The blessings or disasters produced by hard technology are dependent upon the behaviour of humans who manipulate the technology or are dependent upon the soft technology controlling hard technological innovation. Therefore, it is necessary to adequately develop the positive aspects of new technologies while taking measures before hand against their potentially negative or even disastrous impacts. This, of course, places even more importance on the task of developing specific institutional innovations for the emergence and development of new technologies and new industries. In other words, the process of the application and industrialization of any new technology (hard or soft), such as biological technology, robotic technology, nuclear energy technology, gene technology, cultural technology and emerging intelligent service technology, all need the support of related soft technologies. As a result, the need for regularizing soft technology also arises. Therefore, the joint effort of hard and soft technology experts is needed to discuss, conclude and summarize the related requirements of technological institutions in the process of operations.

Take the development of cultural industry as an example. Owing to the dual value of cultural technology, regulation of cultural industries, in the form of company law, anti-monopoly law, etc., is needed, just as is the case for all other industries. In addition, copyright law is especially pertinent to cultural industries. The publishing and printing of all publications, the production and playing of movies, television and broadcasting programmes and the creation and the performing of art programmes - in other words, the 'products' of cultural industries - are all afforded protection under copyright law. Furthermore, many countries have laws aimed at creating moral conditions in cultural industries. For instance, there is an Illicit Publications Law[15] in Singapore that restricts and controls the content of publications and many countries ban the production and spread of books and programmes with pornographic and violent content.

Japan is sometimes called the 'Kingdom of Robots,' owing to the fact that it owns almost 60% of the world's industrial robots. More than 20 institutions, rules of laws and projects concerning the development of robots have contributed to their striking development in Japan. Listed below are some of these examples:

- Loan system enhancing short-term investment (started in 1992) is used to encourage investments in labour-saving equipment. Investors can get long-term cheap credit from the Japanese Development Bank and the Northeast Development organizations in Hokkaido.

- Temporary Measure Law promotes special enterprises' innovations (Business Innovation Law) stipulating industrial robot users who meet the specified conditions in this law, which can allow the users to receive special compensation and extremely soft loans.

- Non-interest loans promote the popularization of industrial robots and their applications and encourage the development of high-level industrial robots and their applications by providing necessary non-interest loans to manufacturers for the expense of machinery manufacturers and corresponding software developments.

- Registration system of robots and engineering technological enterprises, with formal enterprise members and sponsoring enterprise members of the Japanese Robot Association as its object, provides consultancy and technical guidance to help those industrial robot users solve all kinds of economic and technical problems.

- Technology development projects to improve the working environments of SMEs, loans for equipment of modernized SMEs, interest compensation systems for loans used for industrial robot equipment, subsidy system of industrial robots, etc., are all used to encourage SMEs to introduce robotics systems, improving their working environments, preventing work injuries and enhancing the competitiveness of enterprises.

- Credit insurance system of instalment and loans in the field of machinery employs instalment and credit insurance systems to equip SMEs with modern equipment and reasonable management so as to achieve the goal of vitalizing mechanical industry.

- Robot insurance and damage insurance companies (21 domestic and 24 foreign insurance companies provide robot insurance in Japan). The insurance covers all parts of the industrial robot body, software, robot peripheral equipment and semi-manufactured products.

- The Manufacture Science and Technology Centre and the Mini Machinery Centre are set up to promote the research and development of robot technology and FA technology.

Another example may be found in the financial collapse of the American company Enron and its relationship with the Anderson Consulting Company, a topic that was a front-page event in the business media during 2002. This incident not only illustrates the importance of institutional innovation for business enterprises and for innovation in accounting laws, it also poses a challenge to the fast developing intelligent service industry (i.e. the need for pertinent soft technology innovation and institutional innovation).

The process of designing, evaluating, establishing and implementing technological institutions is very complicated and there are institutional requirements associated with all aspects of scientific research, fundamental technological research and applied research associated with technology development and commercialization. The complexity of technological institutions and the difficulty of managing them is at least as great as that of other kinds of institutions. In addition, the boundaries of institutions at different stages of development may overlap. For example, gene technology creates a bright future for medical developments and human health; however, at the same time, its impact on ethics and social security will make people shudder with fear and its challenge to the law is also unprecedented. Laws and judicial practices related to genetics are not isolated from international laws, different political systems and legal systems, economic development issues and the cultural backgrounds of different countries.

With recent breakthroughs in the life sciences, most countries have strengthened their research concerning life, ethics and the issues of human rights protection. The United States established its fundamental framework for the regulatory system pertaining to the life sciences and medical care in the early 1970s. Related research organizations and institutions were subsequently established, for example, the DNA Reconstruction Advisory Committee (RAC) of the National Institutes of Health (NIH); National Biological Ethics Advisory Committee (NBAC) under the leadership of the president; Ethic, Legal, Social Problems, Investigation Programme (ELSI), centred around research on human gene groups; the Institutional Research Board (IRB) system; etc. These groups actually conduct the advanced soft technology research and development that is needed for the future development of the life sciences and are undertaking the related institutional innovation. Accordingly, the budget in the US during 2001 for these kinds of activities was 18.8 billion US dollars, an increase of 5.6% from 2000.

As to the security of transferred gene biology, all governments and international organizations currently attach importance to the creation of laws to govern the transfer and security of biological/genetic materials. The manner in which this is accomplished varies internationally, according to differences in technological levels, economic interest and cultural backgrounds and public acceptance.

Although China has attached importance to research in this field in recent times (e.g. the Applied Ethics Research Centre was formed in the Chinese Academy of Social Science), there is still a great gap in soft technology research aimed at the application of gene technology, especially in the area of institutional arrangements. There is a lack of systematic laws, regulations and other related institutions concerning the research, development, application and industrialization of gene technology and the use and protection of genetic resources. Because it is lagging behind in lawmaking for the protection of genetic resources, China failed to protect part of the gene map of its own population. One foreign organization has defrauded China of more than 10,000 blood samples 'in ignorance and passion' under the guise of sponsoring a health project. The patent for the gene associated with asthma has consequently been applied for by people outside China, even though the resources for the work came from China. These are two example of where China has lost some national advantages owing to a lack of advanced soft technology research. As a result, China has not only lost the opportunity of turning genetic resources into wealth but has also lost the above mentioned genetic research asset.

Technical standards are among the technological institutions that affect the relative competitive advantage of firms and nations in industrial development. The ones who control, or own, the process of establishing related technical standards will tend to dominate the market by manoeuvring for their standard to become the dominant one. Part of the great value of technical standards is that they enable generalization and interchangeability of product parts and technical components across organizations, regions and countries. Increasingly, however, technical standards will become the main form of non-tariff barrier.

Why does the traditional Chinese medical manufacturing industry, which has accumulated more than 2,000 years of experience and has more than 300,000 classical prescriptions and 6,500 factories producing medicines, account for only about 3% of the international trade in Chinese traditional medicine? One of the most important explanations lies with the fact that there is a lack of standards for all the linkages between different aspects of the Chinese traditional medicine industry, from planting, to harvesting, to production and to distribution. Similar problems have also created the so-called 'green barrier' for the exportation from China of food, ceramics, leather, tobacco, vegetables, mechanical and electronic products and toys - thereby leading to many missed opportunities for the Chinese economy.

The field of pharmaceuticals provides an excellent illustration of the salient issues. Technical standards are usually created by foreigners and executed by the Chinese.[16] However, there is a challenge and an opportunity for China to do something to reverse its misfortunes in this area. An example of what might be done is the GEP standard ('Good Extracting Practice' standard) of the Chinese traditional medicine industry, which was first pushed forward by the Tianjin Tianlishi Group. The GEP standard is designed to take into account the peculiarity of the Chinese traditional medical system. It is also the first occasion of a Chinese company setting the rules of the standards game in the international pharmacy field. Hopefully, many more examples of this kind of institutional innovation will soon emerge in China and other developing countries.

3. Conscious Research and Development in Soft Technology

1) There is an essential difference between conscious and systematic innovation and the stimulation of an accident or incidental single project. From the initial concept to the operable solution - involving the birth of basic technology, through invention of technological products, then through innovation and eventually to market extension - technology commercialization is a long and complicated process.

The steam engine is an example. Denis Papin, a Frenchman, designed the first steam engine in 1687. The first equipment for driving water pumps by using steam to make a vacuum was invented by Thomas Savary, of Britain and he gained the patent for the steam pump (the Miners Friend) in 1698. In 1707 Papin published a book on steam engines. In 1786 Jonathan Hulls of Britain received the patent for the steam engine boat. In 1765 James Watt of Britain invented the condenser and revolutionized the steam engine. In the mid to late 1780s, James Fitch of the United States conducted some important experiments with steam-powered boats, paving the way for waterpower transportation in the early nineteenth century.[17] The end of the nineteenth century witnessed the replacement of sailing vessels with the steam engine; however, even until 1880, most of the large cargo shipments worldwide were transported by sail vessels.[18]

Take the application of steel and iron in the field of transportation as another example. Benjamin Huntsman of Britain invented the crucible steel-making method; R. Reynolds of Britain designed the cast iron railway in 1767; in 1784, Henry Cort of Britain invented the puddle method of steel-making technology; in 1811, Germany established the Kelubo Iron factory. In 1822 Britain launched the first iron ship. In 1825 the first railway in Britain was built and put to use; in 1830 the American railway was open to traffic; and railways were put to use in France in 1833 and in Germany and Belgium in 1835.

Historically, it has taken almost a hundred years or even several hundred years for a revolutionary technological invention to become widely used. The slow pace of technological innovation stemmed mainly from the fact that the incentives for developing new technology were only incidental. Under those circumstances -

where, as Douglas North [19] has pointed out, systematic property rights in the field of innovation did not really exist - technological inventions could be imitated at very little cost and the inventors would often go without reward.

However, property rights were not the only reason. It is very interesting to analyse why the first industrial revolution was centred in Britain, rather than in Portugal and Spain, which were the overlords of that time. The Portuguese and Spanish accumulated great wealth by exploiting the colonies by monopolizing trade with the Orient, pirate robbery and the slave trade; and they were also the owners of shipbuilding technology, navigation technology and compass technology. It is also interesting that the first industrial revolution did not happen in either the Netherlands, which was the overlord during the first half of the seventeenth century, nor in India, which was the number one textile industry giant of that time.

The pre-conditions for the industrial revolution in Britain can be traced back to the thirteenth century. David S. Landes, who has analysed many aspects of the background of the revolution, has identified a number of features of the political and social system of Britain over several hundred years that played a role, including the elimination of slavery in the fifteenth century and the overall economic management mechanisms that emerged in a distinctive manner within that country. Other examples are the road and canal systems that were all built and managed by private enterprises; agricultural development, especially the commercialization of agriculture; urban and rural life; the initial formation of industrial clusters; a culture that favoured punctuality and time-saving; and loose immigration policies (in the sixteenth and seventeenth centuries, because Britain was accepting towards immigrants, many craftsmen and businessmen who were fleeing religious persecution and war from other European countries, such as France, Germany and Netherlands, brought with them invaluable skills in textiles, drainage, intensive farming, financing management techniques and other experience, which contributed to the economic boom of Britain).

Therefore, although Britain did accumulate a great amount of wealth through colonization - just as did Portugal, Spain, the Netherlands and France - the key reason why Britain was located at the centre of the first industrial revolution was because Britain had *consciously* implemented institutional innovation and the development of a creative culture. As discussed in the section of chapter 1 dealing with the long development history of commercial technology, many modern soft technologies in the field of commerce were first invented and institutionalized in Britain.

For example, the first overseas trade chartered company, Moskel, was set up in Britain in 1553 in the form of a joint stock company; in 1581, the first formal stock company in overseas trade was established in Britain; in 1657, a comparatively stable stock exchange organization first appeared in Britain; in 1561 the modern patent law was formed and in 1624 the first invention patent law appeared in Britain; in 1610, the first advertising agency appeared in Britain; in 1812, the first formally and professionally organized advertising company in the world was set up in London; during the seventeenth century, paper currency, the European contemporary currency, first appeared in Britain; founded in 1710, the Sun Insurance Company was the first share-holding fire insurance company; in 1762, the first life insurance company in the world, London Fair Insurance Company, was set up in Britain; founded in 1945, Britain's Industrial and Commercial Finance Company (ICFC) was the first venture capital company; although the modern financial industry emanated from Italy, the Bank of England, established in 1694, was the beginning of modern banks, and during the beginning of the nineteenth century, London became the money house of the world; the Charter Law and the Royal Charter, issued by the British king in 1694, were the first bank laws. Furthermore, the Company Law of 1844 in Britain, together with all the other innovations just mentioned, helped to create a good institutional environment for the industrial revolution in Britain, while the mercantilist policy of the British absolute monarchy further encouraged pioneering creativity.

As a result, from 1642 to 1764 the technological achievements of Britain were much higher than Italy, Spain, Portugal and the Netherlands. During that period, Britain was responsible for 59 of the 220 crucial events that occurred in the history of western science and for 93 of the 137 most important events in the development of western technology history. Simultaneously, by one account, Britain was responsible for one quarter of the 93 important events that took place in the history of western social culture development.[20] In addition, from the beginning of the seventeenth century to the end of the eighteenth century there were 53 important economic events that happened worldwide, 18 of which took place in England.[21]

After the first industrial revolution, people consciously expedited the development of modern soft technology, especially commercial technology innovation and institutional innovation. This resulted in the second industrial revolution, which occurred less than a hundred years after the first. This time, the centre of innovative industrial activity shifted from England to Germany and the United States, primarily because of the role of soft technology.

In the United States, a large number of phenomena created the institutional environment for the flowering of the second industrial revolution. These included the great innovation of the patent system, the quick expansion of the research institute system, the conception, theorization and normalization of 'scientific management' technology, the creation of batch production techniques, the popularization of the stock market, the development of monopoly enterprises, the sanction of the antitrust laws established during the first enterprise annexation tide and the open immigration system. All of these things, together, created the environment for the emergence of the second industrial revolution. They also elucidate the development and entry of commercial technology into the institutionalized stage.

Centred in America, a climax in the development of commercial technology was reached in the 1950s and 1960s and again in the 1980s and 1990s (see the earlier section of the book dealing with the history of commercial technology). As a result, the centre of the third industrial revolution was without doubt located in the United States. This has been the age of ubiquitous creativity in soft technology, pushing the world economy to enter into the new age of the intelligent service economy (see figure 2). For many decades now the United States has continually occupied first place in the world in competitiveness in science and technology. Since 1985, 65% of the 128 scientists who have won Nobel Science prizes are Americans (or their main scientific research work was accomplished in America). This is mostly because the United States attaches importance to the development of soft technology, consciously pushing institutional innovation and ensuring that is synchronously matched with innovation of hard technology. The United States even carries out proactive research on institutional innovation.

The great achievements of scientific discovery and technological invention during the last several hundred years have been transferred into operable products with remarkable success. The result was the formation of great industries during the twentieth century, the success of which stemmed from the large amount of modern soft technology created during the course of successive industrial revolutions, especially the second and third. The majority of soft technology applications involved institutional innovation and, together with innovation in countless traditional soft technologies, the speed of hard technology innovation was thereby increased.

In short, the level of efficiency of invention and innovation in soft technology affects the speed at which the invention, commercialization and market-expansion of hard technology may take place.

2) Because of the relative rigidity of institutions, new soft technologies need to be continuously designed, demonstrated and assessed until the institutional innovation is accepted. The above paragraphs expatiate the necessity and contribution of soft technology and its related institutions to the development of new industries and new industrial forms. Conversely, old institutions can also act as a tremendous restraining force on the development of new technology and social and economic development.

Once soft technologies have been regularized in the form of governing tools such as institutions, policies, rules, laws and formal assessment criteria, they enrich the soft environment for a certain period and provide the essential conditions for (soft and hard) technology innovation. However, once soft technology forms the governing tools and institutions that are fully recognized and accepted by society and government, it usually becomes solidified. Before a soft technology can be enforced as the content of an institution, it must undergo much experimentation and also receive public recognition and eventually be approved by governments or other institutions. For example, the World Trade Organization must pass any formulations of major international trade rules before they can be implemented effectively as institutions. Furthermore, soft technology innovation always affects the interests of groups or individuals with vested interests related to the old institutions; and, hence, it always encounters resistance and the risk of rejection. Thus the task of replacing old systems, laws, regulations and policies - necessary for the development of new soft technology - can often be daunting.

For instance, in China the integration of applied industry-oriented universities and research institutes has been advocated for many years. However, it has been extraordinarily difficult to accomplish this goal - as reflected in the Chinese metaphor ‘keep two skins between technology and economy’. Besides the influence of vested interests in the mechanisms of distribution, there is another reason why the status quo has been largely maintained. In the orthodox system of centralized planning, which lasted for a long time in China, scientific and technological activities and economic activities were separated in two completely different administrative systems, involving different behaviour patterns, different value preferences and different sets of interpersonal relationships. Together, these factors created a kind of organizational and social culture that has prevented the two systems from transmogrifying and infiltrating into each other. Moreover, the selfish interests of each system have usually been justified under the banner of the wider interests of the community and state, thereby increasing the overall rigidity of the established institutions.

Good institutions will encourage creative spirits and promote technological innovation but if institutional innovation cannot keep pace with the progress of (soft and hard) technology and the needs of economic and social development, it will turn into a great obstacle to the development of enterprises or even of a country as a whole. For example, many industries in China were not open to private capital and private enterprise, while in the coastal regions (especially in Shenzhen and Zhejiang) where such restrictions were relaxed, the economy developed much faster. Before the entrance of the WTO, service industries, such as finance and insurance industries, were not accessible to domestic enterprises; but now that access is permitted, domestic enterprises are handicapped by inexperience and are placed at a disadvantageous position in competition with foreign enterprises service areas. Industrial and business innovation in Chinese enterprises has been limited by too many restrictions and old institutions and policies.

Therefore, the old prevailing institutions are usually the biggest obstacle of innovation; they first need to be dismantled before new institutions and new innovations can flourish. As North said, 'Institutions provide a framework for people to exert mutual influence on each other and they establish the relationships which compose the society or rather the relationships in which economic orders cooperate and compete.'[22] The environmental changes in society, the economy and technology require further adjustments to the balance between cooperative and competitive relationships; and those behaviours that are illegal or inimical to the new kinds of relationships of cooperation and competition need to be restricted by new mechanisms (in other words, the new institutions need to be established). Conversely, it is also necessary to relax or abandon restrictions that do not accord with the new environment and new technology (in other words, the old institutions need to be abandoned).

In conclusion, institutional innovation must synchronize with technological innovation and much keep pace with economic, social and technological developments; only when soft technology R&D progresses at least as fast as the R&D of related hard technologies can appropriate institutional innovation be guaranteed. Only through innovation in related soft technologies - consciously and with clear objectives - may an adequate theoretical basis and experience be provided for future institutional and systematic innovation. When people are aware of this, they may boldly create the soft technology needed by their country or community. They may also flexibly absorb and introduce selected advanced foreign soft technology, taking into account the actual situation of their country, and promote related institutional innovations (this is different from seeking to clone foreign institutions which, in any case, should only ever be treated as references rather than as globally replicable models). Just as Robert M. Solow, the Nobel Prize winner for economics, has indicated, only those individuals, enterprises and countries that perceive the rules of new games in advance can occupy an advantageous position in the new globally competitive environment.

Ishiguro Issen, a law professor at Tokyo University,[23] criticized the liberalization of the service trade and the intellectual property regime in his article 'Globalization and Law', pointing out that 'the theory of the neoclassic school, which put all emphasis on the market, is academically insufficient. Now that Japan's background is different from that of the US and Europe, why should it follow the US in so-called multi-international laws concerning aviation, finance, insurance, intellectual property and the environment?' I believe that, apart from the fact that the US is an advanced economy, there is another reason why the US consistently and continuously develops soft technologies, regularizes them, makes them into various institutions and laws during the course of its application - and then requires others who use them later to abide by them: the US has created new games in many fields and has made relevant rules for these games. Developing countries should work harder at creating new games and then they will have the chance and right to make their own game rules, therefore, assuming the advantageous position in the competition. They should not allow the US always to set the rules. In addition, since the rules tend to involve vast commercial profits, making the rules of the game is not a pure technological issue. It is also very important to incorporate non-technological factors.

4. To Achieve 'Leap Frog' Development and Institutional Innovation

Developing countries always advocate 'leap frog' strategies for development. This is a laudable wish but it is important to keep a clear mind about exactly which aspects of development are amenable to this desired leap frog approach. For instance, the general education levels of a country and cultivation of its citizens cannot be skipped over; neither can industrialization and to some extent infrastructure, be skipped over - because there are rules of economic, social and technological development that must be followed. However, leap frog development can be achieved in terms of the speed of economic development and the change of economic structure and technologies in some fields. Nevertheless, even in these fields, leap frog development must be based on conceptual change and must start with institutional innovation. For example, to develop the western regions of China, it will be necessary for institutional innovation to take place, aimed at, among other things, providing incentives for investment in these regions. The appropriate institutions may be designed by drawing upon insights from the experience and lessons of other regions, taking into account unique local circumstances as well as international conditions. Such initiatives may be the first steps towards speeding up the development process. In addition, the ongoing cultivation of the required institutions for development in the western regions must be guided by participation in globalization, learning about international management styles and an understanding of new business paradigms. Allowing these relevant institutions to keep pace with international standards and international evaluation criteria is a primary challenge for China as a new member of the WTO.

Special attention should be placed on the fact that institutional innovation is not a magic elixir for development. Across the broad spectrum of business activities, including those associated with intellectual property management, we can see thousands of instances where the limitations of institutions are revealed. Institutions alone are insufficient constraints on human behaviour and human psychological activity. The fundamental solutions to problems related to human behaviour rely upon trust and awareness-raising of the public at large. This is why research and education on business ethics have become more important for the future society.

C. Soft Technology and the Innovational System

With reference to the above, the essence of innovation is the application of soft technology, which includes the application of new soft technology and the application of existing soft technology in a new environment or towards a new object. However, when we talk about the innovation of a region, a country or even an enterprise, we must consider the system of innovation. There are two reasons for this: 1) a single soft technology cannot function on its own and its successful application depends upon it being integrated and combined with other soft technologies; 2) as shown in figure 6, the components of the innovational system - whether they are concerned with hard technological innovation, industrial innovation, or institutional innovation - are all connected with each other, forming a system, through soft technology.

There are a variety of ways in which the innovational system can be portrayed, depending upon the perspective from which it is viewed.

1. The Subject of Innovative Activities and the System of Technological Innovation

As is shown in figure 8, the innovation system is made up of the enterprises, universities, scientific research institutes, social communities, associations and other non-profit organizations, governments, individuals, or consumers, of the society, each having its own indispensable position and role.

- **Enterprises.** Enterprises lie at the core of technology innovation. Technology innovation is the process in which technology is realized in its application by users, and economic and social values of most technologies are realized through what we may call the 'economic body' - enterprises.

- **Non-government organizations.** Non-government organizations, such as communities and associations are important social resources because they coordinate government and the market; they also embody the economic and social values of social technology in the social market to form the so-called social industry and social economy.

- **Government.** As a non-market association, the government has several roles to play in the innovation system. Firstly, it can create environments, nourish markets, map out of relevant strategies, formulate relevant institutions, laws, regulations and policies (e.g. policies favourable to innovation or tariff barriers to protect new or weak technologies) and supervise the implementation of policies. Secondly, through education and training, the government may improve civil quality, train experts and create a cultural atmosphere to fit the requirements of innovation. Thirdly, it can continue pushing and expanding institutional reforms, establishing the bridges between government, industry and the academic world and it can promote connections between the world of enterprises, the academic world and the financial world. Fourthly, it can direct innovation, provide technological foresight and support strategic technological innovation through direct investment (such as by investing in and carrying out long-term R&D projects or large-scale science and technology plans. Fifthly, government can shoulder the responsibility for protecting domestic technology (the military and civilian technology of its own country) in the face of international competition.

- **Universities and Research Institutes.** Throughout most of history, technological innovation was dependent mainly upon individuals and entrepreneurs. However, the growth of universities and research institutes, especially industrial research institutes, following the nineteenth century, changed the mixture of sources for innovation. As the main agencies of producing, accumulating and spreading knowledge and technology, they have become responsible for providing the dominant sources of inventions for the technological innovation system.

- **Entrepreneurs**. It is not enough to emphasize universities and research institutes as sources of innovation. Research has revealed that although industrial laboratories and research institutes provided many technological sources for innovation during the first half of twentieth century, individual inventions were still the important source of innovation. [24] More than half of the 70 important inventions during the first half of the twentieth century came from individual inventors. A similar pattern exists in the case of minor inventions. The development of the Internet has narrowed the distance between individuals and enterprises and has tightened the relationship between customers and enterprises. In addition, an increasing number of technologically talented people are self-employed. People want to make full use of their own talents and demonstrate their own values to sell their own products in the market. Individual creativity, innovational desire and motivation become an important part of the driving force of technology. Individuals are becoming an important innovational resource. Some people even claim that the future is the time for self-employed workers. The numerous small and medium enterprises (SMEs) that exhibit vitality and strength in technological innovation have emerged for this reason. It is also for this reason that the present business world attaches such great importance to customer-based innovation. Individuals are playing an increasingly important role in the start-up of companies. Creative entrepreneurs and experts themselves are an important source of wealth to enterprises and they represent the innovative ability of enterprises.

Figure 8: The Main Bodies of Technological Innovation

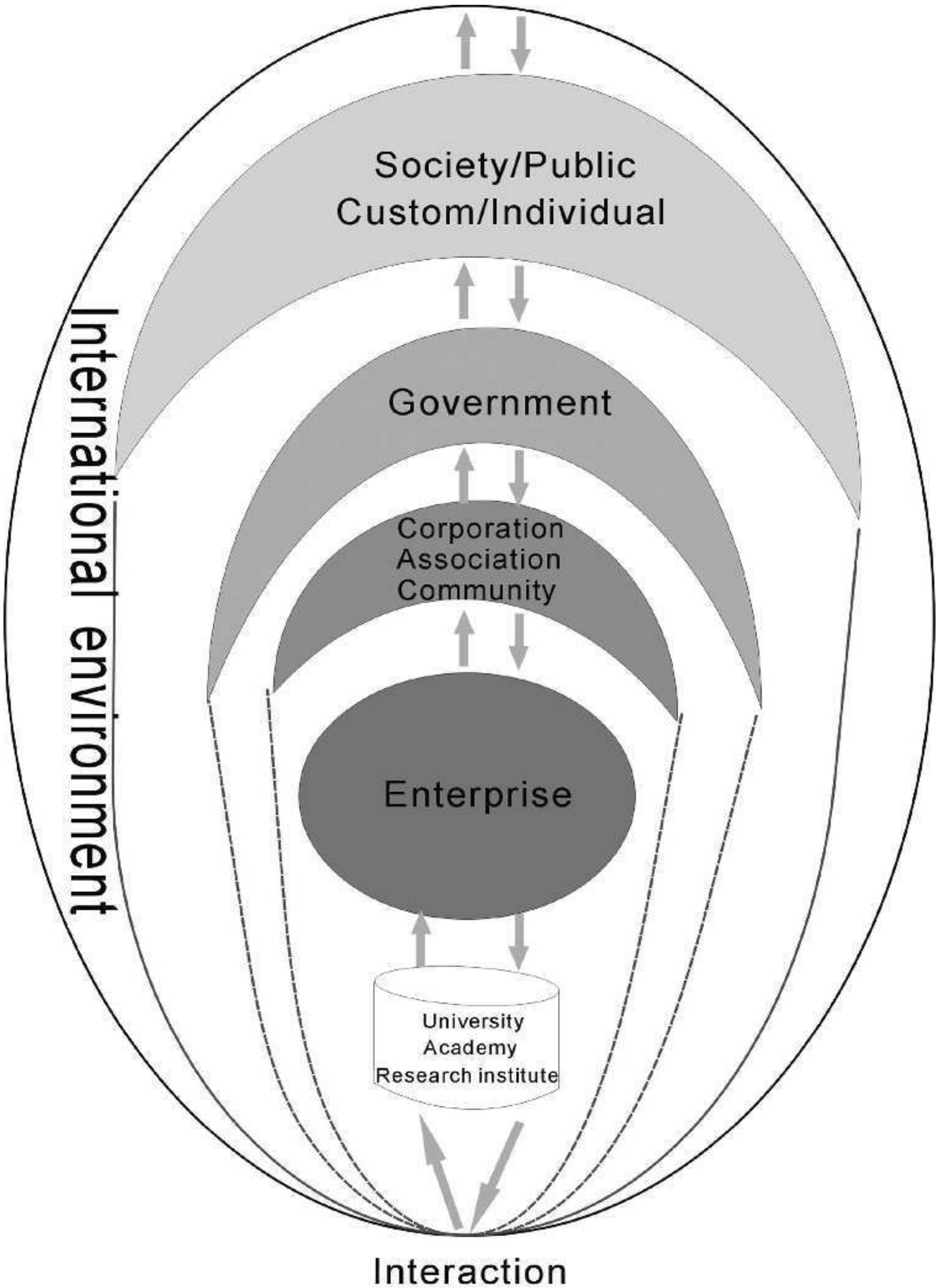
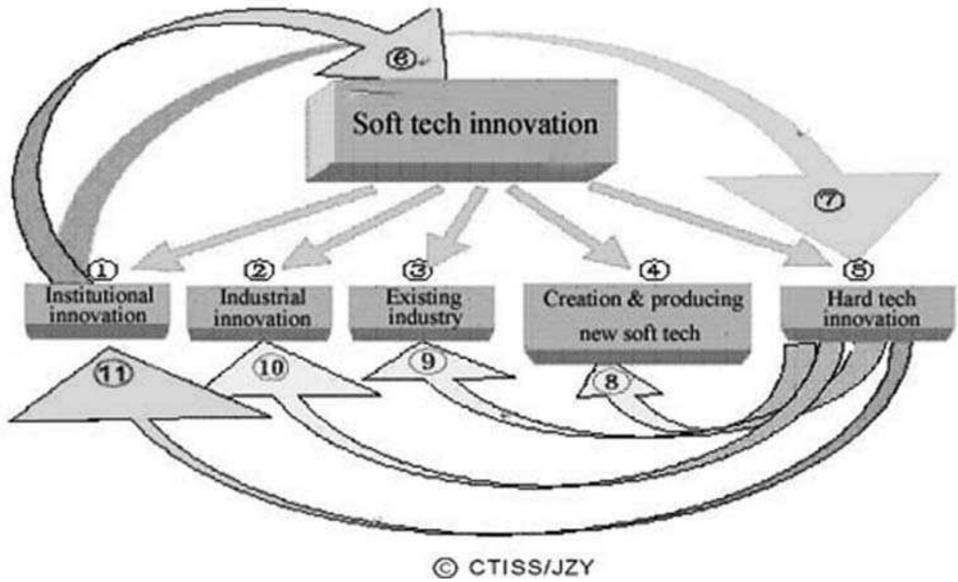


Figure 9: The Procedure of Technology Innovation



1) Provides bases, connotations and demands

2) Provides the core of technology

3) Improves productivity, management model innovation and updates structures

4) Improves intelligence input, creates new fields and new applications of soft-tech constantly

5) Hard technology must be innovated through soft technology, the latter providing innovation tools/means

6) Creates innovational environment, provides new subjects (soft technological demands), invents new challenges

7) Creates innovational environment

8) Provides new innovation tools and means

9) Improves productivity, manages model innovation and updates structure9)

10) Provides core technology

11) Provides demands

One of the reasons for China's weak technological innovation before its reform and opening-up was that the country ignored and lacked encouragement for individual innovation. Owing to the long-time influence of left brain thinking, individual innovation was seen as the symbol of individualistic heroism in the eyes of many Chinese people. In the time of economic globalization, individuals have become more important to the core of innovation. As the most important resource of technological innovation, experts are footloose and can be easily attracted to those places with environments most conducive to innovation. In addition, even the special social organization of 'units', which is unique to China and to which every Chinese townsman is obliged to belong, is also weakening. Slogans and spiritual encouragement alone will be ineffective in the attraction and cultivation of experts if they are not complemented by mechanisms for nurturing the co-development of individuals and enterprises. The innovation system should include the mechanisms and environment for investing in individuals.

The main elements of the innovation system do not function as discrete, stand-alone items; rather, they are mutually dependent on each other and require mutual promotion and mutual constraint. Moreover, to be effective, the national innovation system must be open and connected with the international innovation environment and should be coordinated with the process of globalization. A foreign expert, of Chinese origin, recently commented on the high-tech R&D strategies of some Chinese organizations, saying that the biggest problem was that they were not internationally competitive. The reason given, apart from insufficient access to information in the R&D process, was the 'closed down thinking' pattern that allowed researchers to continue having their one-sided wishes granted. China should learn to face both domestic and overseas markets and make full use of and share domestic and overseas resources, including experts, technology, capital and natural resources. China also needs to engage in global institutional innovation.

2. The Structure of the Innovational System

Technological innovation must be interpreted as involving technology in its broadest sense, described earlier in this book, otherwise it will be no more plausible than a one-wheeled car. Accordingly, the innovation system, as shown in figure 6, can be divided into five interactive innovation centres (soft technology innovation, institutional innovation, hard technology innovation, hard technology industrial innovation and soft technology industrial innovation) and three sub-centres: knowledge production, new model innovation (economic, business and enterprises) and industrial integration, which are derived from the interaction of the main centres.

3. The Flowchart of Technological Innovation

Figure 9 shows the relationship of the five sections of institutional innovation, industrial innovation, existing industrial innovation, invention and production of soft technology and hard-tech innovation with the soft-tech innovation.

4. Innovation Space

An awareness of technology, in the broad sense, enables us to move innovation from the sphere of production activity to the whole process of creating value; from hard technology innovation to soft technology innovation; from innovation in the sphere of material production to innovation in the sphere of spiritual production; from economic activities to cultural, social and all international activities.

D. Soft Technology and the Strategic Adjustment of Chinese Enterprises

Viewed from the perspective of enterprises, technological innovation refers to the activities of developing new products, markets and services through creating, communicating and applying new thoughts and new technology in order to improve competitiveness. Managers of Chinese enterprises need to first of all expand their concepts of technology and technological innovation and then systematically adjust their mode of managing and their strategy for all of the functions in their enterprises. That is to say, if an enterprise is to succeed, as is shown in figure 10, it must persist in the combination of soft and hard technology innovation. The key to innovation is conceptual change.

1. Innovation and Business Division Strategy

• Constant opening up of new business divisions to expand the life cycle of enterprises.

The key to a successful enterprise lies in the business division strategy. What is more important is that managers adjust their managerial philosophy and development strategy with the times and according to changes in the market environment.

• Getting out of the office to find inspiration in the real world.

Most Chinese company leaders are eager to attend conferences, new product exhibitions and project seminars. They think that these conferences will provide business opportunities or new projects for them and, accordingly, they feel obliged to attend. In contrast, if they receive an invitation to attend a world forum or a conference of an international future study association, they probably think it to be a waste of time and money. If their company is a large state-owned enterprise, the officer in charge may not allow the firm's leaders to go abroad to attend such conferences. In contrast, foreign companies such as Sun Microsystems have sent their people to attend various forums of this kind over the past ten years. These forums may not offer ready-made remedies, concrete programmes and projects for enterprises. Instead, they provide a setting for different kinds of creative persons - successful entrepreneurs, Nobel Prize winners, poets, artists, scientists, sociologists and economists - to get together to voice their viewpoints and achievements and to share their pioneering explorations and their views on the world and the future. Entrepreneurs must learn to communicate with those who have 'nothing' in common with them in order to discover inspiration regarding new markets, products, services, organizational methods and new business divisions. They should not merely depend on their subordinates' reports.

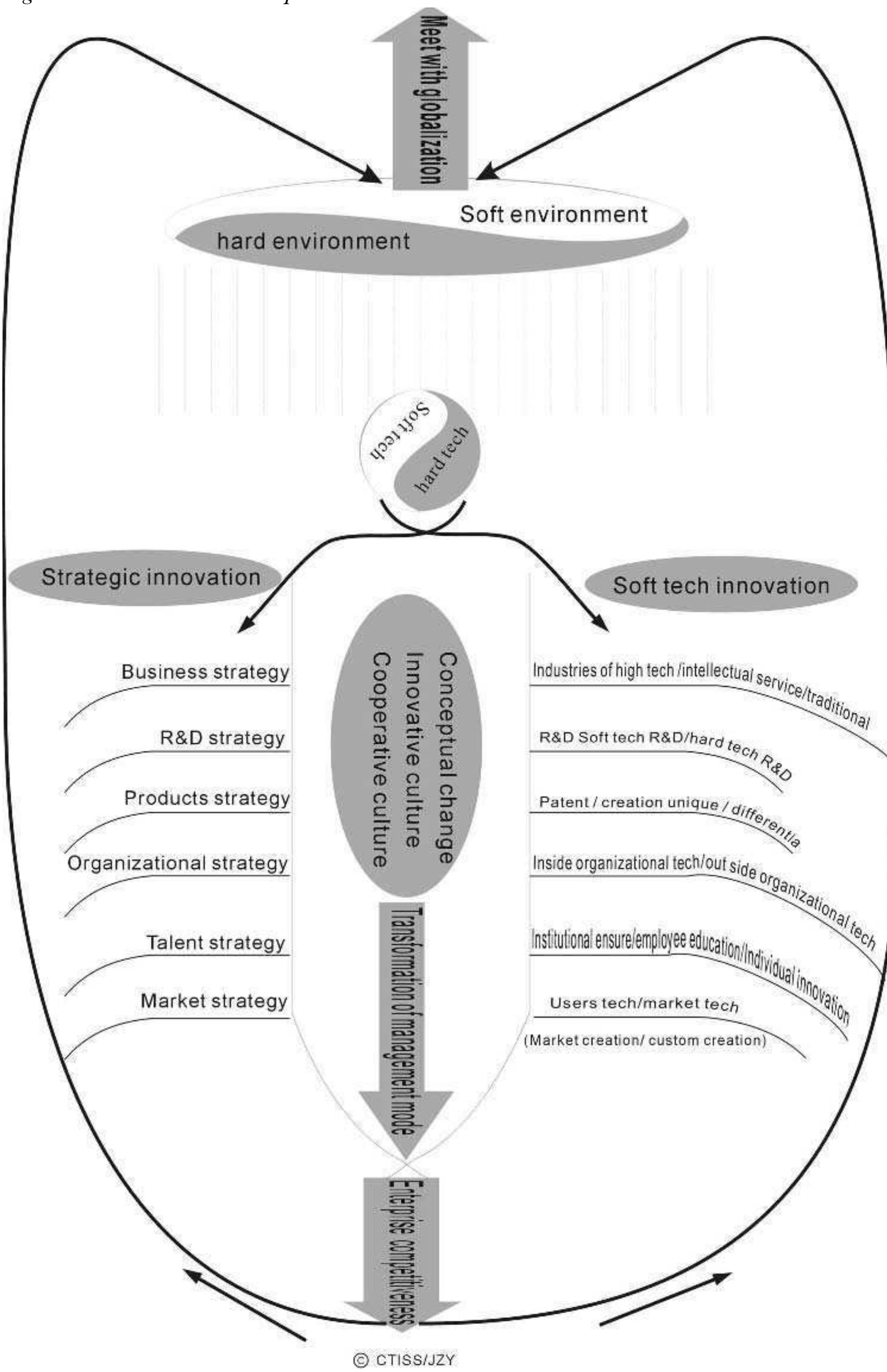
- **Moving past misunderstandings about the new economy and moving towards intelligent service.**

Many people think that the supporting industry of the new economy is the high-tech industry or simply the information industry. However, they are quite mistaken. The new economic phenomenon, whether it is the new economy or the knowledge economy, is not only supported by the high-tech industry but also by the intelligent service industries and the manufacturing industries.

What is the real challenge that China now faces after entering WTO? Ever since China carried out its policy of reform and opening-up, foreign transnational corporations have occupied nearly all the Chinese high-tech markets with their advanced technology, abundant funds and advanced sales methods; and in the name of cooperation and for the purpose of introducing their products, they have swallowed up many of China's famous brands. For example, the Chinese car market has been divided up among joint ventures. Brands that have been famous for a long time, such as Shanghai and Red Flag, are now struggling. While China was working hard at creating material production and striving to be the best manufacturing country in the world, enterprises from developed countries took advantage of emerging opportunities in China by dominating new service industries, especially finance, insurance and other high value-added industries.

Chinese leaders and citizens have now realized that many Chinese high-tech markets, such as the mobile communications market, have been forfeited to foreign enterprises. However, while Chinese people are mourning the loss of those markets and experts in the high-tech sphere that have been appropriated by foreign enterprises, other foreign enterprises are occupying the 'last fort'. In the name of the new commercial approaches, China's market for services is being lost, without being noticed, to foreign corporations. Several of the largest consulting companies in the world have entered China's market and are making a fortune from Chinese

Figure 10: Innovation in Enterprises



firms and joint enterprises. Transnational corporations in the retail field have broken into the Chinese market on a large scale through supermarkets, chain stores, shopping centres, convenience stores and discount shops. The French Carrefour Supermarket, for example, has entered 15 cities in China and has established almost 30 supermarkets in their chain. Carrefour's business is booming day by day.

Big cities, like Beijing, Shanghai and Guangzhou, should develop intelligent services as supporting industries for the future economy. In this way they will be in a position to confront and conquer markets in the west of China, the entire country and the entire world. So long as they make full use of their special advantages, they are sure to find a new world of opportunities in the intelligent service industries.

In other words, in the new market environment, each enterprise must position itself according to its own advantages and potentials. Those Chinese entrepreneurs who are determined to open up new businesses may consider moving towards soft-tech industries and becoming entrepreneurs in the intelligent service industries; or they should take the lead from the market and their customers and turn their existing businesses in the direction of the service industries. This approach may be particularly suitable for those private entrepreneurs who decide to undergo their 'second start-up' but who are not quite familiar with fields of hard technology.

- **Reflect calmly and 'get to the truth by verifying the facts'**

... technological 'highness' is not the key to success.
Chinese entrepreneurs should learn first to combine ambitious long-term goals with the reality that making profits is their main purpose. Enterprises are profit-oriented and they need to emphasize products that contain market value or that have the ability to further develop. A successful enterprise need not necessarily pursue new products that are 'high' in technological terms. It should pursue those products that are 'high and innovative' in terms of their application and their added value. In the end, not all products of high added-value in the future will be derived from the high technology of the present. Enterprises should not blindly follow academic fashions.

If China follows in the footsteps of economic globalization and 'knowledge-ification' along its present trajectory, based on its present level of industrial competitiveness, it will remain on a lower level in the international division of labour in industry. Therefore, the research and application of new and practical technology is a critically important job of most enterprises and most research institutes. It is imperative that during the upsurge of high-tech development nationwide, China does not ignore applicable, mid-level and indigenous technology. All developing countries have their own advantages. For example, foreign enterprises will generally find it difficult to match Chinese organizations in the local market in matters that involve culture, sales networks, relationship networks and customer information - at least in the short term. Hence, Chinese enterprises have a better chance than foreign enterprises to design and produce products that require sensitivity to the distinctive material, spiritual, cultural and service needs of local Chinese customers.

Many successful cultural companies have begun to emerge in China and there are also many high technology opportunities associated with soft technology. Enterprises should not follow the academic tidal wave blindly. The Chinese company Legend, for example, has developed during the last ten years from its beginnings as a computer assembling and sales commission company to its present status as a sophisticated information technology company. Since Legend was familiar with the demands of the Chinese customers, it was able to control sales channels. By the late 1990s Legend had become the largest enterprise producing Chinese-made computers. It was reported that the market value of Legend increased from 200 million US dollars in 1994 to 4.3 billion US dollars in 1999; by March 2000 Legend succeeded in raising 3 billion RMB by rationing Legend stock in the Hong Kong stock market, most of which will be used to develop Legend's Internet business and to open up Legend's business to the multiple fields of the Internet. The Kelong Group, the biggest refrigerator manufacturer in China, started as a village and township company. Facing fierce competition caused by the overproduction of refrigerators, they conducted a design strategy that focused on consumers from villages and small towns. As a result, the products were cheaper in price and simpler in function. In addition, the Kelong Group provided more advanced refrigerators for consumers in the coastal developed areas, while turning higher profits.

2. Strengthening R&D for Soft Technology

What should the focus of research and development in Chinese enterprises be? In the age of the industrial economy, ordinary enterprises conducted R&D according to the 'gender' of their products. Today, however, we understand that the technological foundation of products and services comes not only from hard technology but also from soft technology. Whether a company's main business lies with high-tech industry or with traditional industry, it may benefit from strengthening R&D in relevant soft technology and by constantly conducting R&D for new 'games' around its business fields in order to add value. Patenting business methods in the US and the recent operations of the United Sates Patent and Trademark Office is a good example. Soft technology may be the endless source for future spiritual products.

In the past China did not conduct enough R&D on service industries because managers in both the government and companies tended to think that no high technology existed in service industries and that the service itself was not 'high' enough to warrant the effort. However, an increasing proportion of the added value in manufacturing industry is derived from services. At present, the Chinese IT industry also has begun to 'forge' new concepts for sales by applying new services.[25] For instance, Tsinghua Tongfang and Legend have produced high, medium and low options for computers for different consumer groups; and they are becoming sophisticated in matching the promotion of products for specific market niches. In addition, they have become adept at imprinting enterprise philosophies and brand images in consumers' minds through interesting and entertaining advertising methods. However, all these examples are simply the creation of services centred on hard technology; R&D around soft technology remains 'virgin soil' in China. Very few Chinese organizations conduct R&D in sports and the culture industry. At present, most soft technologies emanate from western countries, especially from the United States, and of course, the relevant rules of 'games' are formulated by them.

Thus, R&D in Chinese enterprises should stress both hard and soft technology and should emphasize R&D for both professional technology and industrial technology.

3. Creating Product Strategies, Patent Strategies and 'Peculiarity' Strategies

If an enterprise wants to earn monopoly rents, it should own the characteristics of the product structure and technological structure and must open up a unique market, service and management mode. Through studying soft technology we can create new concepts of technology, products and service. This will provide new perspectives on product design, market orientation, consumer orientation, service content and new ways of becoming allies with users or competitors.

Realizing and understanding this can help enterprises to avoid focusing their search for intellectual property rights on hard technology or on so-called high technology. This realization is extremely important for those SMEs that are regarded as the source of technological innovation.

Chinese SMEs need not continue to dream of receiving small shares from a market that is already occupied by large enterprises, or of only transferring technology from abroad. According to the concept of soft technology, SMEs may well base themselves on creating their own innovative platforms and they may also develop new spheres in the intelligent service industries to prolong the lifecycle of their enterprise through the 'small but specialized', 'small but peculiar' and 'small but new' markets, products and services.

Only when an enterprise has its own technology and products and actually owns the property rights can it seize a certain market in order to obtain the monopolized profits for a certain period of time. At present, many Chinese enterprises do not have a strong sense for intellectual property rights and they do not pay much attention to applying for patents and to the advantages of owning patents over time. Recently many of the S&T projects in China's Ninth Five Year Plan have been reviewed and appraised. Many projects are regarded as having produced advanced technology at national and international levels. Some projects have cost tens of millions and billions of Yuan but most companies do not really pay attention to studying how many of these projects have produced technologies suitable for patenting, let alone applying for patents for technologies from their own small projects.

Chinese enterprises badly need specialized institutions and personnel to conduct research on intellectual property and know-how development, including how to produce, package, file and apply patents. This is an important aspect of strategy that will enhance competitiveness. Just consider how some large (foreign) enterprises manage to apply for hundreds of patents in a single year. Between the implementation of the patent law in China in 1985 and the year 2000, applications for patents exceeded one million, which is far too few when compared with developed countries. For example, the number of patents applied for in a single year by one international enterprise exceeded the number applied for by all China's enterprises put together. Patents are seeds from which these companies' fortunes may prosperously grow.

4. Organizational Innovation

Organizational innovation is the premise and basis for technology innovation. Chinese enterprises normally conduct organizational reforms when adjusting agencies and appointing new leaders. This is far from enough. Why do so many promising young people in China prefer to go out and start their own small companies, rather than work for state enterprises?

Internal organizational innovation in enterprises refers to the system by which internal venture companies are formed, internal project organizations are formed and branch companies are established. This may also be referred to as facilitating 'intrapreneurship'. It provides a good way to create an innovative environment and to protect the enterprise against the loss of creative talent.

External organizational innovation of enterprises involves the flexible operation of coordination technology, merger technology and virtual-organization technology, all aimed at increasing enterprise competitiveness. Making use of virtual manufacturing methods to gain access to external resources and to more effectively employ internal resources of the enterprise are examples. In addition, Chinese enterprises tend to be weak in R&D, so it is not necessary for every company to establish its own research institute or adopt formal research institutes. They should instead consider using virtual research institutes. For example, when Haier Company, located in Shan Dong province, moved into the intelligent robot business and established a common research institute for intelligent robots with the Harbin Industry University, which is located in Heilongjang province and has assumed an increasingly important position in the Chinese robot industry.

5. Talent Strategy

The global competition for managing talent has just started. It is reported that in the third quarter of 1999 the demand of the United States for managing personnel increased by 16% over the previous year while demands in Asia increased by 40%. Bill Gates said Microsoft suffered for two years because of talent shortages and that this situation will continue for 15 years. A major headhunting company predicated that in 2001, 1,500 positions out of 10,000 would be Internet positions. Now many enterprises with long histories cannot hire business graduates because Internet companies recruit the graduates.

- **What kind of talents do enterprises need?**

Innovation is a continuous process of bringing out the full potential of people. In the age of the university degree, people are somewhat biased in their perception of talents. They put more emphasis on the number of those holding masters and doctorate degrees in enterprises. However, human abilities should be categorized into the possession of knowledge, skill or technique and intelligence respectively.[26] Ability can also be divided into the categories of congenital ability and acquired ability. For example, although a person's intelligence may be perceived to be based on judgement, insight, leadership ability and charm, it may really be based on education and experience. However, numerous examples show that these qualities are closely related to given factors, such as genes, heredity and cultural background, and are developed by the combined force of given factors and acquired factors. Acquired abilities are determined by the education a person receives (the education provided by family, school, work and life) and the environment in which that person grows up (family, social and economic). Therefore, people who receive the same education may exhibit different abilities; conversely, people with similar congenital abilities may exhibit different abilities in practice owing to the different environments in which they were educated, raised and employed. Thus, congenital ability and acquired ability are complementary but cannot be substituted for each other. It is important to realize this and admit it. It matters a great deal to employ talents correctly and to bring into play the abilities of different people appropriately, i.e. bring everyone's ability into full play.

The new character in Japanese business circles Sun Zhengyi has succeeded because of his extraordinary ability and charm. His courage and resolution in decision-making have put him ahead of other entrepreneurs, enabling him to make money by using time intervals; he is good at making use of wide interpersonal relationships in order to establish super partnerships all over the world; he is good at recruiting worthy talents and he practices the art of respecting and using talents. He has attracted senior management talents from Japan's successful enterprises, such as Mitsui and Company, Ltd. and Nomura Securities Companies to form the 'base of the Internet Revolution'.[27] After starting up the companies, he entrusts executive operations to an expert in the relevant area. He does not micro-manage experts under his authority. Therefore, those tycoons in the financial and business circles were able to bring into play their creativity and ability, even under Sun, and he, himself, began to consider new businesses. Hence it can be said that what pushes the software bank is the brain bank around Sun Zhengyi. Such ability to create new enterprise does not have much to do with possessing a doctoral degree, as it is easy to recite the theories. Rather, in the complicated environment of contemporary enterprises, intelligence is more important than knowledge.

The gap between developing countries and developed countries lies, in the final analysis, in the shortage of soft technological personnel. In particular, far-sighted pioneers like Sun Zhengyi of Japan and Zhang Ruimin of China's Haier Group are rare finds. Good personnel are the real wealth of their enterprises. With them, the funds needed can be raised and technology and talents can be acquired. Thus, the key to success in the enterprise is to dig out, find, train and protect creative talents without any constraints. The so-called innovational system should be the first of all mechanisms and environments to invest in 'people'. As for the intangible assets of enterprises, its property rights can be established through original shares, operating shares and technological shares and the institution can guarantee that the interest of creative talents and start-ups will be protected.

- **It is worthwhile to train the internal talents of the enterprise.**

Managers of Chinese enterprises ought not to fix their eyes just on talents from overseas and other regions. Take e-commerce as an example. In 1999, 8.9 million people subscribed to the Internet and the Internet population surpassed 45.8 million in July 2002. A great number of e-commerce products are produced every day; and all kinds of e-commerce consultants, online shops, online-monopolized shops and online auctions are born daily. IBM ordered 13 billion dollars worth of products from 12,000 online suppliers in 1999. This company saved 6.5 billion dollars through virtual purchases in the four years prior to 1999. In such global management environments, it will be impossible for Chinese enterprises to wait for external technicians to carry out their business. We have to train our own technicians internally.

- **Emphasize and encourage personal innovation**

As discussed above, the role of the individual is one of the important sources of innovation. Many enterprises can be acceptant and tolerant with ordinary employees who are incompetent, but disputes and conflicts occur with creative employees after they have displayed outstanding achievement. Why does the branch company inside the enterprise not set-up and give stock shares in order to provide a foundation for them to run the company independently, or adopt their innovational achievements into the enterprise system as their investment and let them have the stocks or the right for dividends?

6. Market Innovation – Creating Customers, Markets and Industries

Innovation of market technology is the sphere with the richest content and greatest potential.

The market network of Kodak is a really wonderful example. The Kodak company came into China in 1994 and has since expanded into several large cities. In the short period of six years, it has established itself in over 500 large and medium cities, the number of allied shops has increased to 5,000 retail chains networking in China (the 700 shops in the West created 5,000 jobs) and the company provides 40,000 jobs for the local labour force. At present, the annual consumption of film per capita in China is 0.1 of a roll and the growth rate of popularization of cameras is 15% per year. Compared with America's 3.6 rolls per capita, there is still great potential. The yearly increase of the Chinese photography market is around 10% every year. Based on this estimation, Kodak introduced a 'start-up with 99,000 Yuan' project for medium and small investors. Therefore, as long as investors invest 99,000 Yuan (including buying one set of 955E colour developing equipment and shop decorating fees), one can immediately become the owner of a Kodak Express Printing Shop (KEX) after the investor installs the necessary equipment and finishes the required decoration. Kodak plans to increase the number of chain stores in China to 5,500 this year.[28] This programme met the local demands of small investors who are eagerly looking for chances to invest their money but are fearful of taking risks. It has also broadened the marketing channels and has increased the number of product agents. Such a technique of market broadening falls into the soft-tech category of organizational technology.

7. Innovation of Concept and Culture

The enterprise culture that encourages innovation cannot be summarized in a few sentences of management psychology. Nevertheless, the enterprise culture creates the atmosphere and cultural environment that encourages innovation and advocates cooperation.

For instance, how a company deals with on-the-job inventions and individual innovations is a symbol of the company's culture. Does your enterprise respect knowledge? Is it willing to pay for concepts and advice? Does it use outside experts flexibly? Some companies are willing to pay millions of dollars for hard technology and for investments in universities and hard technology research institutes ... but not for soft technology, because it is 'soft,' and apparently they think anybody can create it.

Although we always say that failure is the mother of success, for decades China has been good at summarizing its successful experiences but very reluctant to admit its failures, summarize the lessons and learn from its failures. In many high-tech development zones in China, the number of companies going bankrupt exceeds half the number of the new companies established. Whether those who failed in running businesses will be allowed to return to their original companies and be allowed a new opportunity is an indicator of whether or not a culture of tolerating failure exists.

8. Integrating Strategy with Internationalization

Whether it is a network company, a consulting company, a material company or an agriculture company, every company should adjust to the trend towards the information economy, globalization and 'knowledge-fiction,' and it should learn how to work on creating an appropriate new management platform. The business and product strategies of companies need to address economic and technological globalization. Chinese companies should try not only to obtain the optimum resource distribution worldwide but also to strengthen their awareness of credit and follow international rules in order to maintain competitiveness.

The Haier Group has been endeavouring to internationalize now for several years. For instance, its refrigerators have been marketed to incorporate local design and local management in the countries where they are distributed. By 2000, Haier had set up 15 factories, ten information centres, six branches of design departments and 36,000 commercial networks across the world. This international network has enabled it to collect the most advanced refrigerator production technology available at any one time and to carry out local designs and developments according to the different demands of local consumers. This has also helped the Haier Group to establish its reputation as a world famous brand.

The Davos annual conference of the World Economic Forum held in 1999 proposed three essential conditions for an enterprise in the twenty-first century: organizational structure adapted to external market changes, global brands and the capacity for online sales. Haier has implemented three changes to comply with the above three conditions: the shift to a market chain involving reproducing the business process and organizational structure, so as to shift the goal of the enterprise from profit maximization to serving clients; the shift of market direction from domestic to international; and the shift of industrial direction from manufacturing to service industry. Haier has set up three promotion headquarters: physical circulation, commerce circulation and capital circulation. These promotion headquarters provide a platform for the promotion of e-commerce to line up with the external market. It also set up the Haier Group E-commerce Co., Ltd. and began to cooperate with the Chinese Construction Bank in the e-commerce mode of payment.

9. The Model Change of Management and Administration

Early in 2001 a remarkable piece of news in the Japanese business world appeared. '7-11', the convenience store, overcame the unfavourable influence of continuous economic stagnation and the dramatic depreciation of the Japanese currency and managed to obtain a retail value and increase in profits of 4% and 15%, respectively, compared with the previous year. This became the biggest retail sales outlet in Japan, taking the place of DAIEI, the supermarket magnate in 2001. Apart from strict management, the company benefits from flexibly using various kinds of online sales, connecting with more than 8,500 stores throughout Japan, tracking and satisfying customers' demands and forecasting the new trends of each day. It has also helped its suppliers improve efficiency and has helped commercial networks and manufacturers to control stock. This is called the revolution of supermarkets. We can see that whether it is a traditional or an IT industry, an enterprise must change its old mode of management in order to meet the changes of economic and social environments.

Indeed, the new transaction model based on e-commerce has brought good opportunities for enterprises. The characteristics of the Internet, such as its emphasis on openness, sharing and inter-linkages, have created inestimable pressure for change in the management modes of enterprises. For example, movie producers have to join efforts with high technology firms and manufacturers are moving towards informational manufacture. At the same time, the complexity of the network is a great challenge to the management of traditional enterprises.

Nonetheless, the so-called new model of management is not simply the new application of high technology in business or the dissemination and application of e-commerce. The key is that all aspects of business, including the concepts employed by managers and staff, managerial psychology and the methods of making profits, must fit in with changes in domestic and international competition. Chinese enterprises should especially try to create, adopt and comprehend these new business models and rules of the game as soon as possible in order to survive and win in the new competitive environment.

Table 8: The Change of Concept

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Chapter 5: Soft-Tech Industries

A. The Third Industrial Revolution and Soft Technology

As it entered the twenty-first century, the United States had experienced a decade of steady and forceful economic growth characterized by low inflation, low unemployment rates, low financial deficits and prosperous science and technology stocks - leading to what some economists have called the 'new economy'. On the other hand, people involved in science and technology have been paying attention to the contribution of the IT revolution and high-tech industries to world economic development and globalization. The development and wide application of IT and high technology has played a key role in the persistent economic growth of America. Therefore, the new economy has been called the network economy, the digital economy or the knowledge economy, while the industrial part of the economy, focused on product manufacturing and marketing, is referred to as the 'old economy', in spite of the multitude of high technologies that it employs. Events of recent years have demonstrated that the new kind of economy cannot escape the basic laws of economic life. The American economist and Nobel Prize winner Milton Freedman has heralded this theme by stating that the 'economy is still "old"' and that it is running according to proven economic rules.[1] However, the present development trend in the economy has raised far-reaching challenges to traditional economic viewpoints and traditional management modes.

No matter what the phenomenon of the 'new economy' should be called, it is clear that we are experiencing a change similar to that of the industrial revolutions at the end of eighteenth and the beginning of the nineteenth centuries. We are witnessing a great change in human society from an industrial economy era to a service economy era. Some experts have already described this revolution as the 'third industrial revolution' caused by IT and the Internet, arguing that it is deeper and wider than the first two. If we say that the defining characteristic of the first industrial revolution was mechanization and that the defining characteristic of the second industrial revolution was electrification, then we may say that the defining characteristic of the third industrial revolution is that it is leading human beings into an information society. What it brings to the world is not only the expansion of high-tech industries typified by information technologies, networks and telecommunications but also by increasing productive efficiency in all industries stemming from the wide infiltration of high technologies. More significantly, the third industrial revolution incorporates a new business model and a new enterprise management model that is conducive to the encouragement of creativity and the entrepreneurial spirit. It involves not only a variety of changes in institutions and social life but also in the function of governments and the boundaries of nations, as well as the problems regarding the environment and human beings.

What, then, is the driving force of the third industrial revolution? What propels the breakthroughs in the development of information technology and biology technology? What helps to create new companies, new industries and new business models, so that enterprises can organize their production in more effective ways? What drives the emergence of new products and new technologies and their worldwide application to push forward economic growth?

Just like the misunderstanding many people have had about the main driving forces of the first and second industrial revolutions (for details see chapter 2, ‘Patent Technology’), few people have noticed the driving force behind the third industrial revolution. That force is the soft technology wave of the late twentieth century.

Let us take the ‘new economy’ in the US as an example. On the surface we can see that the integration of micro-electronics, computers and telecommunication produces many new companies and new industries, helps to increase the productive efficiency of traditional industries and, in turn, quickens the social life tempo with dazzling new products that enrich people’s lives.

However, if we look below the surface we can see that soft-tech innovations – such as global management, transnational companies and transnational corporate annexations, venture capital, virtual organizing technology, together with complementary institutional and policy innovations, such as removing government controls, opening markets, solidifying financial markets and implementing new currency policies, etc. – have formed the primary engine of the third industrial revolution. On one hand, they have promoted innovation in hard technology represented by information technology and biological technology. On the other hand, they have also created conditions for innovation in traditional industries, to enable more effective operations and continuous innovations labour utilization, products and capital markets; and they have helped create global capital markets, global trade and global flows of technology and talent. With its economic strength and its influence in the world, the US enjoys the benefits of globalization, realized through optimal resource allocation globally, including human resources. Furthermore, soft-tech innovation and the rapid expansion of soft-tech industries in the United States have quickened the adjustment and optimization of that nation’s economic structure, assisting the transition from an industrial economy to a service economy.

Table 9: Soft Technology and the Three Industrial Revolutions

Interestingly, the hard technologies that are serving as the driving forces for the third industrial revolution are themselves technologies derived from natural science that contain 'soft' characteristics (see table 9).

Japan serves here as a sharp contrast with America but can match America in the field of hard technology. The Japanese economy was declining in a number of ways during the 1990s and faltered in its efforts to get on the right track with regard to the new economy. The key to Japan's decline was not a lack of high technology or a lack of intellectual property but rather to mistakes it made in macro soft-tech operations; in particular Japanese institutional innovation failed to keep pace with the times and with changes in the international environment. For example, the Japanese risk investment system is rather conservative and Japanese universities do not have a system encouraging innovation like those in contemporary America or contemporary China.

B. The Economic Era of Intellectual Service and Service Innovation

The greatest influence of the third industrial revolution on economic structure is the softening of the economy and the rapid development of intellectual service industries. We can say that the third industrial revolution has initiated the era of the intellectual service economy. Of course, this change is not new. As indicted in table

3, the GDP of tertiary industries surpassed that of primary and secondary industries in Britain and America as early as the 1950s, while other industrialized countries achieved this transition during the 1960s and 1970s. The above changes have accelerated worldwide, including most of the developing countries, since the 1990s with economic globalization and the rapid development of information technology. The main content of industrial growth in the tertiary sector during this period has been soft-tech industries, with intellectual services at the centre, accompanied by the growth of the intelligence component of traditional service industries. The scale and speed of the expansion of soft-tech industries is amazing and it has added greater charm to social, economic and technological development. Together with high-tech industry, soft-tech industry is now another important driver of the 'new economy'.

Soft-tech industry is industry in which soft technology is the core technology. It played a key role in the adjustment of the world's industrial structure during the second half of the last century and contributed to the transition of the world from the era of product economy (with product manufacturing and marketing at the centre) to the era of the service economy (with intellectual service at the centre).

The driving force in service economics is innovation in services. Because people do not tend to treat services as a special domain of technology and have rarely treated the techniques, methods and rules of service as a research theme (with the exception of marketing), our vocabulary for discussing service technology is rather limited. We have a rich repertoire of words and expressions for talking about primary and secondary industries and creative technological development within these industries has always been a subject of great interest to economists and scientists, with much appropriate research consequently ensuing. In contrast, there are few specialized R&D institutes anywhere in the world doing systematic research on service innovation, yet alone devoting attention to the topic. In China, for example, many intellectual services are labelled simple as 'schemes' and it is widely felt that anybody (no matter how little skill or training they have accumulated) is capable of operating 'schemes'. The result is that, in the domain of services, 'the genuine is mixed with the fictitious'. In America, even though the Petty-Clark law was developed in the early 1940s, it was not until the 1980s that the government began relaxing restrictions on industries like aviation and telecommunications and that entrepreneurs in the above industries began to turn to the academic world for solutions as to how customers may be won through high-quality service. These changes are of historical significance: market demands have initiated interest by business people in concentrated research on the service industry within the academic world. Nowadays, courses like service management and service marketing are offered at almost all business schools in America and there are a great number of students pursuing Ph.D.s in service fields.

At present, over 60% of the GNP in developed countries is derived from service industries. For example, 60% of the GNP and more than 60% of employment are from service industries in Japan, while in America the two figures are 71% and 73% respectively.[2] The growth of the percentage of people with occupations in service industries has two features: first, there is a rapid growth in the market for personal services, combined with the emergence of thousands of new categories of personal services; second, continuous innovation in service technology has led to the appearance of new modes of service and to new types of services with high added-value.

In the year 2000, S. Robson ('Sam') Walton, Chairman of the Board of Wal-Mart Stores, Inc., became the richest man in the world, taking the place of Bill Gates who had previously been listed as the wealthiest man in the world for three consecutive years. When Walton's company was first founded in 1962, it was only a small store. Today Wal-Mart has 3,500 chain stores in America and over 1,000 stores abroad, with the total number of employees reaching almost 900,000. In 2001 it became the biggest company in the world, remaining so for three years (2001, 2002 and 2003) and dominated the Fortune 500 in America. Of the top 20 companies worldwide listed in Fortune 500 in 2001, seven were service companies and of the 15 richest people in the world, nine were from service industries. Service companies entered the Fortune 500 in 1995, an important symbol of the service economy.

An article entitled 'High-tech Industries and Coffee Shops Propel a Revolution' was published in the *Financial Times* in Britain on 2 March 1999.[3] It pointed out that during the previous 30 years the economic output of the service industries of Britain had increased from accounting for one-half of the total economic output to accounting for two-thirds; the number of employees in the private services sector took up half the total number of employees; and if people working in government departments were added, the figure would be three-fourths. The growth in the proportion of service industries was not achieved primarily by the increase of fancy coffee shops, wedding ceremony photography or personal coaches but by providing professional services for enterprises and communities, which include companies specializing in management services, intelligence gathering from other companies, computer services, telecommunication services, financial services, accounting management services, etc. Furthermore, these services are becoming increasingly internationalized.

In fact, as chapter 3 of this book defined service from the soft technology perspective, soft technology service not only covers all types of services —

individual services, firm services and social services — but also filters all types of industries and brings into being other services such as the agricultural service industry, manufacturing service industry, commercial service industry, cultural service industry, health care service industry, sports service industry, etc. Thus, service is an abundant innovational resource. Overall, growing awareness of soft technology has expanded the notion and meaning of service, the knowledge and technological content of service has been enriched and the added-value of service has increased. This is why the innovative activities in service technology have become increasingly common, leading to the transformation of service industry to high-tech industry - and to the emergence of the intellectual service industry and the substitution of the diversified services age of the twenty-first century for the diversified-products age of the twentieth.

The percentage of investment accounted for by R&D has gradually become larger in the service industries than in the manufacturing ones. In 1980, R&D investments in service industries in the US reached only 4.1% of total investment in those industries, while in 1996 the percentage had reached 19.5%. Service industry expenditure devoted to R&D in Britain accounts for 4.02% of the gross sales in those industries, surpassing the equivalent figure in the manufacturing industries of percentage 3.165 %.[4]

The data in the table below further illustrate that the most outstanding change in the economic structure of the United States during the last several decades has been the

Table 10: The US GDP Composition (1982 fixed price), Billion US dollars

Item	1989/1980 ratio
GDP	30%
1. Agriculture, Hunting, Forestry, Fishery	31%
2. Manufacture	40%
There into: Machinery (electrical equipment excluded)	106%
Electricity, Gas and Health Service	60%
3. Trade	43%
4. Finance, Insurance and Real Estate	30%
There into: Mortgage/Commodity Agent and its service	255%
5. Service	47%
There into: Management service	89%
Entertainment and Consumer service	67%
Other professional service	51%

rapid development of the intellectual service industry. Table 10 shows the GDP growth of the US during the ten years from 1980 to 1989 and compares the growth proportions of several industrial sectors. The growth of GDP as a whole during the period averaged 30%, while the sector of the economy devoted to services in finance, insurance and real estate industries increased by 225%. Service industries as a whole grew by 47%, management services grew by 89% and entertainment and consumer services grew by 67 per cent.

Table 11 documents changes in the added-value of tertiary industries in China during the 1990s. It shows that the top four fastest developing sectors in the service industry are postal services and telecommunications (1501%), social service

Table 11: The Growth Rate of Value-Added in Chinese Tertiary Industry

industries (762%), scientific research and comprehensive technological services (619%) and education, culture, art, broadcasting, movie and TV industries (507%). These industries are, in the broadest sense, intellectual service industries of soft-tech industry and they have the greatest future potentiality in China. However, the growth rate of all tertiary industries combined is still lower than that of the secondary industries and is even lower than the growth rate of the total GDP. This lagging growth of China's tertiary sector will seriously limit the sustainable growth of its economy.

In the past ten years, the development of information technology in India has brought along with it the intellectual service industries, such as communications, software, finance and banking, which grows by 8% annually and has become one of the fastest developing sectors. This is the new economy of India. Network TV, music and entertainment are important sources of wealth in India and they are not only the engines of Indian economic development but are also sources of wealth for India's civilians. Today the Indian middle class includes a hundred million members and 50% of the income of Indians is derived from the service industry. The Indian service industry is now worth six billion US dollars and it has been forecasted to reach 87 billion by 2008, providing seven million job opportunities.[5]

The causality of the rapid development of intellectual service industries, broadly defined, may be analysed as follows:

1) Changes in people's values are the primary factor behind improvements in the added-value of services, the fundamental driving force of service innovation and the source of the rapid development of intellectual services.

2) High technologies are developing at such a speed that without corresponding professional services it will be difficult for them to hold their ground. Victory will be awarded to whoever can better apply soft technology when faced with high-technology competition. This is the reason why the so-called 'second economy' was formed in Silicon Valley. In addition, because of the characteristics of modern technological innovation, more and more added-value will come from soft technology, including a multiplicity of service technologies, thereby pushing forward the rapid development of intellectual service industries.

3) In order for the primary and tertiary industries to adapt to market changes and to strive for survival amidst fierce competition, two options are at hand: on one hand, promoting efficiency, improving quality and reducing cost by further increasing their 'technological' content, so that agriculture and manufacturing may become increasingly 'knowledge and technology intensive' industries; on the other hand, increasing added-value by increasing their service content, so

that the professionalization and industrialization of intellectual services are facilitated.

4) The rapid drop of the Engel's coefficient in developed countries also indicates that human material needs, comparatively speaking, are limited and that spiritual needs are unlimited. The improvement of material living conditions worldwide encourages human needs for spiritual products, which helps the rapid conversion of cultural, artistic and entertainment technology into thousands of kinds of products and services, forming a large scale culture industry. This has become an important part of intellectual services, broadly understood.

5) The rapid development of high technology improves human ability. In many fields, it is possible with high technology to grant the wishes of a wide section of the population for whom this was previously impossible and even to help satisfy the more 'extravagant' desires of people. It further forces the wide application of knowledge and technology to the service industry, which gradually becomes an intelligence-intensive industry.

6) Economic globalization promotes the rapid development of trade in services, thereby intensifying the trend towards the globalization of services. As production, technology and research become internationalized, the extent and scope of the dependency of countries on others increases. The parties involved in international trade require mutual services; import and export activities involve not only products, technology and two-way investments but also intelligence and service. The service industry has become an important export industry. At the same time, the features of trade have changed. For example, e-commerce and online transactions are gradually becoming mainstream modes of trade; and culture trade, intellectual service trade and even 'concept trade' have become the new content area for growth.

Since the 1970s, trade in services, including banking, insurance, transportation, telecommunications, tourism, information services, patent transfer, etc., has developed considerably, at a greater speed than the annual growth rate of trade in goods. By 1996, world trade in services had reached 1,200 billion US dollars.[6] Furthermore, China is about to open service trade fields, such as commerce, foreign trade, transportation, education, healthcare, finance, insurance, telecommunications and various kinds of intermediary services. Beijing City's Foreign Economic Trade Committee has established a service trade sector for this purpose.

C. Soft Technology Industry and Industrial Structure

As mentioned above, the third industrial revolution, driven by globalization, information technology,and other modern soft technologies, has accelerated changes in industrial structure. Economists try continuously to track such changes and to re-classify industries from different angles or to offer new definitions and explanations for newly emerged industries.

In 1962, Fritz Machlup, an American scholar, introduced the concept of the knowledge industry for the first time.[7] First, he divided knowledge into five categories: practical knowledge (professional, practice, operational, political, military knowledge and others), intellectual knowledge (satisfying curiosity or the awareness of cultural values), entertainment knowledge, religious knowledge, redundant knowledge and knowledge obtained by chance. Machlup separated the knowledge profession into six levels: transporting knowledge, transmitting information, modifying knowledge (changing the form of knowledge, e.g. a shorthand typist), dealing with or processing knowledge (changing the content of knowledge and information, e.g., accounting), interpreting knowledge (lecturing, translating, analysing) and creating knowledge (original innovation of new knowledge). He believed that the knowledge industry could be understood from two angles: the aggregation of industries producing knowledge and the aggregation of professions (no matter in which industry) producing knowledge. Machlup later added education, R&D, media (printing, publishing, magazines, photography, stage and theatre, movie and broadcasting), information machinery, information service, etc. to the knowledge industry.

In 1977 Mark Paratt and his partners in the US proposed the idea of the fourth industry (quaternary industries) in their book *Information Economy,* in which they divided national economic activities into agriculture, industry, service and information; they elaborated the concepts of primary, secondary, tertiary and quaternary industries in terms of industrial divisions and the speed of development.

Sue Roger (1999) in France proposed that the primary industry sector is actually the agricultural subsistence economy as the mainstream; the second industry is the industrial-equipment economy and the third sector is the paid-service economy. Now the world is ushering in the fourth industry sector, which is a human-centred economy and it is an economic stage that concerns individual 'production', e.g. individual educational status, personal ability, health, personal social relationships and even genetic heredity.[8]

During the 1998-1999 upsurge in China of studying the 'knowledge economy', many scholars discussed change in the modern industrial structure. Most of the points of view expressed at that time were derivations of Paratt's ideas, pointing to the independence domain of the information industry as the fourth industry sector. Others, quoting Machlup, proposed to classify the so-called knowledge industry as the fifth industry following the information industry. Yan Jianjun, in his book *The Rise of the Fourth Industry*,[9] defines the fourth industry as the 'industry creating social wealth using knowledge and the "brain industry" to communicate with and coordinate between the primary, secondary and tertiary industries. It is searching for the key points for productivity by developing and making use of information ... intelligence industry.' In addition, Yan also believed that the fourth (quaternary) industry could be divided into hardware and software categories.

In fact, it is problematic to take the knowledge-intensive industries out and have them constitute an independent industry - the knowledge industry. This is because most of the new industries in the future will be knowledge-intensive industries and this kind division would make it difficult to study industrial structure at all. However, it is not appropriate to treat an industry with a certain technology as the core of an independent industry and then treat it as belonging to the same spectrum as the tertiary and secondary industries, thus treating the information industry as the fourth industry sector. Since there will be many new technologies in the future, the width and depth of their infiltration into primary, secondary and tertiary industries will be pervasive and will be no less diffused in other industries than in the information technology. For example, the biological revolution is regarded as a significant event that occurred at the end of twentieth century and is another milestone after the application of the steam engine, electrical energy and information technology in the modern history of technology.

The great economic powers in the world all regard biotechnology to be a critical technology for their economic-technological development in twenty-first century and are fiercely competing with one another in the field of biotechnology. The Blue Books on biotechnology in the twenty-first century published by the US National Science and Technology Committee in succession since 1992,[10] indicate that biotechnology is now commencing its second tidal wave, after the first surge (in the medical and health care area). They emphasize development of the following: 1) agricultural biotechnology, 2) environmental biotechnology, 3) bio-manufacturing and bioprocessing technology, as well as energy research 4) and oceanic biotechnology.

Modern biotechnology has provided means for human beings to thoroughly understand and change nature and to potentially overcome a series of critical problems, such as the population explosion, food shortages, environment pollution, harmful diseases, severe shortages of energy and resources, destruction of the ecological equilibrium, as well as the extinction of species. At present, 30% of the 10,000 patents issued each year worldwide come from biology technology.[11] Research, development and industrialization in biotechnology has brought about great changes to the world's industry structure and these new industrial factors will also help in forming new high-tech industrial groups fields, such as agriculture, medicine, food, chemistry, energy and environmental protection.

In addition, nanotechnology brought about another wave of technology development.[12] Nanotechnology has emerged from across the fields of chemistry, physics, electronic engineering and biology. The application and diffusion of micromation devices and molecular-electronics ('molectronics') devices into traditional industries, such as the electronics, machinery and chemical industries, will cause revolutionary changes in healthcare, aviation, space, medical care and possibly every field of human life. Scientists predict that the nanotechnology revolution will bring more striking large-scale industrial changes than did micro-electronic devices in the twentieth century. Today the annual output value of this technology in the world has reached 50 billion US dollars and there are 323 nanotechnology enterprises in China alone.[13]

Thus, if we call the information industry the fourth major industry sector, then in the future there will also be a biotech industry sector, life industry sector, nanotechnology industry sector, genetic industry sector, etc. that should be called the fifth, sixth, seventh and eighth industries and so on. It is clear that it is not feasible to continue to list new industries in this way whenever new technologies sprout and develop; furthermore, all these industries belong to industrial groupings in which the only defining differences are their core technologies.

I would suggest that we take all those high-tech industries whose root technology comes from natural-scientific knowledge, such as the information technology, software, biotechnology and nanotechnology, to be the fifth industry sector (the *Quinary* sector) - or the high-tech industrial trade or the high-tech engineering industry. Here we stress high technology from natural scientific knowledge, owing to the existence of high technology in modern soft technology.

A fresh understanding of high technology industry is essential at this point. High technology is relative and temporary. Steam engine technology, electrical technology and radio technology were all 'high-tech' in their time; they all promoted the industrial revolution of their time and formed the basis of the high-tech industries of their age. As they were applied became mature, they were filtrated, absorbed, fused and diffused into the agriculture trade, industrial trade, traditional service, intellectual service and life industries, just as the widespread application of information technology has happened in different industries, such as agriculture, manufacture, finance and biotechnology industries, today. As the result, on one hand, the technological intensity and efficiency of existing industries has been improved (in other words, high levels of industrialization have occurred); on the other hand, mature high-tech industrial firms now contract out specialized manufacturing activities or service activities, thereby shifting them into other industry classifications within related, but currently existing, industries. Dale W. Jorgenson, an American economist, proposes that manufacturing of computer and telecommunications facilities and software be treated as the output of information technology at the gross level (GDP) and be included in the information products manufacturing industry, which has already been adopted by the US National Income and Production Audit (NIPA).[14]

E-commerce is another example. As e-commerce technology becomes diffused on a widespread basis, e-commerce should not really be considered to be a discrete industry in its own right, because the services that support e-commerce innovation for every industry come from related intellectual service industries. Not all industries using e-tools to change their mode of conducting transactions and to improve their competitiveness - such as the finance, manufacturing, circulation and media industries - belong to the e-commerce sector. A profession that specializes in offering e-commerce service has already been developed in Shanghai - e-commerce consultants. It has been calculated that 25,000 enterprises in Shanghai will need at least 150,000 e-commerce professionals within their businesses. This means that it is necessary to include e-commerce as a profession. E-commerce may be defined as the profession that involves sharing non-structured and structured business information by using e-tools (EDI, WEB, etc.) and managing and accomplishing various kinds of transactions in business, management and consumption activities by using those tools.[15]

It is evident that high-technology industries are continuously developing, polarizing and flowing. With the maturity of these industries, industry structures will continue upgrading and optimizing and then the high technology and high-tech industries of the new generation will emerge. Therefore, high-tech industries of different ages have different content. Thus, the industries associated with information, software, spacecraft and bioengineering, etc., should be called 'the present age of the high-tech industrial trade'. The content of high-tech industries of the next generation should be different from earlier ones. The high-tech industrial trade can also be divided into hard-tech industrial trade and soft-tech industrial trade (see table 12).

The biggest issue in the change of industrial structure exists in the service industry. As mentioned above, with the softening of the economy the service industry is taking up a larger proportion of the total economy. If it is not properly classified, the service sector will exert unhealthy influences on economic development planning and have a negative effect on both research and policy adjustments pertaining to industrial structure. Therefore, experts have conducted a good deal of research on the classification of services.

In 1978 Kusaka Kimindo, a Japanese scholar, proposed that tertiary industry could be separated into three parts: the service industry that is physical-power oriented, the service industry that is intelligence oriented (so-called knowledge and information type) and the service industry that is psychology oriented. The third part refers to the emotional satisfaction type or informational presentation type and is proposed as the fifth (quinary) industry, while the second part is proposed as the fourth (quaternary) industry.[16]

In 1983 Makino Noboru argued for classifying the new type of the service industry into intermediary services (consultants, counsellors, tax managers, accountants, designers and recruiters), computer software services, security and insurance services, social services (education, health, traffic) and personal services (express delivery, medical treatment, lawyers, tutors, etc.).[17]

In 1986 Maeda Kazuhisa[18] suggested that the service industry should be divided into the third industry (physical-power service industry), the fourth (equipment industry), the fifth (intelligence service), the sixth (emotional service) and the seventh (religious service). According to him, the third industry consists of the provision of hands-on services, e.g. baggage carriers, tailors, taxi drivers, etc.; the fourth consists of combined services that developed by using intelligence but are protected by physical powers, e.g. railways, real estate, hotels and banks, etc.; the fifth consists of providing intelligent services using the brain, including industries centred around consulting, think tanks, writing, designing, teaching, broadcasting and providing news; the sixth provides emotional services to please people, for instance, industries such as the entertainment, movie, art, theatrical and music industries; and the seventh provides religious services to set people free from the uneasiness regarding death and to help gain psychological calmness.

It is obvious that the keystone for change of industrial structure is the tertiary industry or the traditional service industry. However, as described above, the content, role and significance of service exceed the traditional sense of service, thus it is difficult to strictly distinguish between the service industry and the manufacturing industry. Furthermore, within the service industry itself, it is also difficult to divide traditional service from a new type of service. It is for this reason that I used soft technology industry in this study.

Since the method and means of service belong to one of the soft technologies and service innovation requires the concept of soft technology innovation, I would propose classifying soft technology industry by the key soft-tech that forms its industry, namely, dividing the present tertiary industry category into the traditional service industry, intelligent service industry (broadly defined) and the life industry and again to classify the intelligent service industry (broadly defined) into intelligent service industries (in the narrow sense), culture industries and social industries, depending on the core soft technology.

Those non-material production industries based on fixed assets, such as transportation, brick-and-mortar retailing, hotels, restaurants and real estate, etc., should still be considered to be part of the tertiary industry sector.

Soft technology industries, such as intelligent service industries (in the narrow sense), culture industries and social industries should be separated out from the present service industry category and be included in the fourth industry category (quaternary sector) or the intelligent service industry (broadly defined). The quaternary industry is not labelled a 'new type service industry' in this book. The reason is that although it is easier to distinguish it from the traditional service industry, the new and old (traditional) industries are always two relative concepts and these concepts are not accurate enough to be used to define an industry. Moreover, the traditional part in the modern third industry will gradually decrease over time.

I am also suggesting the separation of the industries related to the human body, human life and health from the service industry and that it be named the sixth industry, or life industry (the sextenary sector - the sixth industry category). As a special industry, its isolation from the general service industry may be justified on several grounds. First, it is centred on the human body; second, the orientation of its development is more closely related to culture, ethics and morality than is the case with the intelligent service industry; third, since there have been different understandings of and solutions to life and health in the West and the East since ancient times, we need to integrate traditional Chinese medicine with western medicine and develop science and culture from the two sides as a whole; fourth, no other industry needs such a wide range of disciplinary integrations. As life expectancy rises and the geriatric society looms over us, there is an urgent need to provide for high-quality life for elderly people. Apart from what may be offered by the general medical and healthcare industries, there are new technologies and industries, such as those concerned with disease prevention, prevention of ageing and anti-senescence, that are emerging. In addition, special manufacturing industries that produce artificial organs, blood vessels, bones and skin, etc., will also be separated out into their own industry.

The life industry will consist of two parts: one part includes hard-tech industries that are mainly composed of medicine, healthcare, medical technology, human genetics and human organ manufacturing industries; another part includes soft-tech industries, such as traditional Chinese medicine, life prolonging techniques and health and wellness industries (including the combination of Chinese and western medical science).

Table 12: Soft-tech Development and the Change of Industrial Structure

The main role of soft technology in the primary, secondary and tertiary industries has been to serve as a tool for technology transfer and innovation. It also serves as the core technology in the quaternary industry. In addition, in the fifth and sixth industries, besides serving as a tool for technology transfer, it infiltrates deeply into original hard technologies, increasing their added-value and softens them. Therefore, there are hard and soft parts in both the fifth and sixth industry sectors. For instance, software, human intelligence and the genetics industries within the fifth industry sector are categorized here as soft-tech industry.

In the above discussion, I consciously avoided using terms such as ‘knowledge industry’ or ‘knowledge-based industry’ for the following reasons. First, no matter whether it is part of the fourth, fifth or sixth industry sectors, all industries are knowledge-intensive. Second, modern agriculture (a so-called ‘primary’ industry) is gradually becoming a knowledge intensive industry, with land as its object. An American farm owner said that eight high technologies including satellite communication and computer technology are in use on his farm. This enables America to provide enough food for the entire country with only 2.7% of the total workforce employed in agriculture, while remaining one of the world’s main exporters of grain. Third, modern secondary industry, especially manufacturing, has already become an equipment-based, knowledge intensive material production sector. Finally, the fifth industry sector should be called the ‘high-tech industrial trade’ sector, considering the fact that high-tech agriculture industrial trade will achieve rapid development along with the industrialization of agriculture.

To sum up, the special theme of the industrial age - the division of industry into manufacturing and non-manufacturing - is losing its practical significance and it is no longer feasible to strictly classify industries into the orthodox categories of primary, secondary and tertiary. Under these circumstances, researchers are trying to stipulate new industrial classification standards, auditing criteria and statistical systems for industry.[160]

D. The Characteristics of the Soft Technology Industry

Compared with traditional industry, soft technology industry has many distinctive features. These include the factors listed below.

1) Price

Price is greatly influenced by values. For example, the prices of products of famous brands, new recreational machines, special services, etc., are based mainly on consideration of the benefits of the creators and the extent of spiritual satisfaction created for the customers, so there is an obvious gap between price and production cost. This tendency is most noteworthy in the cultural industry, e.g. in the fashion industry it is difficult to explain the causes of the increase or decrease of gross sales by simply using orthodox economic concepts associated with traditional products, such as price, quality and service.

2) Input

Inputs are similar to those of other industries. Entrepreneurs (start-ups or initiators) and investors (sources of financial capital) are the two indispensable inputs for soft-tech industries. Nonetheless, in the case of soft-tech industries, entrepreneurs are the primary input and capital is the secondary input. In other words, in a soft technology start-up enterprise, originality is the first important element and adequate capital is the second.

3) Psychological factors

As mentioned above, one of the key variables of soft technology is the psychological factor. In the age of intelligent services, the factors that give people excitement shift from novel product function, good product performance and low product prices, to the dream of life, the meaning of life, interests and hobbies and self-fulfilment. Consequently, people's demands change from function type, essence type and rationality type to feeling type and emotion type. It is therefore important that human services try to meet these demands. Accordingly, Kusaka Kimindo has even put forward such ideas as the exchange position of psychology and economics in the new age and the 'emotional-ization' of service.[19] At the same time, when government departments contemplate institutional innovation, they should consider the psychological endurance and reaction of the mass of people; likewise, in industry, successful enterprise managers need to first of all consider how to satisfy the psychological pursuits of their customers when developing new products and should try to materialize the psychological needs of their customers in a timely manner.

4) Resources

Traditional industries mainly develop material resources, whereas soft-tech industries draw upon a variety of resources including natural resources, intelligence resources, cultural and artistic resources, social resources and human body resources, etc., thus enabling development to take place across a broader array of fields.

5) Integration and fusion

Soft-tech industries involve the fusion and integration of different types of knowledge and technologies, of science and art and of hard and soft technologies. The boundaries between various soft technology industries are therefore blurred and often ambiguous.

6) The features of products

Typically, the products of soft-tech industries are intangible and therefore cannot be stockpiled or stored. In soft technology industries, demand and supply occur simultaneously. In other words, production and application take place at the same time.

7) The cradle of new conceptual enterprises and entrepreneurs

Soft technology is the headspring for brand new ideas, the growth point for new industries and for new conceptual enterprises. The integrated innovation of soft and hard technologies, in particular, is a seedbed from which immeasurable business opportunities may sprout. At the same time, the professionalization and industrialization of soft technologies will create a great diversity of entrepreneurs, e.g. cultural entrepreneurs, design entrepreneurs, educational entrepreneurs, social entrepreneurs, etc., even entrepreneurs of entrepreneurs (e.g. incubators) and will also provide more diversified job opportunities for each society.

The focus of the following section is on intelligent service industry (in the narrow sense), cultural industries and social industries.

E. The Intelligent Service Industry in the Narrow Sense

The intelligent service industry, which aims at the service market, provides services for other industries, groups or individuals with intelligence as the main means of service.

1. Consulting Industry

The consulting industry is the most mature example of intelligent service industries, not only because its history commenced more than a century ago, but also because it exhibits a high-level division of labour on the basis of specialization. It is an industry specialized in providing judgement, intelligence, insight and solutions - related to a variety of fields, including strategic planning, enterprise management, trade negotiation, legal consultation, technological advice, personal health consultation, etc. The development of hard technologies has provided newer and better tools for the consultation industry, whereas the development of soft technologies will further expand the service field and the influence of this industry.

2. Intermediary Service Industry

Strictly speaking, the intermediary service industry is one type of consulting industry. It is listed as an independent category because of its special role in modern economic and social development and in international cooperation.

3. Public Relations Industry

Along with the globalization of economics, technology and services, the public relations industry has expanded to cover all fields of social and economic activity, such as media relations, government relations, image design, product and service markets, large-scale events, community relations and crisis management.

4. Various Specialized Management Industries

Various specialized management industries provide professional services for enterprises and communities, including companies devoted to asset management, financial services, production services, talent services (including headhunting companies), computer services, accounting management services, legal services, tax administration services, logistics services and physical distribution management, etc.

5. Advertising Industry

See the section about advertising technology in chapter 2.

6. Venture Capital Industry

See the section about risk investment technology in chapter 2.

7. Incubator Industry

See the section about incubator technology in chapter 2.

8. E-commerce Industry

The e-commerce industry specializes in providing new technologies and new services for e-commerce. Like information networks, e-commerce can only create wealth through the specific content of transactions (the products or services around which transactions occur) or business. The objects of e-commerce services can be divided as tangible commodities, media, information commodities and online services.

9. Modern Finance and Insurance Industries

These are intellectualized traditional service industries.

10. Design industry

Design can be separated into two classes: hard design, which is product design, construction design, industrial design, interior design, city design and transportation design, etc.; and soft design, which includes enterprise design, business division design, image design and enterprise image design, etc.

11. Re-engineering Industry

The re-engineering industry specializes in providing new services such as the technology of technologies (e.g. the design of technological institutions), the design of designs, the engineering of projects, the business of businesses and the market of markets (e.g. a market broker in the stock market). The re-engineering industry is the industry that specializes in creating new games through re-designing, re-engineering or re-organizing existing games.

12. Concept or Idea Industry

The concept industry specializes in providing new concepts, brand new ideas and original ideas. The experiences of the last few decades prove that each new concept brings about many business opportunities, followed by the development of hundreds and thousands of enterprises, such as the Internet, multimedia, e-pet, etc.

13. Modern Physical Distribution Industry

See the section about Physical Distribution Technology in chapter 2.

14. R&D Industry

The R&D industry is focused on providing new technological resources through systematically organized research activities and development activities. Besides providing hard-tech resources, it may also provide soft-tech resources for further commercialization and industrialization.

Since the 1980s, intelligent services have gradually been developing and gaining acceptance in China but awareness about intelligent services is still at the stage of consultation, intermediary work and the planning of schemes. Tomorrow Design Co., Ltd., in Shenzhen[20] is one example of a comparatively successful company in the field of intelligent services. It was once listed in the top ten planning companies in China. This company started its business by focusing on designing enterprise images and later broadened the scope of its activities to involve all fields of management. Advertising for this company in 1999 indicates that its business fields had grown to cover almost all aspects of the intelligent service industry: image design, brand planning, strategic planning, regional development, market research, management consulting, social activity planning, cultural integration, enterprise re-engineering, project planning, public relations, capital management, printing, factory design, product packing, gifts and etiquette, movie and TV ads and photography, real estate promotion, decision-making consultation, management mode design, staff training, market planning and acting as advertising agents, etc.

The incredibly broad scope of the business of Tomorrow Design indicates how low the level of specialization in the soft-tech industry is in China. Generally speaking, the extent of usage of outside intelligent services of an enterprise reflects the enterprise's management level and development level of a country but most Chinese enterprises do not yet use outside sources of intelligence when dealing with problems. For example, there are over 30 public relations companies in China with relatively permanent customers and more than 20 of these are funded solely from within China, including more than ten joint ventures.[21] Unfortunately, 80% of the customers of the 30-odd companies are foreign. Furthermore, turnover for the Chinese consulting industry was ten billion RMB in 2000, accounting for only 0.11% of GDP but the majority of this percentage belonged to emigration consulting, study-abroad services and advertising design, etc. In addition, enterprise management consulting accounted for less than one billion RMB.

F. Social Industry

Social industries are formed with social technologies as their core technology. They create and embody economic and social value in the process of solving social problems and handling social affairs by developing and applying social resources.

1. The Value of Social Technology

The economic value of social technology is the value created by social activities that can be measured by currency. Social activities themselves have always been accompanied by economic activities, in the traditional sense of being funded through the redistribution of public resources and investments, the expansion of charitable donations, or self-financing. These economic activities can only be maintained through the support of public investments and donations from traditional economic sectors, the main sources of which are business transactions. However, if we want social technologies to create more value for social development and for these activities to independently complement the traditional economy, 'aid' and 'charity' alone from the traditional economy will not suffice.

During the last seven decades social activities have gradually formed the basis for alternative forms of transactions. All types of transactions within social industries, such as career services, social services and networking exchange services, can achieve their aims by using another kind of exchange tool - complementary currency (see chapter 2) - and by forming an economic domain completely different from the traditional economy (which uses financial capital to develop material resources). As society develops, this economic domain takes up a larger proportion of the national economy and becomes the major service field for social technologies.

The social value of social technology is expressed by the degree to which it contributes to achieving socioeconomic development through the following approach: handling a greater volume and greater complexity of social affairs; enriching people's lives; acquiring more knowledge, skill and opportunity for enjoyment, so as to satisfy people's social aspirations; solving problems that cannot be solved by the government or market, including moral issues; and, providing a favourable environment for creativity, originality, responsibility and initiative.

However, there is a dichotomy in the value of social resources. The development of social resources may bring high quality economic growth, employment opportunities and multifarious social benefits but may also have a negative effect or even a devastating effect in some cases.

Portes [22] describes four aspects of the negative effect of social capital:

1) The same strong ties that bring benefits to members of a group common1y enable it to bar others from access.

2) The obverse of the first because group or community closure may under certain circumstances prevent the success of business initiatives by their members.

3) Community or group participation necessarily creates demands for conformity. The level of social control in such settings is strong and also quite restrictive of personal freedoms, for example constraints on individual freedom and creativity.

4) There are situations in which group solidarity is cemented by a common experience of adversity and opposition to mainstream society. In these instances, individual success stories undermine group cohesion because the latter is precisely grounded in the alleged impossibility of such occurrences.

   I would like to add another negative effect.

5) Depending on the organizers or handlers of social network who follow different standards of internal social resources, the value of social resource may become negative. The extreme example of this situation is the criminal syndicate, the Mafia and heresy organizations.

The attitude to the negative effect of social capital is the key factor for different public and corporate institutions of a country. This also is a main cause of the strict restrictive policy for developing a social community or NGOs in China.

2. The Social Market

From the perspective of demand, social industry comes into being in response to the demands of the social market, which are nowadays becoming greater. The issues that generate this demand include: 1) demand to resolve social problems: with the maturing of the industrialization society, many complex social problems such as environment, energy, population ageing, urban and traffic issues, family disintegration, teenage crime and violence, ethics, the gap between the poor and rich, etc. are increasing; 2) as we enter the age of economic globalization and information, the number of fields in which both the government and the market are inefficient or ineffective is gradually increasing; 3) the demand for improvement in the social function of self-discipline: with social progress and the improvement of people's educational levels, common awareness of the necessity for social self-discipline is rising; 4) the rapid development of hard technology has amplified the negative effects of high technology, as embodied in issues related to freedom of scientific inquiry, deep conflicts between the pure scientific development and ethics, morality, world view and culture, sustainable development and public safety; 5) the existent and developmental demand of external social resource: working hours are generally decreasing worldwide, spiritual demands are increasing, lifestyles are becoming diversified and people are living longer, thus accelerating the rise of an ageing population. People are paying more attention to and are involved in more activities associated with informal organizations, such as community organizations, social groups, associations, learned societies and unions. Social resources are therefore becoming more abundant and increasing their economic value; 6) demand of development social industry: see details about social industry; 7) with economic globalization, we need to develop ways to protect and develop regional economies and to protect the diversity of culture, minority resources, ecology resources and history resources; 8) the functions of the government are constantly changing and the challenges of social affairs are rapidly increasing; 9) decisions related to the challenges of sustainable development and of economic and technological internationalization need to address multiple dimensions of society, the economy and technology and need to be formulated in a multi-disciplinary manner within an integrated framework; 10) demand of the new economy: the inherent conflicts of the traditional economy (GDP number one, especially periodic financial crises) calls for the development of another type of economy (human-centred and sustainable) to serve in a complementary coordinating role alongside the conventional economy.

3. More Attention is Being Given to Various Types of Social Industries

Although the development of the social market and social industries have a long history, our understanding of social relations and social activities as a kind of social resource (in other words, developing social activities as one special field of economic life - social industry) began only a few decades ago.

An article by Sue Roger entitled 'The Main Source for Social Economy' was published in the French newspaper *Le Monde*[23] in 1999, which proposed that social activities are an important source of economic resources that form a basis for the 'social economy'. Roger points out that social economy has always been the basis for all kinds of associations whose role is to solve problems that cannot be solved by the government and the market, such as medical and health treatment, training, social relations and ethics and moral issues. Roger says that in addressing such needs social industries play an important role in the creation of wealth. In France it is estimated that the social economy accounts for 4% of the GDP, comprises one million employees and involves 80% of all the French people in its constituent social activities.

The WIR[24] system, which was founded in 1934 by 16 members in Zurich, Switzerland, is a community that survives on mutual economic help by exchanging materials and services within the community or getting credit loans from related centres. After 60 years of development in this most conservative country with the highest living standard in the world, WIR's residents and SME members are continually growing and the system has developed to a respectable size. It had 80 thousand members in 1994 and had a trade value the equivalent of two billion US dollars during that year. The LETS system, which was developed in the Canadian province of British Colombia during that country's period of high unemployment in 1982, has expanded to 25 to 30 regions in Canada, becoming the most widely applied system in the world. Similar community economies are developing rapidly in the US, New Zealand, Australia, Japan, the UK, France, Germany and other European countries.

In recent years Neal Kocurek, of David's Health System of Austin, Texas, has engaged in a special incubator career. Working with the government to provide services for citizens, they specialize in helping related departments of local governments solve problems in strategic planning, traffic and labour force; work together with universities to solve problems concerning education and tentative planning for a new type of university; cooperate with enterprises and the government to solve problems of e-commerce; coordinate with hospitals to solve problems related to healthcare; and help leaders in different fields to expand relationships and networks, etc. Through the regularization of these activities, which are then managed by specialized individuals and organizations, a new type of enterprise is forming - a community system company, a traffic system company, etc. People who establish these kinds of enterprises are called 'civil entrepreneurs' or 'social entrepreneurs'. These activities fall under the rubric of 'entrepreneurial incubation', which is a new field within the intelligent service industries.

Analysed from the angle of institutional innovation, this is one form of institutional innovation that concerns government in the field of public affairs management. The function of government has changed from directly managing public affairs to entrusting and authorizing the right of management to others, through contracts to enterprises engaged in social industry. The government is granted supervisory rights in society through laws and policies and it can also intervene in society indirectly by means of purchasing or subsidizing when necessary. The introduction of competitive mechanisms into public departments, as in the above examples, may not only benefit the public, but may help avoid problems of unclear property rights in public agencies, lack of competitiveness and low efficiency in government administration.

More than half the world's population now live in cities: in developed countries more than 75% of the population live in cities; in developing countries it is 38%. Whether in developed or developing countries, cities are facing similar problems, such as employment, pollution, traffic congestion, public security and housing shortages. In China, all social public affairs have typically been managed directly by government. Over time this resulted in the burden of government growing increasingly heavy, leading inevitably to an overload in the responsibilities of government officers; on the other hand, enterprises and even research organizations in China have had to be responsible for society. These features of Chinese society run the risk of weakening the country's social capability for self-management.

Regarding public social affairs, the challenges of separating administration from management exist not only in China, which is undergoing the transition from a planned economy to a market economy, but also in developed countries. This challenge involves a fundamental transformation of the function of government.

Actually, along with the maturing development of the market economy, the complexity and volume of the public social affairs worldwide are continually growing. This creates pressure for government to out-source the administration and give part of the right to managing public affairs back to society at large, establishing a concept of 'social government' in the relationship between government and the rest of society.[25] The administration of part of the public affairs by social organizations will improve the capability of social self-management and self-discipline and gradually set up the autonomous mechanism for economic development - the 'wild horse'. An example from the US may illustrate how non-government associations may act as a basis for the development of social industry and the soft-tech industry. The All America Brokers Association is a stellar example of an organization that promotes financial self-discipline in the US.

New kinds of civil entrepreneurs are now emerging who manage city and town affairs as a kind of private or social business. This is an example of how conventional government administration can be delivered through the vehicle of independent enterprises. Some entrepreneurs are even taking on the challenge of creating new cities with new functions, as independent ventures in their own right.

Other opportunities for social industries include urban infrastructure, training and education, medical treatment, providing services for the aged, housing and employment services, etc. These kinds of managerial activities need not be restricted to urban areas only but can also be the basis for creating series of new businesses and new industries in small towns or villages.

4. The Characteristics of Social Industry

As to the characteristics of social capital, there is stringency study in the report of PIU.[26]

- Social capital is not the exclusive property of any one individual. Social capital is shared by a group, or by groups, of individuals. To the extent that all members of society or a community have access, it may constitute it a *public good*. But to the extent that groups of individuals can control access by other individuals, it may correspond more to a *club good*. This distinction has important consequences for whether and when the impacts of social capital are likely to be economically and socially beneficial and for the role of government in promoting and shaping social capital.
- There has been some controversy about the use of the term 'capital' in this context, with its implication that there is a stock of social capital assets on which returns are earned. This is directly analogous to the controversy over the term 'human capital' and the response is much the same. Classical analyses of capital as financial, physical and other tangible assets neglect the value - even in narrow economic terms - that lies in social networks and shared values that facilitate cooperation between actors, just as they neglect the importance of knowledge and skills.

- The term also helps to highlight the potential 'fungibility' between financial, physical, human and social capital. In general, _*physical capital* includes plant, machinery and other assets; *natural capital* includes clean air, water and other natural resources; *human capital* includes knowledge, skills and competences; *social capital* included social network, criterion , belief, etc.; *cultural capital* includes familiarity with society's culture and the ability to understand and use educated language;[27] and *financial capital*, used to fund, acquire or invest in the other forms of capital. These different forms of capital are not wholly independent of each other but are mutually interdependent and re-enforcing. Social and cultural capital play a key role in shaping human capital and vice versa, which will in turn affect and shape physical capital and decisions about the investment of the economy's flows of finance.[28]

There is another characteristic of social capital: although social capital is described as an intangible capital endogenous within the structure of human relationship, there are also many tangible carriers of social capital (external resources) and tangible social capital (many public good).

Based on the feature of social capital as described above and the definition of social industry in this book, the characteristics of social industry can be described as follows:

1) The aim: the main purpose of developing social resources is not to obtain profit, in the traditional sense, even though social industries consist of economic activities in the social market. The fact that pursuing maximum profit is not the primary purpose of social industries is the biggest element that differentiates social industries from industries in the traditional economy.

2) Resource: the main resources of social industry include two kinds of social resources: *club good* resource (attribute), described above, and the *public good* resource.

3) Product: the objects of exchange in the social market are not commodities, in the traditional sense. Rather, they mainly consist of various kinds of services; moreover, ethics and morality are inseparable aspects of social industries.

4) The feature of management: social industry is about managing social capital and this perspective impacts non-profit enterprises or organizations.

5) Scale and quality: the scale, dimensions and quality of social industry is strongly influenced by the history, cultural tradition, value, religion and social structure as well as the economic development level of a country or a region.

6) The diversity of the income source.

7) There are two types of exchange tools in social industry: traditional financial currency and complementary currency. With the development of social industries, the second set of tools will become more prominent. The latter has many advantages. For example: complementary currency disappears in the process of being used, thereby avoiding many potential problems in issuing formal currency of the conventional financial kind; it is resistant to the influence of the bubble economy and inflation; it typically does not accrue interest; it is beneficial to regional economies and community economies; it may be a convenient form of capital for SMEs and for the operation of non-profit organizations; and, it can be conducive to the cultivation of harmonious interpersonal relations. Once a complementary currency system is running in a benign circle, it is pos-

sible for a community to form a self-reliant system for solving social problems without social subsidies or payments from taxpayers. Bernard predicts that complementary currency systems will top 10,000 worldwide by 2008; complementary currencies will represent 20% of total domestic trade in the most advanced countries by 2020.[29]

8) The economy formed by social industries will be different from the economy as traditionally understood. The general economy may be thought of as the 'Yang' type economy, with material resources playing the lead role in economic development and traditional financial currency as the primary means of exchange and unit of measurement. In the general economy globally competitive business transactions take place with 'Yang' currency because of its higher efficiency in facilitating competition. The economy formed by social industries is a 'Yin' type economy that is beneficial to communal and regional economic development. It draws mainly upon the development of social resources with complementary currency as the major means of exchange and the primary unit of measurement. It is most appropriate for the 'Yin' economy with the 'Yin' type of currency to be developed and coordinated in a complementary and cooperative manner with the 'Yang' economy and the 'Yang' type of currency.

5. The Types of Social Industry

According to our present understanding of social industry, various types of social industries can be classified according to their main supporting body, as follows:

1) Social 'economic' bodies, such as industrial organizations (associations and chambers of commerce), research institutes, social communities and other non-profit organizations. As society and the economy develop, an array of new social organizations will arise to fulfil important functions that government and markets are unable to properly fulfil; and the range of such organizations will spread, including organizations involved in fields such as consulting services, intermediary services, industrial administration, government relations (lobbying), international relations and social education, etc. In China, for example, the Chinese Science and Technology Association has more than 3,000 organizational members, more than 70,000 academic groups and over four and a half million individual members. These are valuable social resources, which have not been fully developed.

2) Economic activities of communities, social groups and neighbourhood committees

3) Civil enterprises and social enterprises

4) Schools, training centres, hospitals and healthcare etc. all kinds of public sector institutions

5) Other non-profit organizations, including political ones, such as government organs, parliaments and courts

Social industries can also be classified in terms of the social market, as follows:

1) Resolving social issues, handling social affairs, coordinating relations between government, enterprises and the public

2) Activities surrounding the socioeconomic development of a region or community

3) Concentrated information exchange activities, including seminars, exhibitions, commodity fairs and various types of exchanges, etc.

4) Civil business markets, urban and town management markets

5) Education and training activities

In addition, the education industry pursues the cultivation and training of people and seeks, as its main function, to nurture people's abilities; but in most cases education is not an appropriate medium for the pursuit of profit and nor are industries run by schools.

6) Medical treatment and healthcare fields

7) The undertaking of services for the disabled

8) Social welfare, including nursing of the aged and terminally ill and family services

9) Disaster prevention and environmental protection fields

10) Planning, strategy, decision-making and forecasting in all dimensions

All the above discussion about social capital, the characteristics of social capital by PIU and social resources (internal and external social resources) is from the perspective of sociology. However, after discussing social industry and the classification of social industry and considering the function of government in this field, it is necessary to expand the content of social resource. Social resource is for the formation of social capacity and the improvement of social function; social capital is the capital of social capacity.

G. Cultural Industries

1. What is Cultural Industry?

The development of cultural industries is closely related to the level of economic development and the quality of national culture in a country. Adam Smith remarked as early as the eighteenth century: 'Whether a man is wealthy or poor can be judged by seeing to what extent he can enjoy necessities, conveniences and recreations.'[30] Western developed countries made important moves in the development of cultural industries as early as the 1930s and 1940s. Today, the national economies of advanced industrial countries are balanced on top of cultural industries. According to an annual report of UNESCO in 1998, the share of the total economy occupied by cultural and education has been increasing by 11.3% annually, worldwide. In 1998, job opportunities in Las Vegas, Nevada (the 'entertainment city' in the US), increased at a rate 8.1% higher than any other city in the country.[31] Furthermore, cultural industries have long become an important export industry, with America's Hollywood being the most remarkable example.

Kusaka Kimindo, a representative Japanese scholar in the field of cultural industries, has proposed that there will be an age of culture development after the economic development age, social development age and qualified personnel development age. In this age, members of society will devote a great amount of income, time and ability to self-fulfilment and the pursuit of happiness. In his 1978 book *New Culture Industry*, Kimindo calls for a policy of 'nation-building on the basis of culture' to be implemented in Japan, arguing that culture can produce high profits and can be sold at high prices; and, in addition, that cultural symbols can enhance the income of commodity businesses. Kimindo advocates the exportation of Japanese culture, art, movies, TV programmes, music, books, tea ceremonies, IKEBANA, language schools, entertainment, martial arts, I-go, etc. He also proposes that the conditions for creating cultural industries are as follows:[32] 1) the general improvement of material life (which can turn cultural products into popular spiritual products, rather than the luxury of a few), 2) the general improvement of the national cultural quality of people, 3) rich cultural resources, 4) in institutions, providing lots of opportunities for introspection (introspection on the weaknesses and deep-rooted habits of a nation, as well as those 'illnesses' that are caused by the cultural factors in social and economic life), and 5) a high level of manufacturing capability suitable to support the commercialization of culture.

The level of cultural innovation and cultural industrial development in a nation is an indicator of the maturity of that nation and is also an important symbol of the stage of its economic development. In China, people tend to be more concerned about the challenges that conventional industry and agriculture are facing now that China has entered the WTO than they are about the prospects for cultural industries. However, Chinese cultural industries and even cultural traditions, are going to experience profound and serious shocks. The splendid cultural heritage of China is a great treasure in which immense wisdom can be found and it can also be the source for creating countless soft technologies and spiritual products, in thousands of forms. The issues facing China in this area are how Chinese culture and arts may be integrated with modern high technology to develop a Chinese type of cultural industry and how to maintain the country's noble traditional culture in the face of foreign cultures that are entering China on a large scale. At the same time, a more important task is to identify how Chinese culture may be exported positively and establish its position in the world of cultural industries. China, with the implementation of its policy of reform and opening up, has witnessed a rapid boom in the cultural market, accompanied by the enrichment of material life. Since the 1990s, Chinese scholars have also increased research efforts on cultural industries.

Understandings of the meaning of cultural industry vary according to different starting points of the research. Examples are below:

'Cultural industry is the complex whole of all industries that provide services for the demand of spiritual life and entertainment.'[33]

'Cultural industry is an industry engaged in the production and service of spiritual and cultural products. It takes cultural products and activities as the main object, dealing with production and management to exploit and build up administrative and service sectors. It mainly includes culture and arts, education, sports, science and technology, tourism, religion, etc.'[34]

'Cultural industry is the special industry dealing with the production of cultural products and providing cultural service. Its essential feature is to transform all human activities of knowledge, intelligence, spirit, art and information and their successes into cultural products that can be consumed, enjoyed, exchanged and transacted by using certain materials as their carriers. The biggest difference between the cultural industry and other industries is that its cultural content and function is much higher than its material content and function. Its peculiarity lies in taking original spiritual activities as its foundation.'[35]

'Cultural industries are the industries born for creating culture, which entails creating a certain culture, selling this culture and its symbols.'[36]

Overall, the cultural industry exploits and utilizes cultural values and cultural resources, as well as commercializing them. The main value components of the products and services of the industry are cultural content or cultural values. In view of the dualism of cultural values, an analysis of the features of cultural products is an important first step:

1) The development of culture commodities should adhere to the principle of healthy culture and 'uphold the good and repress the bad'.

2) Cultural and artistic products require more individuality and creativity than is required for the production of material resources and products.

3) A large disparity may often exist between the price and cost of cultural products.

4) The exportation of cultural products not only creates economic benefits for the exporting country but also plays the role of disseminating its culture. American movies, McDonalds, Japanese cartoons, Japanese video games, Japanese sushi, Chinese martial arts, Chinese cuisine, Korean 'kim chi', Korean Tae Kwan Do, etc., are creating quite large markets worldwide, thereby actually helping to disseminate the cultures of these countries.

5) Owing to the non-commercial nature of spiritual production, some cultural activities or products with good social benefits may have little or no economic benefits in the medium or short run. For example, cultural heritage development, elementary education and research on basic science may cost more than they generate. The development of cultural industries, therefore, needs conscious coordination of social and economic benefits. Not all spiritual products or activities can be commercialized and we should not seek to commercialize cultural and works of art activities simply for economic reasons.

2. The Classification of Cultural Industries

There are a wide variety of ways in which cultural industries may be classified, depending upon the frame of reference of those doing the classification. We will now look at some important contributions in this area.

The classification of cultural industries offered by Kusaka Kimindo in 1980 is as follows:[37]

1) Industries that make active use of spare time, including the life-long education industry, the interest industry, sports industry, long-distance education industry, music industry, publishing industry, self-fulfilment industry, etc.

2) Industries centred around conducting household choices and enjoying family activities, including the household agent industry, the catering industry, the processing industry, the family reunion industry and new forms of agriculture and horticulture, etc.

3) Industries that nourish life, including telecom selling, vending machines, sole-agent stores, advertising industry, large-scale retail activities, etc.

4) Industries that expand the circle of friends and acquaintances, including the dating industry, urban entertainment industries, the lovers industry, tourism, the beauty industry and other cultural industries, etc.

According to the project *Research on Developing Cultural Industries in Shanghai,* which was organized by the Shanghai Municipal Government in 1998,[38] cultural industry is the industry of producing, selling and utilizing cultural and artistic commodities. The Shanghai project classified cultural industries as listed below.

1) Cultural product manufacturing: the book, newspaper and magazine publishing industry; the duplication of recorded media; the manufacture of musical instruments and other cultural entertainment products; and the manufacture of handicraft articles, etc.

2) Cultural product retail trade: the retailing of books, newspapers and magazines and retailing of stationery commodities, handicraft articles, etc.

3) Cultural service industry: entertainment service industry, art industry, publishing, relic industry, books, archives establishments, mass and popular culture, news, cultural and artistic dealers and agents, broadcasting, movies, television and other cultural service industries.

Professor Li Yining of Peking University has divided cultural and artistic articles into products in material form (such as music and audio-video products, artistic works, books and magazines) and spiritual service products (services provided to the society by cultural and artistic sectors and organizations, like artistic performances), from the vantage point of economics.[39]

However, the classification of cultural industries is becoming more difficult as all kinds of cultural products and services tend to intersect and merge with each other. Take the entertainment industry as an example. The rapid development of digital technology promotes the 'high technologification' of entertainment technologies and alters our concepts of entertainment technology, the entertainment mode and even entertainment itself. It also blurs the boundaries between television, PCs, recreational machines and mobile phones and enables the convergence of all entertainment-providing media, such as music, movies, television, electronic games and the Internet, thereby giving birth to digital entertainment. In the twenty-first century, digital entertainment will surely change the mode of life and business of people dramatically. With the popularization of high performance broadband Internet access, all the single direction media, such as broadcasting, television, movies, magazines, newspapers and books will be challenged.[40]

Based on the understanding that cultural industry may be seen as the aggregation of professions engaging in cultural production and services, we may classify ten typical cultural industries:

1) Entertainment industry

The entertainment industry creates entertainment, produces and disseminates entertainment and manages entertainment. Entertainment factors are important for increasing the added value of products. The entertainment industry includes the music industry, the movie and television industries and the performance art industries, etc.

2) Sports industry

The sports industry can be divided into three categories: 1) engaging in sports (professional and mass sports), 2) appreciating sports (the fan groups are loyal customers of the sports market) and 3) managing sports.

3) Tourism industry

4) Leisure industry

Industries with the aim of helping people to have a more colourful life, providing more interesting ways of spending their spare time, providing tranquillity and peace of mind, coordinating work and rest. The art of lute playing, painting and calligraphy, fine arts, travelling, communication and dating, etc. are examples of the leisure industry.

5) Hobby industry

The hobby industry is closely related to the cultural and educational background of consumers. The rapid development of the hobby industry is mainly due to increases in income, free time and the improvement of the average educational levels of a population. There are also 'spare time development centres' in Japan. People's hobbies like handicraft making or collecting artifacts are the basis for the development of the hobby industry

6) Feeling and experience industry

7) Beautification industry

This includes the beauty industry, the fashion industry and the image design industry, etc.

8) Media industry

The media industry disseminates information (news, broadcasting, television, movie, etc.) via the publishing industry, information service industry and so on.

9) Self-fulfilment industry

I-go and chess players, judo players (with its level system), cooks, professional athletes, lawyers, architects, accountants, photographers, auditors, treasurers, doctors, professional information services, comprehensive information services, etc.

10) Cultural and artistic management industry

The cultural and artistic management industry includes: cultural and artistic brokers and agents, firms that provide organizational and management services for entertainment, the organization and management of the sports industry, the auction industry and programme hosting services, etc.

3. A Reflection on the Purpose of Innovation

As discussed above, we have expanded the concept of innovation to include all value-creating processes. Nonetheless, what kind of a result has been developed from the innovation of 'gainful economy'? Terms such as 'technological innovation', 'knowledge economy', 'knowledge commercialization', etc. have become quite fashionable. It seems everything has some connection with the economy and everything is closely related to commercialization. During the seven days of China's May Day holiday in 2001, there were almost 74 million domestic travellers, producing a tourism income of 28.8 billion RMB ... thereby helping Chinese people to realize in a vivid way what the ‘holiday economy’ is all about. Billionaires such as Bill Gates have become icons of the Internet age and have consequently become the focus of worldwide media attention for their strategies, competitive market positions, property, road to financial success and even for their lawsuits. Their success has become the dream of millions of young people around the world.

However, as mentioned in chapter 1, there is dichotomy of cultural value: people should recognize that the development of cultural technology and a cultural industry is not equal to cultural and artistic commercialization. It is a common phenomenon throughout the world that the more the economy develops, the less warm-hearted relationships become, the less respect there is for elders, the less elders care for the young, the harder it becomes to find family warmth, the greater the gap becomes between rich and poor, juvenile delinquency rates grow higher and divorce rates rise. Although material life may become rich, love becomes poorer and ‘the milk of human kindness’ becomes harder to find. Are those outcomes the reason we aim to pursue economic development and the purpose of innovation? No wonder many middle-aged and elderly Chinese are now yearning for the days of the 1950s and 1960s. During that time, although they were comparatively poor with regard to material life, they were rich in human relationships and their social ethos was captured by sayings such as ‘When a difficulty should arise, support from all directions will gather’. Is it possible for us to keep a healthy balance between material civilization and spiritual civilization and collaboratively work for the development of society in which all of us enjoy our human lives? Is embracing the market-oriented economic system, stressing competition and efficiency, really the best thing?

Economic ‘knowledge-ification’ is an inevitable trend and it is worth striving for. However, we should be careful about overemphasizing the ‘economic-ification’ of knowledge and culture. A recent article from France, entitled ‘Thursday Event’, analysed today’s Internet stars:[41] the culture is eaten up by the Internet which is swallowed by its simplicity. Culture is a human activity that may easily be destroyed by computers. Although the Internet will play a more important role in education in the future, it can never take the place of teachers who teach by making themselves an example, especially an example of how to be a decent human being, and it can never take the place of family education. Online communication can never replace education through love, caring, feeling and face-to-face emotional exchange (although some people are already researching how the Internet may become a medium for smells!). Online movies and music can never take the place of the spiritual happiness that occurs when hundreds of people enjoy seeing art in a theatre or a concert hall. In the wake of these trends, and influenced by the pressures of the market, the proportion of people who would like to dedicate themselves to the development of 'science itself' has decreased.

In conclusion, industrialization has damaged our natural environment and ecological resources. We should learn from our past mistakes and never allow the commercialization of knowledge and culture to further erode and pollute humanistic social and cultural environments.

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Chapter 6: What is Technological Competitiveness?

Every developing country wants to catch up with and surpass the developed countries as quickly as possible. The reality, however, is that along with the economic globalization and 'informatization' the gap between developing and developed countries has become larger and the gap between the poor and the rich has grown. In the hope of narrowing the gap as soon as possible developing countries constantly adjust their strategies and policies, invest more in science and technology and seek actively to develop their high technology capabilities.

China is a prime example of the above phenomenon. During the last 50 years China has allocated a large amount of human resources, materials and funds to developing high technology and high technology industries. The purpose of this activity has been to pursue international economic competitiveness. Since the 1980s the Chinese government has started a series of programmes aimed at the development of high technology, including the '863 Project', the 'Breakthrough Project', the 'Touch Project' and others. In addition, 53 state level High-tech Development Zones and Experimental Zones have been established. Indeed, the Chinese government has placed a great deal of importance on the advancement of technology and Chinese scientists have put great effort into pursuing the vision of global technological competitiveness. While there have been many great accomplishments through these initiatives, the overall position of China still lags behind global advanced standards in most technological fields and a 10-15 year gap still exists between China and advanced countries in many fields. In some fields the gap continues to widen.

What, then, is the problem? At the end of the last century, the topic of the knowledge society and the knowledge economy was widely discussed within the Chinese government and the academic world, as well as within the media, and many people believed that the knowledge economy represented another 'great opportunity' for China. We should ask whether that is really so.

What is the key to narrowing the development gaps and to enabling developing countries to reach the advanced stages of development? What is the essential element in the distance between developed and developing countries? Is it high technology, is it the knowledge economy or is it something else?

A. Knowledge and Technology are Merely Potential Sources of Competitiveness

It has been said that high technology is the core of competition for comprehensive national power and that knowledge is the kernel of international competitive capacity. However, many informed observers have begun to question whether knowledge or high technology themselves always lead to success.

1) The United States of America is the most advanced country in terms of technology and knowledge. However, in the 1980s, it lagged behind Japan in many industrial fields (see chapter 5). In middle of the 1980s the Japanese semi-conductor industry held 50% of the world market. The US government, on one hand, criticized the support policies of the Japanese government and forced Japan to buy US products; on the other hand, it strengthened its own support policies and implemented a series of strategic measures including preferential trade and import laws. By the 1990s, the semi-conductor and other important industries of the United States were restored to leading positions.

2) The former Soviet Union had a complete high-tech system that could compete with the US. Its education level and the quality of its citizens were high. The Soviet Union also had a strong industrial base. Nevertheless, the Soviet Union collapsed. Besides the obvious political factors, the economic backwardness of the Soviet Union was one of the underlying causes of its collapse. The advanced technologies of the Soviets, which included the capability of sending people into space, were not transformed in a timely manner into products containing market value. In short, Soviet science and technology did not make a sufficient contribution to economic development.

3) Japan built the so-called 'Japanese miracle' out of the ruins of World War II through 30 years of hard work and managed to move ahead of many western countries that possessed more advanced technologies and stronger economic foundations. Besides the favourable international environment, the first reason for Japan's great productivity improvements was the passive, but effective, institutional reform of Japanese industry and agriculture that was carried out under the supervision of the American occupation army. The second reason was that the right development road was chosen. The mode suited Japan's national situation and incorporated a realistic and down-to-earth strategy for the development of technology and the economy. Japan has introduced a great amount of suitable technology from the US and has also hired consultants from technologically advanced countries to help with technological transformation, thereby paving the way for Japan to eventually shift from imitative innovation to independent or endogenous innovation. The third reason lay with the fact that the management and administration technology employed in Japan was imbued with Japanese characteristics. In particular, Japan excelled at applying integration technology and organization technology, transforming foreign advanced ideas into product technology of Japanese enterprises and even integrating the

doctrines of Confucius and Mencius and the military science of Sun Zi of China, with modern management techniques. Many new American technologies and inventions were first commercialized in Japan, making Japan a country with one of the largest numbers of new products and patents each year. We can say that the key to Japan's success was resolute institutional reform, an appropriate development mode and the fact that its management technology and managerial art was imbued with Japanese characteristics. However, institutional innovation, development mode, management technology and organization technology are not 'technology' as traditionally understood. They are examples of soft technology. Institutional reform has probably been supported by effective soft technological innovation. It is unfair to claim, as some people have done, that the Japanese are simply experts at imitating western technologies. In reality, Japan's advantage and potential stems from its prowess at developing and applying soft technology. Today, Japan retains first-class technology. However, since the late 1980s it has been mired in the consequences of its bubble economy. Lack of hard technology is not the reason for Japan's recent economic difficulties and for the decline in its competitiveness.

4) Microsoft did not achieve its success by merely depending upon advanced technologies.[1] Microsoft has been a master of applying soft technology.

5) The Haier Company, which started in the middle of 1980s by introducing refrigerator technology from Germany, is one of the very few Chinese enterprises that have been successful in both domestic and foreign markets. The company has carried out successful strategic adjustments and innovations at different stages in its development. For example, at the beginning it emphasized creating a prominent and effective brand; during the next phase it emphasized the diversification of its product range; and currently it is emphasizing a strategy focused on internationalization. As Zhang Ruimin has concluded, Haier manages to seize opportunities in a timely manner by having conceptual innovation as the forerunner, technological innovation as the means and organizational innovation as the guarantee. To sum up, the success of Haier has depended more on continuous innovation in soft technology than on the advancement of refrigerator technology.

6) Science and technology research in China over several decades has been very fruitful. Particularly since the adoption of its reform and opening-up policies, the central government has attached great importance to the development of science and technology. The number of people receiving science and technology awards is increasing and the quality of their work is improving. However, these advances have not reversed the backward situation of the county in either industrial technology or high technology fields. China has not yet managed to occupy a leading international position in any high technology or industrial

technology field. The technologies driven by the effort of the 'two bombs and one satellite' project of the 1950s and 1960s, such as electronics, materials, chemistry and machinery, failed to lead to the sustainable development of appropriate industries. According to an evaluation by IMD, Chinese international competitiveness in science and technology ranked twentieth out of 46 major countries in 1997, thirteenth in 1998, twenty-fifth in 1999 and twenty-eighth in 2000.[2] Although the authenticity and comparability of IMD's index of science and technology competitiveness are questionable, it nevertheless reveals that China's science and technology capability lags far behind that of developed countries. This runs counter to China's effort, inputs and expectations.

We should emphasize that the 'technology' that has been the focus of the above discussion and of China's policies is 'hard technology', as defined in this book, and not soft technology.

B. Where Does Technology Competitiveness Come From?

1. Strong R&D Capacity is the Source for Creating Competitiveness

R&D is the process of creating core technology, as well as the means for 'producing' sources of technology. Only by constantly researching and developing technologies with independent intellectual property, competitiveness in the market and with corresponding products, can a country provide rich technological sources for the development of its national economy. Otherwise, so-called 'technology transfer' shall become rootless, just like water without a source or a tree without roots. Lucent Co., for example, maintains its leading position in the telecommunications industry through maintaining the research capability of its Bell Laboratory. It is reported that during 1996 one patent application per day came out of the Bell Laboratory and that by 1999 the number had increased to four per day.

There are two essential conditions for creating core technology: human capital input and financial capital input. If a country does not have a comparatively strong industrial base and economic strength, it cannot possibly afford the necessary R&D expense for the development of critical technology. The United States ranks first in science and technology competitiveness but, not incidentally, its R&D expenditure is also the highest in the world. For example, US spending on R&D in 1997 was 211.9 billion US dollars, which is the sum of the R&D input of Japan, the UK, France, Germany and Canada combined. This figure reached 264.2 billion US dollars in 2000. However, capital alone will not suffice. If a country is to succeed in science and technology-based economic development it will need to obtain excellent human resources and generate soft environments, including institutions and culture that are favourable to innovation.

What needs to be stressed is that, in order to be successful, R&D must include soft technology and interdisciplinary science and technology as its objects.

Several points need to be made with regard to soft technology R&D. First, only when a country carries out advanced soft technology research, based on an essential awareness of institutions, and embraces continuous institutional innovation can it build advantages in setting the rules of the game of global competition. Second, only through soft technology research and development suited to local situations and forming fully reinforced soft-tech industries (especially intelligent service industries) will it be possible to remain clear-headed in the continuous sequence of soft-technology waves (corporate mergers, modern physical circulation techniques, incubators, high-tech development zones and various kinds of new business models, etc.) and only then will it be possible for countries to find equal opportunities in the face of new technologies and new products.

With the increasing complexity of modern science and technology, the integration and merging of fields has become one of the main features of technological development. No important inventions can be produced without interdisciplinary research and the integration of expertise from many fields. Although it is widely known that interdisciplinary integration and coordination is likely to result in great breakthroughs later on, few countries have placed interdisciplinary research on their research agenda. There are problems with the classification of R&D funding, R&D personnel and equipment devoted to interdisciplinary projects. However, the main obstacles to the success of interdisciplinary R&D come from weaknesses in the communication of ideas, from problems in the academic language of experts and through the intrinsic difficulties of managing interdisciplinary cooperation.

2. Soft Technology is the Tool for Creating Competitiveness

Soft technology is an indispensable tool within all the processes related to the creation of economic and technological competitiveness.

It is clear that the competitiveness of a country in hard technology is expressed in the number of competitive technologies that emanate from its enterprises and are then transformed into industrial technologies of that country. That is to say, the competitiveness of knowledge and technology is embodied in markets through commercialization (including military applications). All market applications of hard technology occur by means of soft technology. Therefore, soft technology is the key to technological competitiveness.

1) Approaches to obtaining hard technology

The first approach to obtaining hard technology involves three processes: independently developing core technology and then transferring it into product technology in some companies and then diffusing it as industrial technology. The second approach involves introducing or purchasing core technologies from outside, transferring them into technology within companies and then transferring them into industrial technology. The third approach involves applying generic technology and then transforming it into enterprise technology by recombining it with other hard technologies, through the process of soft technology innovation, and then turning it into industrial technology.

2) The process of creating technological competitiveness

Hard technologies may be transformed into organizational technologies (e.g. enterprise technologies) through the process of being converted into products and then being commercialized through the development of customers and markets. They may then be further disseminated through building greater market shares and eventually forming industrial technologies.

It is evident that no matter which way hard technology is developed - either through obtaining technology from external sources, or through the endogenous process of building competitiveness - all the pertinent processes are related to soft technology. Hard technology may not produce real productivity improvements and competitiveness without appropriate soft technology, no matter how advanced it may be. Accordingly, research by David Sawers shows that only one-fourth of the failures in technology commercialization projects stem from technological causes and that the balance of failures are caused by business-related factors.

3) Management

All management issues, whether they are related to the internal management of enterprises or to organization and coordination problems at all industrial levels (or even to institutional innovation for creating innovation-friendly environments), belong to the domain of soft technology.

Most of the developed countries have experienced more than a hundred years of industrialization before reaching their current state of development. During the long history of the market economy a great number of soft technologies which encourage innovation and are flexible in the ways they may be applied have been created. Gradually, an appropriate and favourable macro environment has been formed by soft technologies, creating a more complete environment than has emerged in developing countries. For example, those new business technologies, such as modern management techniques, venture capital, virtual technology, incubators, new types of money and Nasdaq-type stocks, etc. were first developed by the US and UK.

Therefore, the speed of absorbing and applying advanced technologies is far higher in developed countries than in developing ones. The same may be said of the efficiency and the profitability of technology transfer. This means that once companies in developed countries have an appropriate high technology with good market prospects, they are able to transfer it rapidly into products and commodities, thus enabling them to occupy a favourable position in the new process of global industrial structure adjustments and international labour division. Hence, for those developed countries, the role of hard technology looks more important and then forms a hot wave of high technology competitiveness.

This is the main reason why developed countries have absorbed most of the global foreign investment (73%) worldwide. It is estimated that the US, the UK, Germany, France, the Netherlands, Belgium and Canada together will account for 59.2% of all foreign direct investments, worldwide, during the first five years of the twenty-first century. The United States alone accounts for more than half of that share (26.6% of worldwide foreign direct investment). In China, provinces in the western area are trying repeatedly to attract foreign investments by proposing preferential policies; however, up until June 2001, the number of projects absorbing direct foreign investment, the amount of foreign investments in contracts and foreign direct investments in actual use in the western area of the country only accounted for 7.3%, 6% and 5.3% of the national total, respectively. What the foreign investors are concerned about is the level of return on investment and the time it will take to appropriate their return.[3]

Developing countries are obviously trailing in their R&D capability and technological prowess. The main barriers to their becoming technologically competitive, however, are failures in technology transfer and low efficiency in absorbing advanced technologies, which, in turn, result mainly from the incompleteness of their innovational environments and from their backwardness in developing soft technology. This is particularly true for China where the main tasks are still technology introduction, digestion and re-innovation. Therefore, technology transfer is the key for success in the coming two decades. However, soft-tech R&D and its application do not gain the positive attention that they deserve in China, although soft technology lags farther behind at the international level than does hard technology. The biggest headache in the development of high technology industries in China lies with the contradictions between knowledge and capital and between technology and market; these contradictions also call for the operation of soft technology. When Martin Kenney talked about the second economy in Silicon Valley, he pointed out the following: 'In many developing countries, the critical institutions of convertible currencies, the ability to sell a company and ease of firm formation and legal transparency are not fully operating.'[4]

Here are several examples from China to illustrate the role of soft technology in improving competitiveness.

Take the difficulties of Chinese state-owned enterprises as an example. Whether they exhibit a deficit or a profit, the hard-core issue is not high-tech but those issues related to institutions, property rights, management, incentives and benefit allocations. Although some issues have been presented as technology problems, in essence the problem lies within human factors. According to my investigation of the failure rate of large-scale equipment systems in China, more than 50% of the faults may be classified as human or management factors, rather than technical factors

Zhou Weikun, the CEO of an IBM China branch, recently commented during a discussion about the desires of Chinese enterprises that, 'rather than certain areas of high technology, Chinese enterprises are wanting in modern management concepts, talent, competition mechanisms, reasonable capital structure and a complete and sound financial system, including financing, investment, budget and planning. When those defects are remedied, talents will come from afar and will bring along technology, which can gather together the needed capital.'[5]

Fang Xuanjun, the General Manager of Chuangshiji Transgenosis Tech Co., Ltd., summarized the three bottlenecks of Chinese bio-tech industrialization as: insufficient intellectual property protection for bio-technology; the difficulty in finding financing for R&D, owing to the fields of genetic engineering in medicine and agriculture being described as 'a sword being sharpened in ten years' (owing to very low short-term economic benefits); and imperfect modernized enterprise institutions and governance structures of corporations.

Another example may be found in e-commerce. Although it represents the transaction mode of the future, it is developing very slowly in China, especially amongst SMEs, which account for 60% of the total value of industrial production and 98% of all enterprises. Chinese SMEs are facing a great e-commerce crisis. Taking members of APEC as an example, developed countries will realize ubiquitous non-paper e-trade by 2005, a target that developing countries are predicted to achieve only by 2010. 'If China does not accelerate the course of e-commerce, it is possible that by that time she will be kicked out of the trade circle and will not be able to be a supplier or seller in e-commerce. market'

It is reported that there are 40,000 commercial websites in China (the total number of websites in China is 240,000), including more than 700 online shops; and the application and development of e-commerce is spreading from a few cities, such as Beijing, Shanghai and Shenzhen, to many other big and medium-sized cities. However, it is estimated by IDC that the online volume of trade in the Chinese mainland will only be 40 million US dollars in 2000 and 3.8 billion in 2003. We can say that e-commerce in China is still a 'great boast, small roast'.

The reasons have been analyzed by experts: first, the information network infrastructure is still imperfect and the technology of network applications is not mature; second, although it is claimed that there are more than 45 million citizens in China, the adoption rate is very low compared to the total population (90% of domestic enterprises are unable to go online and another statistic shows that online enterprises account for one-thousandth of all enterprises in China) and many factors, such as high communication charges, low speed and difficulty in inputting Chinese characters, negatively influence the application efficiency of equipment and networking; third, information from the government, enterprises and individuals cannot be shared through a computer wide area network, a problem that stems not only from the above conditions but also from Chinese social habits; fourth, the issue of network security and the e-currency identification systems create obstacles; fifth, most firms lack credit awareness (in 1998 there were 180,000 credits nullified for malicious overdrawing); and, finally, there is a lack of experts who are familiar with both network technology and e-commerce management, etc.[6]

However, which one of the above factors is the principal obstacle to the growth of e-commerce in China?

Zheng Xiaocong, General Manager of IBM's Industrial and Commercial Enterprises Department for the Chinese Region, believes that the biggest obstacle to e-commerce development for SMEs is not the lack of capital or specialized IT talents but an inadequate understanding of the significance of e-commerce.[7] I fully agree with his view. E-commerce is a commercial form that is based on an advanced market economy and credit consumption and on the maturity of technologies and infrastructure, such as information networks, information security mechanisms, certification systems and electronic bank accounts, etc. However, whether it occurs between enterprises only, between enterprises and consumers, or just between consumers, the essence of e-commerce is still commerce and commercial technology is a type of soft technology. Furthermore, e-commerce is not simply the application of electronic technology in the process of transactions but the use of electronic access to create new modes and channels of transactions. As a consequence, those behaviour modes and habits that were formed during traditional business practices for the past thousand years should be changed.

E-commerce is therefore an important innovation of commercial technology. In other words, e-commerce is an innovation in soft technology.

1) In addition to electronic dimensions the technological parameters of e-commerce include human, social and cultural dimensions. The development and application of new business models are the operating processes of soft technology, which is more difficult and operationally non-transparent than electronic technology. Therefore, the key to success is the former.

2) The application of e-commerce will surely influence and impact the interests, habits and conception of related sectors, individuals and communities. This, in turn, will raise the necessity of regulating the transactional behaviours of individuals and groups. In other words, institutional innovation will be necessary. E-commerce is therefore not only a kind of high technology for commodity exchange but also a brand new business model that has brought about a series of institutional and regulatory innovations.

3) Because soft technology is difficult to standardize and because the characteristics of soft technology contain regional specificity, the application of e-commerce faces the challenge of needing to be integrated with local situations in different regions and countries. The so-called 'local situation' is actually the soft technology environment, which is the most fundamental condition for the development of e-commerce. Variations in this factor are also a major reason for the unequal opportunities for the development of e-commerce between different regions and countries.

The above analysis shows that the key to the implementation of e-commerce lies with concepts, institutions and cultural environments. However, owing to the lack of in-depth understanding of the essence of e-commerce, the focus of research and investigation on e-commerce in China is centred on tackling the key problems of hard technologies, concerned with such matters as information networks, information security mechanisms, certification systems and e-accounting, while ignoring the challenge of tackling of soft technologies. Thus, the size of the gap between different countries that participate in e-commerce will depend, in the long run, upon cultural innovation, institutional innovation and governmental behaviours.

In viewing this situation, the Chinese Ministry of Information Industry has begun to place the focus of its work on creating an appropriate environment for e-commerce. Practical actions along these lines include the elementary elimination of the monopoly system by establishing enterprises such as the China Unicom and

Jitong to separate China Telecom into two parts, namely, destroying the 'Berlin Wall' of Chinese telecommunications; the functional separation of government from that of enterprise management; and the gradual establishment of a fair, moderate and orderly competitive environment, etc.

Japan began investigating US science policy at the beginning of the 1970s. Scholars at that time realized that the gap between Japan and the US did not lie in hard technology. In fact, after World War II, Japan introduced lots of technologies from America almost free of charge and many R&D achievements of America were first commercialized in Japan, thereby greatly narrowing the gap between the two countries in hard technology fields. The report of a Japanese investigation team in the 1970s said, 'There is almost no gap in technology between Japan and the United States. What we should learn from them, just like the situation with European countries, is how to close the gap of efficient management. If we do not improve the efficiency of R&D, the gap between Japan and US in soft science will result in major social issues for the near future.'

It is safe to say, therefore, that soft technology causes the inequality of opportunities for new technologies and new products between developing and developed countries, as well as between different countries and regions.

3. Hard Environments and Soft Environments are the Basic Conditions for Competitiveness

With economic globalization, the macro-environment and the macro-level of management place greater restrictions upon technological competitiveness. A favourable macro-environment is like 'soil' for the cultivation of innovative capability. It is the essential condition for creating competitiveness. The macro-environment can be classified into hard environments and soft environments.

The hard environment includes visible and tangible conditions, such as infrastructure, the industrial base and economic strength (the capacity to provide capital or investments). Since innovation consumes more resources than research, a suitable hard environment is beyond any doubt an essential condition for creating competitiveness.

The soft environment includes invisible fields such as the institutional environment (policies, laws, rules and regulations), the international environment, the cultural environment, market conditions and customer demands (depending upon educational level, living conditions and cultural background, etc.). From this perspective, we can see that soft technology innovation is the basis and content of continuous soft environmental innovation.

Because the soft environment tends to be neglected in developing countries (which also exhibit low levels of industrialization and a weak economic capacity), the institutional environment will now be discussed to illustrate the significance of the soft environment.

During the last two decades China has maintained a high economic growth rate. If there had not been the transformation of the economic system and policy reform of opening up, this progress would not have been possible. Furthermore, every step in the improved competitiveness of China's enterprises has been related to the reform of its enterprise institutions.

A survey carried out by IMD shows that Japanese national competitiveness ranked fourth in the world in 1996 but that it declined to the eighteenth by 1998 and the seventeenth by 2000, even though Japanese science and technology competitiveness still ranked second from 1996 to 2000. The main reason for this sharp decline lies in Japan's financial and management systems.[8] This decline indicates that the institutional environment that supported Japan in achieving its economic miracles has now become an obstacle for further development in the age of economic globalization and is facing the inevitable challenge of innovation. Take the IT industry in Japan as an example. The VI&P plan of produced by NTT in 1991 was the first IT strategy in the world aimed at bringing broadband information networks to every family within the next 20 years. It was three years earlier than 'The United States Information Base Action Guide' but it failed to become a national strategy. Five years later, the computer adoption rate in Japan ranked only nineteenth in the world and 49% of all users were located in the United States, which occupied the first rank. In view of this situation, the Japanese government set up its 'IT Strategy Headquarters' in 2000 and proposed catching up and surpassing the United States within five years. The key here is the sensitivity of the prospect of science and technology development and the decision-making process of the leaders in the US and Japan. Since then, all successive presidents of the United States have attached great importance to the national development strategy by integrating the science and technology development strategy, the national comprehensive competition strategy and the global strategy. The problems of Japanese government strategy are mirrored in the case of the Japanese venture capital industry. Besides the effect of the collapse of the economic bubble, the incompetence and mistakes of the Japanese venture capital industry are also core reasons for the loss of the glory days of Japan's high technology industries.

The technology discussed here is technology as traditionally understood; technology competitiveness refers to hard technology. This conceptual bias results in great differences between the results for technology competitiveness and national competitiveness in the IMD study.

The following two ideas are presently widely embraced in Japanese society: a defining trend of the twenty-first century is the merging of various types of knowledge; and the competitiveness of a country is embodied by new initiatives, new strategies, new management modes and its capacity for implementing these three things. Japan is therefore now seeking to practise a comprehensive type of total-systems reform. For example, when the government began implementing its twenty-first century strategy of 'nation-building on the basis of creation', its first step was to pursue a strategy of overall reform of government organs. The main content of this strategy includes: reorganizing all ministries and their functions; making government information available to the public; improving policy evaluation functions; increasing transparent administrative management; and setting up independent administrative legal personnel systems, etc. The strategy also involves a special step for science and technology institutional reform. For example, the original MONBUSHO and Science and Technology Agency have been incorporated into the new MONBUSHO within the Ministry of Education, Culture, Sports, Science (including social science) and Technology, in order to vitalize science and technology on a full scale. Another example is the installation of an independent administrative legal personnel system in state-run R&D institutes and state-funded universities - which is one of the major reforms in Japanese history. Within the new cabinet system, the former 'science and technology convention' will be replaced by the 'comprehensive convention of science and technology', which exercises the function of coordinating the relationships to science and technology of different government departments. These reforms contribute to the making of a comprehensive strategy by taking science and technology as their object while including a comprehensive approach to the humanities, society and natural science.

South Korea, a country severely afflicted by the Asian financial crisis in 1997-1998, recovered within only one year and managed an economic growth rate of 10.5% in 1999. This should also be attributed to the Korean government's strong resolution to carry out institutional reform, especially financial reforms such as the reorganization of banks. After the financial crisis, the Korean venture capital industry grew vigorously. The resolution and effective policy input of the Korean government played a key role. In a short time, the government finished a unified planning system, established a complete system of organization setups, laws and regulations, research system reforms, capital support, incubator centres and favourable taxes, including the stock exchange system, and strictly defined of the role and limitation of the government and market operations. They also implemented policies in favour of innovation and start-ups ('venture firms') and they even implemented temporary policies, such as exempting young people engaged in start-ups from military service and releasing university professors engaged in new ventures from their duties for three years or permitting them to work only part time. All these measures, especially those acts, laws and regulations that support newly-started SMEs and provide financial support for new technologies, have stimulated and encouraged people's enthusiasm for innovation and start-ups. Many people who left the big corporations during the financial crisis and those who were fired from their companies tried to start new venture companies. It is reported that there are more than one thousand start-up enterprises within the 'Teheran Valley' district of southern Seoul.

Let us compare the software industries of China and India. During the mid 1980s, there was a small gap between the two countries in capital and expertise in developing software and China even enjoyed certain advantages. After ten years, however, India became one of the strongest software producers in the world, while China still lagged far behind, with the gap continuing to widen. The value of software exports of China in 1998 was less than one-twentieth that of India. It is estimated by some that, if the present situation persists, the figure will decrease to one-fiftieth by 2008.[9] Ma Qingguo of Zhejiang University points out in his article *Key to Revitalizing Chinese Software Industry* that the first factor responsible for the gap is 'neither capital, nor talents, but policy (including institution, policy and laws and regulations which influencing the degree of opening up)'. Although the Chinese government now exhibits strong enthusiasm for the software industry, it is 'several beats late in time' and not effective enough. For example, China's preferential policy is that value-added tax has been reduced from 17% to 3% and that new software companies may enjoy two years free of taxes and three years of income taxes at half-rate only, beginning in their profit-making year. The Indian policy is that software companies can receive five years free of income taxes, exemption from duties, exemption from circulation taxes and exemption from service taxes for the first eight years in operation. Actually, the preference given to software in India appears not only in policy but also in the establishment of a series of institutions, including bank loans and venture capital. China's biggest challenge lies in the legal environment of software development. The market value of pirated software in 1999 was much bigger than that of genuine software in which copyright was respected.

China has quickened the pace of institutional innovation during the past ten years. For instance, in the science and technology area, the 'one academy, two systems' reform of the Chinese Academy of Science and the 242 research institutes attached to ten national bureaus under the administration of the State Economic and Trade Committee have been transformed to run as enterprises. This is a beneficial trial in institutional innovation that is beginning to achieve tangible results. This also reveals a strategic shift in technology innovation. The 'Regulation for Zhongguancun Science and Technology Park', which became effective 1 January 2001, is an example of institutional innovation aimed at creating more favourable environments for innovation and start-ups in the Zhongguancun area. It stipulates explicitly, for example, that 'organizations and individuals can engage in any activities, which are not clearly prohibited by law, regulation, or rule, excluding those behaviours that are harmful to the public interests of the society, disturb the socioeconomic order, or transgress social morality'. This kind regulation is the first in China and it is a pity that it cannot be practised throughout the entire country.

However, issues associated with the institutional environment are still the main factors delaying the sustainable development of China's economy and society. Moreover, most people still worry that a single mention of 'institution' will raise political concerns, thereby further delaying institutional reforms.

The rapid growth of all kinds of high-tech development zones and science parks throughout China has stimulated a large number of economic activities in need of regulation. However, with the imperfect market economy currently in place, the China's legal system is far from being able to adequately deal with such problems. It should be admitted that, apart from the preferential policies now in place, China has not yet instituted systematic research on basic institutional innovations and there is still a lack of institutional practices appropriate to special technologies that are suitable for the Chinese situation.

For instance, although grand discussions are currently taking place about the knowledge economy, lack of protection for intellectual property rights is still a salient problem in China. Furthermore, the principle followed in industrial and commercial law is still 'those who invest are those who possess'. In many administrative systems in China, only tangible properties and capital are accepted as having formal value. If there are no proper institutional systems to protect property rights (of the kind that are needed and deserved by start-ups and senior managers in high-tech enterprises, such as Legend and Founder, in Zhongguancun), how can Chinese entrepreneurs be encouraged to keep their enthusiasm for innovation? Hence, there are thousands of laws and regulations that need to be reworked or abolished, consequent upon China's entry into the WTO.

The credit system embodies another critical issue in China today. The basis for the normal operation of the market economy is a sincere and trusting relationship between two sides of a transaction. In this sense, the market economy is a credit economy. During recent years in China, the credit crises occurred frequently in fields such as service, manufacturing, finance, stock-trading and tax, indicating the great need to establish and perfect a credit system that includes credit laws and regulations.

With regard to raising capital, although China has more than 7,000 billion RMB (at end of year 2001) in resident deposits, these immense amounts of social capital cannot be used to support R&D and high-tech industrialization owing to a lack of corresponding mechanisms and rules (including private fund raising rules). In addition, although labour costs in China are low, it is still difficult to attract the level of foreign capital and technology that has been expected because of the low efficiency of technology transfer and because the environment is not favourable enough to allow investors to achieve their expected returns.

Overall, soft technology and the soft environment are factors that have for a long time been neglected in developing countries. Knowledge and high technology alone are not enough to increase technological competitiveness. The three conditions mentioned above need to be satisfied so that the competitive potential of knowledge and technology can be activated and converted into actual competitiveness. Soft technology is the means for activating the potential competitiveness of knowledge and hard technology; and the macro-environment, including relevant institutions, is the precondition for improving competitiveness (see figure 11).

Let's take the Samsung Group, a world-leading high-tech enterprise, as an example. In 2002 Samsung ranked thirty-fourth in the world with a brand value of USD 8.3 billion. In 2002 three companies of Samsung were listed in Fortune 500, with Samsung Electronics ranked fifty-ninth. Six key factors have helped the Samsung Group maintain and improve its competitiveness:[10] 1) nurturing talents and putting them into important positions, 2) good company culture, 3) active investment in R&D, 4) constant operation innovation and structure adjustment, 5) operation at fast speed, 6) leadership of CEO. Among the six factors, the third belongs to the first condition of competitiveness: strong R&D power; the second factor belongs to the third condition: good soft environment; and the other four fall under the scope of the second condition: constant innovation of soft technology for which Samsung laid strong emphasis on a flexible structure adjustment mechanism. During the financial crisis, the Samsung group reduced its organizational structure from over 40 enterprises with different characteristics into 28 enterprises. Thanks to this move, the Samsung Group withstood and overcame the financial crisis of 1998.

Samsung Group builds upon a rich history that extends back to 1938 when it was still a small company called Samsung Products Corporation. Today it is a multinational company with electronics and finance as the main business with 285 offices with legal status in 69 countries throughout the world. Clearly, the growth of Samsung was not the result of advanced technology from the very beginning. In 1950 Samsung started producing products relating to people's livelihood. In 1960 it set foot in the electronics and finance industry. In 1970 it expanded its business into the heavy chemistry industry. In 1980 it entered the semi-conductor industry and in 1990 it established its presence in high technology sectors such as TFT-LCD and CDMA cell phone. However, in the process of enlarging its business scope and realizing a diversified operation, as well as in light of the real operation environment at home and abroad, Samsung did not stake its future only on the innovation of hard technology. It also focused on a coordinated operation of the three key factors of improving competitiveness, which are constant innovation of the organization culture, active investment in R&D in new technology and full utilization of various business soft technologies in the meantime. For example, in its different stages of development, the company used soft technologies including organization technology (structure adjustment), alliance technology, merge and acquisition technology, management technology (operation innovation) to seek further progress in the hard technology sector on one hand and at the same time formed soft technology industries related to the company's logistics, trade, insurance, security, investment trust, venture capital, etc. As hard technology and soft technology complement each other, the details of the utilization and innovation of soft technology always become the business secret of a company. This is why technology-oriented companies can only be fully developed after they are incorporated into large groups. 'The Status Quo of the Total Market Value of the Top 10 Groups' released by Korea Stock Exchange on 20 January 2004 shows that the total market value of Samsung Group accounted for 29.1% of the total market value of Korea, with Samsung Electronics alone taking 22.5%.

In summary, the expansion of Samsung integrated hard technology innovation, soft technology innovation, cultural innovation and institutional innovation to realize the industry innovation. Conversely, the need of industry innovation promoted the innovation of hard and soft technology and contributed to the improvement of overall competitiveness.

4. The Essential Gap Between Developed and Developing Countries

The above discussion shows that the crucial gap between developed countries and developing countries is backward soft technology and imperfect soft environments. However, from another perspective, the serious shortage of soft-technology experts is the core of this gap, regardless of the national level, industrial level or enterprise level.

For the last 20 years, every frustration experienced by Chinese enterprises, as they have entered the market economy and as they have competed with foreign enterprises, has been related to operational mistakes in soft technology and to unfavourable soft environments. Although China has an abundance of scientific and technical specialists (mainly those who have mastered natural science technologies), too few of them know about commercial technique in the international market and how to transfer technology into commodities as part of market competition. Take the Zhongguancun Science Park in Beijing as an example: the correct operation of property rights has already become the bottleneck for the further development of its enterprises. It is claimed that there are more than one thousand intermediary organizations engaging in technical consultation for Zhongguancun enterprises. Nonetheless, a great proportion of scientific achievements (even the ones that are applied in nature) cannot find a place to which they may be transferred; and this is true, despite the fact that lots of enterprises are thirsty for projects and that there is venture capital worth several million RMB in this area looking for ‘good projects’ every day. The reason is that China is lacking in technical brokers with technical backgrounds who can track certain technology over a long time, who are very familiar with both the market prospects and the technical complexity of that technology, who understand market environments (including law and the management of enterprises) and who also know how to choose appropriate experts. It is obvious, therefore, that when China shifted from a planned economy to a market economy it desperately needed a group of soft-technology experts who had not only mastered management technology and a meso-level of market-operation technology but who were also familiar with national soft environments. Such experts cannot be cultivated completely within schools. They must learn through experience and must have opportunities to experience successes and failures in the market, including facing the fierce competition of the international market.

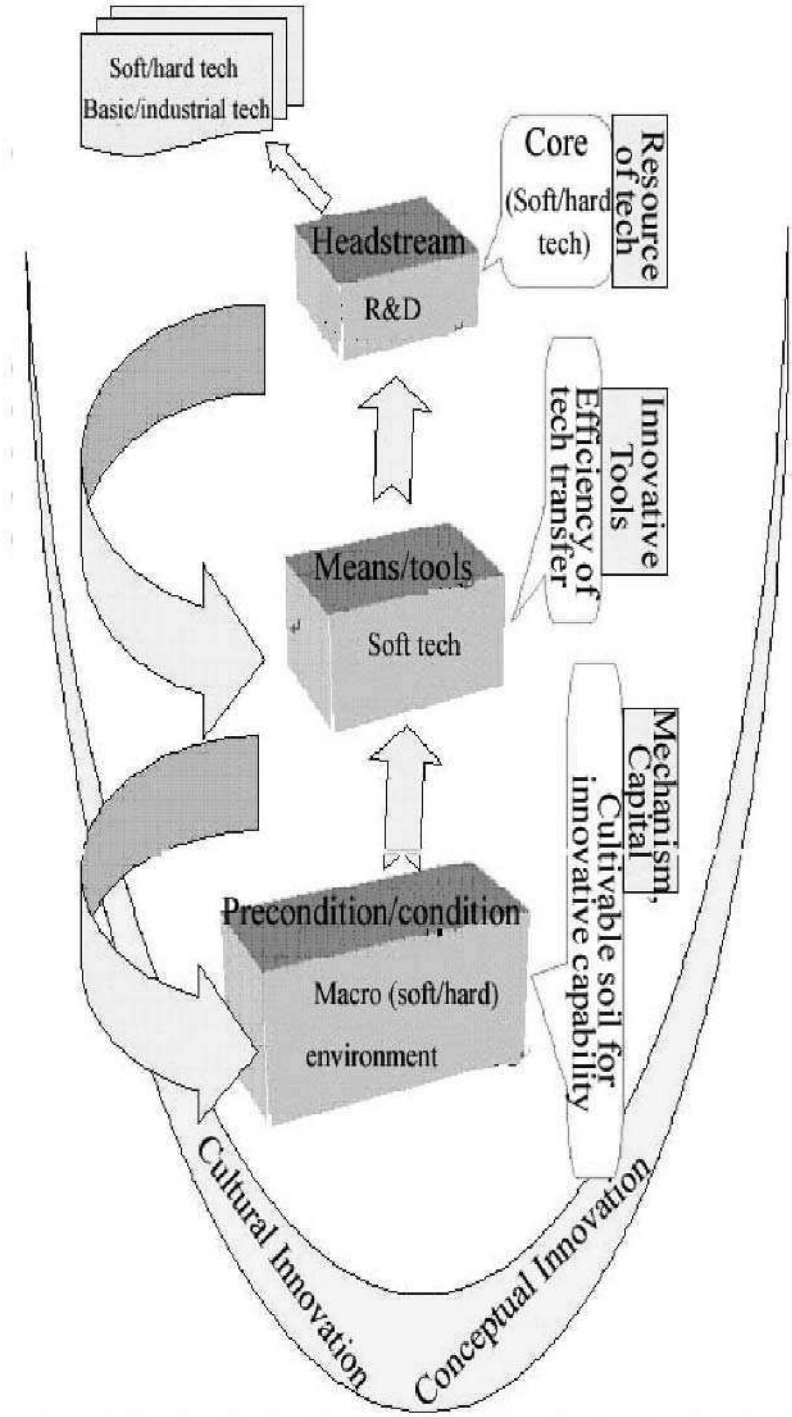
In conclusion, the lack of competitive technologies and high technology products in China, and in developing countries more generally, is primarily a reflection of the gap in soft technology and soft environments. Under these circumstances, developing countries should never just follow developed countries by adopting whatever the developed countries are creating and doing and they should not place too much emphasis on the ‘highness’ and ‘newness’ of hard technology. As a long-term development strategy, developing countries should not only ‘strive for temporary superiority and the enjoyment of temporary satisfaction’ but strive also for a well-grounded pathway of development combined with a balance between soft technology and hard technology.

C. The Way to Improve Technology Competitiveness for China

1. Strengthen Macro-management and Boost Environmental Innovation

For a country such as China, that is just entering the socialistic market economy from the background of a planned economy, the first task is to strengthen macro-management by setting up and perfecting an institutional environment favourable for innovation. In other words, what China wants most for high technology development is not specific technology or capital input but environmental innovation. Environmental innovation depends mainly on government behaviour, social habits and culture.

Figure 11: Three conditions for creating technology competitiveness



1) Properly managing both marketing and government interference

Internationally, high technology development and industrialization have been driven primarily by the internal pressure or demand of private enterprises to increase their competitiveness. The top task of government is to improve the macro-environment, thereby creating conditions for technological innovation. Of course, countries all over the world are strengthening their high-tech macro-management capability so as to directly affect their country's global high technology competitiveness. It is absolutely necessary that governments intervene in the economy by drawing up high technology strategies and by providing reinforcement, guidance and financial support for technological innovation by enterprises. China's problems in this area can be summarized as being too weak with regard to the macro-management level and too strong in its intervention at the micro-management level (i.e. there has been too much direct interference at the level of enterprise management).

2) Adjust government functions and strengthen the role of social organizations

In China, most large and middle-scale enterprises are state owned. The government controls the implementation of major organizational innovations, such as merging or purchasing of companies and also city management. Government behaviours usually cause many of the problems of enterprises and markets in China. The key to adjusting government behaviours is to separate government functions from enterprise management, as well as from the city administration system, and to strengthen the role of non-government organizations and non-profit institutes.

3) Intensify institutional innovation and create a favourable environment for innovation

After entering the WTO, the biggest barriers facing China are the challenges of merging into the world market economic system and carrying out institutional innovation. According to an announcement by the Legal Affairs Office of the State Council, there will be a need to revise and eliminate more than 1,100 departmental regulations following WTO rules, consistent with commitments made by the Chinese government. In addition, a great deal of effort is needed to work out the plethora of new laws, administrative regulations, departmental regulations and other policy measures consistent with membership of the WTO. To fulfil these tasks, the government needs to construct new regulations and provide new incentives.

2. Strengthen Soft Technology R&D and Boost Institutional Innovation

It is important for developing countries to track the cutting-edge of technology at an international level. However, if a developing country develops only whatever is popular internationally, the result will only be 'more haste, less speed'. As stated above, just supplying more hard technology R&D cannot shorten the gap between developing and developed countries in core technology. The Japanese enterprises and Korean enterprises referred to above can be used as a further example. Through industrializing and refining technologies that originated in the United States, such as television technology and videocassette-recording technology, Japan has not only reaped rich profits but also obtained many patents. Similarly, the Korean company Samsung enjoys an advantageous position through its leading position in the development of CDMA wireless communications technology, which also originated in the United States. These examples show that while developing countries try to strengthen their own endogenous R&D capacity, there is also ample scope for them to exercise their ability in applying core technologies that come from other countries.

Because of the special role of soft technology in technological, industrial and institutional innovation, the improvement of soft-tech R&D and its application can make up for the disadvantages a country may currently face in hard technology. Therefore, developing countries should not stick exclusively to the domain of hard technology at the expense of ignoring their own advantages. There are extensive prospects for R&D in intelligent, cultural and social resources and its application. More important is the need to invest in predictive research pertaining to soft technology, especially research focused on the prospect of the developing technology (both soft technology and hard technology) in advance, to continuously supply resources for institutional innovation. Only by doing this can developing countries avoid playing by the rules set by other countries.

3. Cultural Innovation

The cultural environment of a country or a region is an important part of the soft environment. Culture and cultural habits exert deeply rooted influences on innovation, sometimes even surpassing the influence of markets and governments. Countries such as Egypt, India and China, which have stemmed from ancient civilizations and have experienced glorious historical epochs, are now developing countries. These experiences reveal the depth of the connection between culture and the economy and the importance of cultural innovations to the prospects of a nation. Accordingly, discussions have emerged on why modern Chinese science lags behind that of the West - despite China's rich scientific and technological heritage. Scholars in China have been discussing this issue since the New Culture Movement and the Anti-Japanese War and culture has been the focus of their research and debate.

Silicon Valley, in California, is a centre of innovation for America and the whole world. Almost every country has tried to create innovation centres in their own territory similar to Silicon Valley but the world has failed to do so. In general, people have cited the visible factors of Silicon Valley, e.g. high-tech industries, venture-capital funding mechanisms, excellent universities, research institutes, good infrastructure, etc., as explanatory factors. However, it is easy to ignore the most fundamental factor that has supported Silicon Valley, namely, the culture. It is the culture of Silicon Valley, more than any of the above factors, which provides the support system for its success in innovation. The culture of Silicon Valley encourages innovation and cooperation, allows entrepreneurial failures (with the concomitant learning they entail) without punishing the protagonists and emphasizes investing in talented people.

According to my own study of changes in Chinese society, the typical Chinese perspectives on employment, general life, consumption and other topics such as marriage, have altered greatly during the last 20 years. Even the middle-aged and the elderly have changed their ideas about running businesses, start-ups, travelling abroad and divorce. As for the educated younger generation, their pioneering spirit, sense of challenge and consciousness of self-fulfilment, amply reveal the need and possibility of cultural innovation. From another perspective, the great changes that have taken place in China also demonstrate that the Chinese people are striving to create a new culture that favours innovation and to renew old ideas and habits which are disadvantageous to the country's development and are trying to 'take marrow and get rid of draft' from traditional Chinese culture.

Guangdong Province, in China, enjoys the advantages of technological innovation that have been derived from conceptual innovation. For five consecutive years Guangdong has ranked first in examining and certifying patent applications. In 1999, over 70% of the total investments of science and technology in the entire province were invested by companies rather government organizations, causing enterprises to become the main force in technology innovation. Enterprises founded in the Guangdong Province, such as Kelong, Huawei and KONKA, have established research organizations in the United States and Japan. Guangdong's exports of high-tech products in 1999 amounted to 11.8 billion US dollars, accounting for 48% of China's total exports, ranking them number one. Compared with Beijing, Shanghai and Xi'an, Guangdong is a province without first class universities or institutes and it does not enjoy the obvious advantage of a strong scientific and technological base from which to draw for innovation. During the last few years, furthermore, foreign investments have been decreasing compared with the previous several years. However, Guangdong still retains the leading position in China vis-à-vis innovation. Some explanations for Guangdong's extraordinary position, despite its handicaps, are as follows:

1) Guangdong was the first province in China to benefit from the preferential policy of having a special economic development zone. After 20 years of development under the aegis of that policy, Guangdong possesses great economic strength. The province contains only 6% of China's entire population yet it accounts for 10% of the national GDP; at 29% the individual computer possession rate in Guangdong is the highest in the country and is double that of Beijing (which comes in second).

2) Guangdong attracts many qualified personnel with pioneering abilities and forethought from across the entire country because of its relaxed commercial environment. The GDP per capita of Shenzhen (a city of four million people and a history of only 20 years) reached the extraordinary high level of 39,700 RMB in 2000, while the national GDP per capita was 7,078 RMB in 2000, with an output value of high-tech products accounting for 42.3% of its total industrial output value. Shenzen's high-tech product exports accounted for one-fifth of its total export value. In 1999, the output value of the city's information industry was 15% of that of the entire country! In Shenzhen there are at least 150 transnational companies investing in high-tech industries. Shenzhen contains a large-scale IT industry; it is the production centre for China's computer hardware and Shenzhen also produces 30% of the hard-disc drives and 10% of recording heads worldwide. The leaders of Shenzhen are aware of the weaknesses in their city's science and technology base, in qualified personnel and in industrial foundations. Accordingly, they chose to focus on institutional innovation. They also knew, however, that breakthroughs in perception were pre-conditions for breakthroughs in institutional innovation.

3) Open-mindedness and flexible commercial environments are important reasons for Guangdong's success in attracting talented people, new technology and new investments. In China, the meaning of the names 'Guangdong' and 'Shenzhen' are now synonymous with 'open'. Government officials in Shenzen are more open-minded than their counterparts in Beijing and Shanghai. There are also fewer government restrictions for high-tech enterprises in Guangdong and the province no longer allows the establishment of new state-owned enterprises, instead encouraging private companies to unite to compete with foreign companies.

The *Science and Technology Daily* newspaper published the article 'Guangzhou Has Become the Paradise for Making Money',[11] which discusses Guangzhou Jinfa's Science and Technology Development Co., Ltd. The company was founded in 1993 and produces modified plastics. The output value in 1999 reached 0.5 billion RMB and the four original partners all own property worth over 10 million RMB. Within the company there are 20 millionaires who, on average, are under the age of 30. The company works on advancing PPS and PPO technology. They should thank the policy environment of Guangzhou because it helps to incubate these excellent private enterprises. According to a report in *Guangzhou Daily* on 30 May 2001, the savings deposits of Guangzhou city's residents amounts to almost 500 billion RMB, which equals one-twentieth of the total deposits of the entire country, with only one two-hundredth of the total population. Guangzhou has become the largest financial centre across the country.

Another extremely important cultural factor affecting business and innovation is the existence of a system-wide ethos of trust and cooperation.

Zhongguancun spent more than a dozen years developing before it was able to experience the changes that it is now undergoing. It is worthy of praise. However, when compared with the international situation, or when judged against the investments it has absorbed, Zhongguancun's performance would be deemed unsatisfactory, especially compared with the Shenzhen and Shanghai high-tech development zones. For example, the Founder Group in Peking University monopolized relevant markets with their own key technology, realizing that they could be more successful than at present. For 12 years most of the successful people in Zhongguancun have experienced the difficulties of learning new things and of doing everything themselves. Why do they have to do this? Some say it is because only enterprises and not entrepreneurs have been created in China during the past 30 years and that there are no suitable models of entrepreneurship to emulate; some say that most of the Chinese state-owned companies lack the internal pressure or demand for technological change and that it is therefore hard to cooperate with them and that scientists in Zhongguancun therefore have to do everything themselves. As the result, although the government encourages - and sometimes even forces - the combination of research institutes and enterprises, there are few successful examples of collaborative spin-offs of high-tech companies.

The fact that Zhongguancun has been largely ineffective in producing cooperative start-ups can be traced back to the following factors.

1) For long time, China has organized economic activities along the lines of government ministries, departments and administrative regions. Under the mechanism of 'cut up the links among department and regions', the components of the R&D system and the production system have also become isolated from each other and great barriers have been built between scientist-technologist circles and business-industrial circles, causing misconceptions and distrust between each group. In addition, China's distinctive 'Unit System' has been an umbrella that 'legally' protects the interests of each component of the system.

2) People have been known to blame every fault in Zhongguancun on the old system. However, such criticisms are not always justified. People should reflect on the influence of the traditional thinking mode that is encapsulated in the phrase, 'It is better to be the head of a dog than the tail of a lion'. This kind of thinking is hazardous to the healthy establishment of joint ventures, partnerships for start-ups and cooperative development efforts. In addition, it runs counter to the need for inter-disciplinarity and trans-departmental development that is the hallmark of the information age.

3) They need to avoid the trend of over-stressing their own interests. In the modern society the mix of resources required for success in business alters with each stage in the development of an enterprise. In particular each stage requires a different approach to technology transfer, corresponding to the unique mix of problems and risks that occur at each stage. In addition, each stage calls for hard technology, soft technology, capital and resources from different channels, to be integrated at different levels to maintain competitiveness. This is the reason for the growth in alliances, joint ventures and mergers across the world during the last couple of decades. Successful enterprises must learn to cooperate, sometimes on a grand scale, because various resources necessary to the enterprise may only be obtained from external sources. However, in order to optimize their access to resources and their use of resources, managers of innovative technology enterprises must know how to wisely remit appropriate interest to their partners. In other words, they must know that sometimes, 'without 80% of partner's interests, will not meet their own 20% interests'.

China has the longest history of any country and possesses a rich cultural heritage that is an inexhaustible resource for future generations. However, China must overcome some salient attitudes and traits such as blind arrogance and looking backwards rather than forwards with regard to cultural issues; and China should consciously avoid factors that are not favourable to the opening-up of the economy and to innovation, such as continental culture, peasant culture and human-ruled culture. China should also nurture the spirit of entrepreneurs, who were restrained for four decades by the planned economy, and establish a culture conducive to innovation, cooperation, sharing, credit and the toleration of failure. The cultural environment is just like soil for innovation, which is of great significance in retaining qualified personnel and attracting funds and technology.

4. Conduct Strategic Adjustments to Meet International Rules

China's entry into the WTO means the overall integration of China into the world economic system, which, in turn, requires the all-round mapping of the economic rules of the world market. China will have to open its markets worldwide and allow the flow of its qualified personnel, technologies and capital all around the world. On the other hand, China must learn how to obtain and allocate the necessary capital, experts and technologies from across the world. In other words, it must learn how to conduct global operations by taking the initiative in the context of economic globalization. Complaining will not help. Instead, positive action to become globally competitive is what is needed.

China's recent great step onto the global economic stage has created pressure for immense adjustments to concepts and strategies at all levels - from enterprises, to industries, to entire countries and even to international relations. For example, the concept of national security should change from a closed one to an open and sustainable one taking into account all aspects of the international situation. The old idea of establishing a self-balanced economic system mainly emphasized protecting domestic resources and national industries; and the idea of energy security meant maintaining the balance between storing and exploiting energy reserves to ensure the balance of supply and demand. Both of these ideas should be revised. China should be actively embracing the challenge of making full use of the benefits of globalization. This may be done by searching for and allocating the optimum mix of resources for enterprise development *worldwide* and by looking for new business opportunities in the global environment, in keeping with a comprehensive approach to the opening-up of the economy. For example, the new environment created by China's entry into the WTO creates more choices for diverse industries. The fields of physical distribution and finance, which were originally closed even to domestic enterprises, are now open to both foreign and the domestic enterprises in China. Haier, for example, has already been involved in banking organizations and non-banking financial organizations and is constructing socialized physic distribution systems.

Most of the above discussion has centred on China's problems and opportunities in the international arena as it addresses the goal of building global competitiveness through innovation.

Many of the lessons, however, are directly applicable to other developing countries as they struggle to find and implement new strategies to narrow the gap between themselves and the developed countries. The key lesson, for both China and other developed countries, is that in order to succeed in becoming globally competitive they must follow a development pathway that incorporates a healthy balance between innovation in both soft technology and hard technology. Each country must also develop its own unique development pathway based upon an astute assessment of its own endogenous capabilities and the realities of the global economy.

Notes

1. Wu Dongxi, 'Misunderstanding of Knowledge Economy', *Tsinghua University R&D Newsletter*, no. 8, 1999.

2. *The World Competitiveness Yearbook 2000*.

3. 'Advantage', *Economists Weekly* (UK), 2001.2.24.

4. Kenney, 'Institution for New Firm Formation in Silicon Valley', International Seminar on Technological Innovation, Beijing, 5-7 September 2000.

5. *Science and Technology Daily*, 1999.1.10.

6. Li Ping and Jia Zheng. *Science and Technology Daily,* 1999.5.16.

7. Wang Yichao, *Science and Technology Daily*, 2001.6.3.

8. Ryo Hirasawa, 'New Competitiveness in the Era of Knowledge Economy: Lessons from Japanese Enterprises', International Forum on Knowledge Economy and Industrialization of High Technology, October 1999.

9. Ma Qingguo, 'Key to Revitalize Chinese Software Industry', *Science and Technology Daily*, 2001.3.23.

10. Excerpt from 'The Report and Seminar on Development Strategy of Samsung Group', Strategy Research Group on National Innovation System, 19 February 2004.

11. *Science and Technology Daily*, 2000.4.30.

Chapter 7: Soft-tech Talents and the Education Revolution

China's *Science and Technology Daily* recently carried an article entitled 'What will the popular major be four years from now?'[1] It reported on the results of a survey that concluded that major changes would occur during the next decade in China's requirements for qualified personnel. These changes will come about, according to the study, as a result of major efforts devoted to developing six types of technology (biological technology, information technology, new materials technology, new energy technology, space technology, oceanography technology) and nine high-tech industries (biological engineering, biological pharmacy, photo-electronic information technology, intelligent machinery, software, superconductors, solar energy, space industry and oceanic industry) in the coming years. Furthermore, according to a forecast based on relevant statistics from the State Personnel Bureau, the fields in which the strongest demand for qualified personnel will be made in the future are similar to those reflected by the above-mentioned survey. They fall into eight categories: high-tech qualified personnel in the fields represented by electronic technology, biological engineering, space technology, the application of marine resources, new energy and new materials technology; IT experts, electro-mechanical integration professional technical experts, agriculture technology experts, environmental protection technology experts, biological engineering R&D experts, international trade experts and lawyers. It is a pity, however, that finance and economics majors are still having a difficult time finding jobs. Although there is a comparatively larger demand for accountants and auditors, the demand for personnel in the fields of management, economics, finance, statistics, price analysis and national economic planning is small.

Unfortunately, the above studies and forecasts have not focused enough attention on the need for qualified personnel from outside the fields of natural science. In particular, they have ignored the need for people talented in soft technology fields. This oversight is troublesome for a country like China where the development of soft technology is more backwards than the development of hard technology. Shanghai has taken the lead in China in appreciating the value of soft technology experts. A comparison of demand for personnel recently identified in Shanghai and Beijing is instructive. Shanghai has identified that it needs experts in fields such as information technology and microelectronics, finance and insurance, biological pharmacy, petrochemicals and fine chemistry, automobiles and automotive systems equipment, urban agriculture, modern physical distribution, city construction and management, new materials, social services, investment and administration, culture and sports, etc. Among the 12 specialized professions listed by Shanghai, six are related to soft technology industries, as defined in this book, namely, experts needed for the development of intelligent services, cultural industries and social industries. Beijing, on the other hand, does not include such professions in its list of priority personnel fields. In spite of being the national cultural centre, Beijing does not necessarily accommodate more soft technology experts than Shanghai does. The importance of intelligent service industries and the popular high-tech industries are not stressed equally.

People qualified in soft technology are actually interdisciplinary experts. Even though China is currently in dire need of senior management experts, and incurs great expense in recruiting management experts from abroad, and the whole society is in need of institutional innovation (soft technology fields), the training of personnel in China is still oriented almost entirely towards hard technology.

The main reasons for these short-sighted behaviours are, firstly, that most enterprises have not moved away from the established way of thinking that places hope on certain high technologies being the primary vehicle for improving competitiveness. Secondly, the classification and arrangement of social science disciplines is outdated, with the consequence that students educated in the social sciences are generally not equipped to meet the needs of modern social and economic development. For example, the market demand in China for financial experts currently significantly outstrips the available supply of qualified personnel.

Soft technology industries are high added-value industries and they are industries that create and produce of new institutions. Many of the 'rules of the game' in the development of hard technology are produced, developed and updated within soft technology industry. This is one of the reasons why an increasing number of local students in developed countries are shifting towards the realm of soft technology and why such a large proportion of engineers working in high-tech fields in America originate in Asia or other developing countries. A metaphor can be applied here: the role of hard technology experts may be likened to that of 'manufacturing', while the role of soft technology experts may be likened to that of 'product design and marketing'. The latter possesses higher added value at the level of both the enterprise and the international market. For example, there is a severe worldwide shortage of talented IT personnel and many talented hard technology experts educated in China work as senior employees in American companies. In a sense, famous Chinese universities serve only as preparatory schools for these people. Because of the technological gap associated with the current international division of labour, China may have to play the role of the 'manufacturer' for quite some time and reluctantly allow high added value to be accrued by developed countries. Therefore, China's strategy for training and producing qualified personnel must be altered as soon as possible to redress this unfortunate situation.

Education is an industry of the future. Hence, a significant proportion of the efforts should be directed towards the needs of talented personnel during the next one or two decades and directed towards 'import substitution' in the field of educating soft technology experts. If China's plans for educating and training qualified personnel are designed to meet the current (short-term) profile of market needs, or if students are educated only in professions popular in recent years, China will never be able to change its fate as a follower of developed countries and as a passive supplier of casual labour in the global market.

In fact, China began recognizing its need for soft technology experts quite some time ago. Since China began to implement its policy of reform and opening-up, it has promoted many intellectuals to leading positions with the idea of making cadres younger and more knowledgeable. However, by not paying enough attention to the education of soft technology experts, many painful experiences have occurred. For example, some excellent engineers have been promoted to executive directorship of enterprises, outstanding scientists have been chosen to be administrative leaders of academic institutes, some excellent teachers or professors have been promoted to head positions of schools and universities, some physicians and surgeons with excellent medical skills have been promoted to being chief administrators of hospitals, and some technicians without a financial education have been appointed presidents of banks. These kinds of promotions of intellectuals to important positions generally produce situations where neither side gains, i.e. neither the promoted expert nor the organization under his charge is able to thrive optimally. Many examples of these kinds of organizational mismatches have produced bitter experiences that have forced enlightened observers in China to note that excellent engineers are not necessarily capable of being executive directors, and that excellent scientists may not necessarily be competent entrepreneurs. Moreover, entrepreneurs and venture capitalists cannot be nominated or appointed. They emerge. Most people in China lack an accurate understanding of soft technology and the role of soft technology experts in society; and they are even less aware of the importance of properly educating soft technology experts.

We may take management experts as an example. As explained earlier in this book, management expertise requires at least three elements: moral standing or quality, knowledge and technical background, and intelligence and practical ability. As to knowledge and technical background, training and education in soft science and soft technology is absolutely necessary. However, because our understanding of knowledge and technology stresses hard technology and the natural sciences, soft technology has not been regarded as a special field of technology. Thus in China, people with neither social science knowledge nor sufficient specialized education and training relevant to soft technology have been promoted to management positions, and even to extremely important senior management positions. This practice seems to have developed in the belief that managerial capability can be easily gained through experience or be ‘compelled’ through practice.

Many Chinese organizations have paid a high price following poor decisions that arose as part of a ‘trial-and-error’ approach to management, based upon the so-called ‘compelled-into-practice’ approach to management. The seriousness of the mistakes that have happened is related to the managerial levels of the decision-makers. In general, the higher the position of the unqualified manager, the heavier will be the losses flowing from decision-making mistakes. It is widely understood that mistakes of entrepreneurs are responsible for 85% of enterprise bankruptcies worldwide. The approach to preparing and selecting managers that presently predominates in China is inappropriate to an economy moving towards higher competition and away from complete centralized planning.

It is widely believed that the essential conditions for creating high-tech development zones include qualified personnel, sources of capital and capital arrangements, markets and suitable environments. Qualified personnel in soft technology know how to start a business, know how to manage high-risk high-tech enterprises amidst fierce market competition and, of course, are knowledgeable about relevant technology and law. If qualified personnel staff a start-up company then it is easier for that company to obtain access to the required technology, capital and markets. China needs more than just the new high technology start-up companies it is currently seeking; it also needs experts in soft technology.

China has cultivated a number of entrepreneurs over the past ten years, such as the founders of Haier, Legend, Stone and Founder, that have been shaped and ‘beaten by wind and waves’. However, these entrepreneurial models are not enough. It is widely estimated that China needs to have at least 350,000 management experts. China currently possesses only 12,000 domestically educated MBAs. In contrast, more than 70,000 students graduate with an MBA degree every year in America. It is widely believed that China is lagging behind 10 to 15 years in terms of leading-edge technologies. The greater tragedy, however, is that China is falling even further behind in the critically important fields of soft technology.

Education technology is a type of soft technology that was institutionalized early as a means of developing intelligence, producing human capital and training specialized experts. The technology of education was the first soft technology to be recognized and employed by society in the form of a social organization - the school. The first known school in the world was founded in 3500 B.C. in Mali city and the first known university was the Moroccan Islamic University - Qaawiyin University - founded in 859 A.D.[2] However, problems that have faced the university system ever since its birth have included: how to keep pace with the times; how to reform all aspects of the university system, including the mode and content (pedagogy and curriculum) of education; how to manage the relationship between education and practice; and how to produce educated experts who exhibit both moral virtue and intelligence.

The world is now in the midst of the economic era of intelligent services, yet the dominant mode of education is still the same as that which predominated in the era of the industrial economy. The classification and establishment of disciplines, and the operational mode of the old educational system, cannot satisfy the need for qualified personnel in the era of globalization and the intelligent service economy. For examples of the new approach to education we may look to the American company Microsoft, which has developed an association with Cambridge University, in Britain, to address some of its needs in the area of the education and training of its personnel. Cambridge University, in turn, is experimenting with the development of a new type of university that allows enterprises to enter universities and universities to expand beyond their walls. The Vice Chancellor of Cambridge University has announced that the university is attempting to break down the boundaries between nineteenth century disciplines and to build a new system that enables physicists to work together with economists or scholars in other branches of learning.

School-based education alone is insufficient for to pursue the goal of cultivating qualified personnel who are skilled at innovation, enterprise spin-offs and global management. Many important things cannot be learned from books. As to school education, it is far from sufficient for students to learn only about science and technology, let alone only mathematics, physics, chemistry and engineering. Efforts should also be made to promote education in fields such as morality, ethics, history, philosophy, culture and the arts. An understanding of the histories of religions and cultures of different nations is also an essential aspect of the type of education that is appropriate to the new economy and society.

In conclusion, the new challenge for education is to reform the mode and content of education for experts and to build a new educational system for entrepreneurs and interdisciplinary experts.

Notes

1. Wen Tian, *Science and Technology Daily,* 2001.3.16.

2. *Concise Encyclopaedia Britannica*, vol. 4.

Chapter 8: Soft Technology and the Fourth Generation of Technology Foresight

Salient trends in world development include a shift from the internationalization of production towards economic globalization and a shift from the internationalization of R&D towards the globalization of science and technology. Industrial organizations increasingly cooperate through alliances in science and technology, thereby further strengthening the trend towards the globalization of the economy and of science and technology.

Under these circumstances, technology forecasting surveys and long-term technology foresight studies have become important foundations for formulating science and technology policy and industrial policy; reallocating human, material and financial resources; mapping long-range corporate strategies; and adjusting economic and industrial structures. Thus, issues associated with the rationality, effectiveness and operability of *technology foresight* techniques have again been added to the agenda, thereby stimulating new theoretical developments in technology foresight for the new age. For instance, the third generation of technology foresight theory combines society, the economy and the environment; and fourth generation theory places equal stress on soft technology and hard technology.

A. The Evolution and Development of Technology Forecasting

Although technology-forecasting techniques have probably existed throughout history - and nascent versions of modern techniques, such as trend extrapolation, brainstorming and scenario development, etc. emerged during the last several centuries - fully developed normative technology forecasting did not appear until the end of nineteenth century. During the past century technology foresight has experienced three climaxes, has undergone three stages of development and is now entering its fourth stage while the concept of technology forecasting is changing into what has come to be known as 'technology foresight'.

The term 'technology foresight', as discussed in this book, refers to comprehensive technological foresight at the national level. Specifically, technology foresight is the process of identifying technologies (including soft technologies, hard technologies and their supporting fields) that are likely to emerge in the future, by systematically identifying the long-term development trends of science, technology, the economy, the environment and society, with the aim of working out strategic plans and policies and making related decisions. Research, development and application in the fields addressed by this type of technology foresight may be of strategic significance or may bring huge economic, environmental and social benefits.

1. The Three Climaxes of Technology Foresight

Technology foresight (known as 'technology forecasting' in its previous manifestations) has experienced three climaxes in the development of its theories and methods:

The first climax: During the 1920s and 1930s, following the end of World War I, the European and American countries began to shift their attention to domestic economic development issues. 'Scientific' technology forecasting became the prerequisite for establishing a science and technology strategy and articulating associated policies. Technology forecasting during this period consisted mainly of the anticipation by technical experts of the maximum potential, and probability, of the development of various isolated technologies that were still a stage of the epic ideal, or that were clouded with unrealistic expectations.

The second climax: During the 1960s technology forecasting became accepted and developed further with a kind of formalized theoretical framework. In addition, it began to be widely applied in military departments and industrial circles in the developed countries of Europe and America and it played an important role in the formulation of national plans in countries like France, the United States, Britain and Switzerland. This led to an upsurge in the field of futurology. Many forecasting methods emerged during this period, including the famous Delphi Method that was developed through the sponsorship of RAND. New scholarly and professional journals in the field, such as *Technological Forecasting and Social Change*, also began to appear.

Some historical significant forecasting events included: the international conference on the methodology of long-term forecasting, held in March 1966, in Paris; a seminar conducted by the US Air Force team, discussing long-term forecasting and planning, in August 1966; and the industry-oriented technology forecasting conference held in May 1967.[1]

Japan studied and adopted American forecasting methods during its rapid growth period towards the end of the 1960s. Japan has subsequently conducted national level long-term forecasting exercises every five years over the three decades since 1971, thereby accumulating valuable experience and making valuable progress in the theory and practice technology foresight.

The third climax: During the 1990s, for reasons mentioned at the beginning of this chapter, many nations, including developing countries, conducted national level comprehensive technology foresight exercises. The defining features of this phase were the following: first, technology foresight was used worldwide to assist decision-making related to strategic planning and policies at the national level; and, second, the concept changed from technology forecasting to technology foresight. National level comprehensive forecasting exercises in Japan, Germany, the US, the UK and Sweden, etc., have advanced to the stage where technology foresight covers technology, the economy, society and the environment, together - rather than concentrating simply on technology alone, as tended to be the case under the rubric of technology forecasting.

Against the above backdrop, APEC founded a technology foresight centre in 1998. It was the first regional technology forecasting research institute established in the world. The International Conference on Technology Foresight, held in Tokyo in 2000, attracted participants from 14 countries and two international organizations. The conference proposed to carry out international foresight research and technology foresight exercises, aimed at satisfying social and economic needs beyond the limitations of individual countries.

2. From Technology Forecasting to Technology Foresight

Because of its failure to predict the 1973 ‘oil-shock’, scepticism about the validity and utility of forecasting became widespread. Many firms disbanded their long-range corporate planning groups and the boom in futurology, which had begun in the mid-1960s, ended quickly during the late 1970s. Criticisms of long-term technology forecasting became even more trenchant and widespread by the beginning of the 1980s.[2] The scientific and professional communities engaged in technology forecasting found it to be difficult to withstand the pressure placed on them for their technology forecasting exercises to deliver up reliable and rational management tools for decision-makers. They also had trouble living up to the pressure for technology forecasting to accurately anticipate how choices made today would shape or create the future. Technology forecasting activities were therefore gradually superseded by a variety of other activities - covered by labels such as ‘outlook’, ‘foresight’, ‘issues management’, ‘strategic thinking’, etc. - as a way of escaping what had come to be considered as impractical and conceptually vague ‘prophecy making’ and forecasting. The first two of these labels were used mostly within government organizations, while the latter two were popular mostly with managers and analysts in industrial organizations.

Martin and Irvine were early advocates of the change from an emphasis on technology forecasting to an emphasis on technology foresight.[3] They recommended adoption of a definition of technology foresight proposed by Coates in 1985, in which foresight was seen as ‘a process by which one comes to a fuller understanding of the facts influencing the long-term future and that should be taken into account in policy, planning and decision-making'. They also adopted Coates's view that technology foresight was a 'qualitative and quantitative means for monitoring clues and indicators of evolving trends and developments in order to meet the needs and opportunities of the future'.[4]

This definition indicated, first, that technology foresight is a process rather than a set of techniques and that it can help communication and the exchange of information and ideas between academia, policy-makers, industry researchers and others. Second, it also indicated that forecasting techniques had often been treated as a '"black box" for translating input assumptions into outputs taking the form of predictions regarding the future'. Therefore, a conventional aim of technology forecasting was to arrive at predictions that could be justified 'scientifically'. In other words, the predictions could supposedly reliably demonstrating what, when and how events would happen and would incorporate accurate portrayals of their respective premises, methods and data inputs. In contrast, argued Martin and Irvine, technology foresight was concerned much more with creating an improved understanding of possible developments and the forces likely to shape them and was concerned more with the deployment of monitoring mechanisms to provide an early warning of emerging trends and opportunities. Martin and Irvine further classified technology foresight into four levels: the overall level, the macro level, the meso level and the micro level.

The so-called 'scientific' approach to technology forecasting involved the use of relativity principles, probability principles, continuity principles and principles of cause and effect. However, because the economic, social and environmental driving forces of technological change are so complex and because technological and human factors are so intermingled, it is extremely difficult to accurately forecast the future 'scientifically' based on the above principles.

It is therefore reasonable to substitute the new technology foresight theory for traditional technology forecasting theory. The OECD, during a Paris conference in 1996,[5] produced the following definition of technology foresight: the process involved in systematically attempting to look into the long-term future of science, technology, the economy and society with the aim of identifying the areas of strategic research and the emerging generic technologies likely to yield the greatest economic and social benefits. The APEC centre for technology foresight[6] considers technology foresight to be a strategic planning tool and that the results of technology forecasting should be reasonable, efficient to produce and feasible to implement. The prerequisite for technology foresight is therefore the involvement of as many experts as possible from different fields, different disciplines and organizations, and the creation of a permanent network that contains the results of individual exercises in technology foresight.

3. The Theory of the Four Stages of Technology Foresight

During the Tokyo conference in 2000, Professor Luke Georghiou, of England's Manchester University, elaborated upon what he saw as the three phases of the development of technology foresight.[7] According to Professor Georghiou, Britain experienced its first generation of technology foresight during the 1980s, its second from 1993 to 1998, and its third generation from 1999 to 2003.

Analysts and policy makers in each country can judge the level of sophistication of technology foresight in their country by reviewing the degree to which the characteristics of each generation are present. The characteristics of each generation will now be adumbrated.

1) The first generation of technology foresight

The first generation of technology foresight is the 'pure' technology forecasting stage and is concerned primarily with the expansion of scientific fields as its main content and with the activity of natural scientists in forecasting the probability of potential developments in science and technology. In this stage, technology forecasting is the sacred field of scientific and technological experts, who make forecasts on the direction of technological development and on the types of technologies that will possibly emerge in the future and that will need to be developed, from the point of view of pure science and technology. Hence, technology foresight is a tool for pointing to the future research activities of scientists and engineers.

2) The second generation of technology foresight

The second generation of technology foresight involves the combination of technology and markets. It is the stage when experts in academia and industry join together to study future developments in science and technology.

Many countries believe that their technology foresight has been integrated with market assessments from the very beginning of their engagement in forecasting activities. However, the reality is often quite different. A review and assessment of critical technology in the US by Bruce Don, Director of the Science and Technology Policy Institute of RAND, is very persuasive in judging the actual degree to which the integration of markets into technology foresight exercises has happened.[8] A closer look at Don's assessment is in order.

In 1990 the US Congress formed a national critical technology panel to produce a 'National Critical Technologies Review'. This exercise played an important role in the orientation of national R&D policy and the adjustment of the allocation of national key resources, and addressed issues in the comprehensive competitiveness of the United States in technology.

In the critical technology assessment of the US, technologists paid special attention to market needs. According to Don, they 'focused exclusively on industry, depending on several sources: first, firm-level interviews; second, review of industry sector technology roadmaps; third, selected conferences on technology in the industry'. They managed, therefore, to reach agreement about critical technologies in the industrial context. They came to a consensus that software, microelectronics, telecommunication, advanced manufacturing technology, materials, sensor technology, image technology and others were critical technologies for the United States. When it came to the reasons why these technologies were critical technologies, however, there were obvious differences between opinions of industry managers, technologists and public policy-makers. Industry people stressed the key role that these technologies played in the economic performance of the US and focused on the issues associated with technology commercialization. Technologists tended to view these technologies more as tools to express expected discrete technological functions. Industry leaders tended to describe a system rather than just individual key technologies.

Bruce Don's analysis pointed to the narrowness of the concept and method embodied in the US government's 'critical technologies' exercise in 1990s. He recommended that the US should step beyond the limited scope of the current approach to analysis of key technologies (emphasizing the circle of technology-product-application) and should instead establish an approach that looked at the whole system in which technologies were embedded, in the broader sense. In other words, an approach was needed that involved a broader range of participants and that paid more attention on the processes themselves of conducting successful projects rather than just on the eventual 'products' of the projects, in the broad sense of an innovation system. Accordingly, the National Science and Technology Council sponsored a National Summit on Innovation at the end of 1999 to discuss such broader concepts.

In general, technology foresight should not be limited to forecasting exercises within separate, individual disciplines. Rather, it should be anchored in a perspective that underlies the entire innovation system and that recognizes the need to develop strategies that transcend the boundaries of both industries and governments.

3) The third generation of technology foresight

The third generation of technology foresight is oriented towards hard technology. It is also concerned with the dimensions of the market, society, the economy and the environment. In addition, a wide variety of relevant interested parties are included in the technology foresight exercise, which, in turn, incorporates a problem-solving approach that addresses an array of social factors, rather than just technical considerations.

Japanese technology foresight experts believe that Japan is experiencing a transition from the second generation to the third generation of technology foresight.[9] The fifth technology forecasting exercise of Japan covered 16 areas, including: agriculture, forestry and aquatics; information and electronics; materials and manufactures processing; life sciences; space, the oceans and the Earth; minerals; water resources; energy; the environment; production; cities, construction and civil engineering; telecommunications; transportation; healthcare and medical treatment; social life; and so on. The sixth technology foresight exercise covered 15 areas, including: materials and materials processing; electronics; information; life sciences; space, the oceans and the Earth; resources and energy; the environment; agriculture, forestry and aquatics; production and machinery; cities, construction and civil engineering; communications; transportation; healthcare and medical treatment; and welfare.

Japan has always stressed that technology foresight should include not only natural science technology but also technologies from a wider variety of fields, including production, healthcare, environment, security, city construction and society, etc. Forecasting experts in Japanese technology foresight exercises, furthermore, are constituted not only from the natural science fields but also from the social science fields. For example, in the sixth foresight exercise, 37% of experts were drawn from enterprises, 36% came from universities, 15% came from national research institutes and 12 % originated from other types of organizations.

4) The fourth generation of technology foresight

The fourth generation of technology foresight is now upon us. The third generation of technology foresight focused on hard technology under a broad systems framework that included society, the economy and the environment. Owing to our fresh understanding of soft technology, the fourth generation of technology foresight should be carried out according to the needs of sustainable development, within the systems framework of technological innovation (as broadly understood), and incorporating the multiple-dimensions of the market, society, the economy and the environment, etc. It should be focused on both hard technology and soft technology, including related institutions, cultures and social factors.

Accordingly, the fourth generation of technology foresight is not only the joint responsibility of the communities of natural scientists and technologists, social scientists and industrial leaders but should also actively involve as participants the

Table 13: Comprehensive Technology Foresight

related social communities and governmental agencies involved in making institutions, policies and regulations.

B. The Third Generation of Technology Foresight and the Technological Driving Force

The theory of multiple driving forces of technological change is the main foundation of the third generation of technology foresight. The structure of technological driving forces can be classified on three levels: [17] knowledge-economic factors, macro-environment factors, and the interrelationship of all factors.

The first level deals with the relationship between technology, science and economic development. The human motivation to exploit and challenge previously unknown fields, and the vast opportunities of the market, propel the development of science. On the other hand, new discoveries in science, and the continuous renewal of knowledge, not only deepen human understanding of nature and society, thereby enriching our library of knowledge, but they also provide new sources for technology and open up new directions for technological change. New technologies that profoundly influenced society and the economy in the twentieth century, such as integrated circuits, atomic energy technology and biological engineering, were all closely related to great breakthroughs in science.

Conversely, however, the development of science (especially the verification of new discoveries and new theories) actually depends more often than it used to on new technological means and methods. In short, the development and wide application of technology is actually a key factor in the promotion and speed of development of science. The role of the economy in the development of new technologies is related primarily to competition for new products based upon new technologies.

Technology development is the engine for economic development. The driving forces of technological development are, first, the economic motive of profit-making, and, second, human dedication, human desire to exploit new knowledge and the motive for self-fulfilment. In short, technological change drives both the scientific process of knowledge-creation and the process of economic change; and these two processes, in turn, drive the process of technological change. For convenience, we call the virtuous cycle of causes the 'knowledge-economy circle'.

The macro-environment, which we call the 'environment field' and which is composed of both the social field and the natural field, constitutes the second level of driving forces of technological change. The social field includes institutional, cultural and human resources (education), and social organizational factors while the natural field is composed of natural resources, environmental factors and ecological factors.

During the industrial economic age, it was commonly believed that the push of science and the pull of market were the direct driving forces of technological change, while the environment was an indirect force. With the rapid development of hard technology, however, and the concomitant development of social problems, values crises and the critical need for sustainable social and economic development pathways, many informed observers began to place more emphasis on the environmental context of technology as a driver of technological change. Environmental factors may, in fact, be primary causes of technological change rather than secondary causes. For example, the Italian Renaissance and the French Revolution were influences on the technological revolutions of the past. Sometimes, however, as instanced by China's cultural revolution, changes in the environment field may have a destructive effect on technology development.

The third level is centred on interaction between the above-mentioned driving forces and on the interaction of those forces with international factors. Only the coordination and harmony of all the factors from the knowledge-economy circle and environment fields, as well as international factors, can accelerate the development of a country or a region. If the main factors in environment fields are appropriate for its economic and technological development, then a country or region will be expected to develop rapidly. If the main environmental factors are unsuitable, or become bottlenecks, then the economic development and technological progress of that county or region will slow down or even recede. On the other hand, scientific, technological or economic development that is not coordinated with sustainable development and with the goal of the spiritual civilization of human beings will negatively influence or even destroy the environment fields in that country or region.

From the viewpoint of technology's driving forces, the second generation of technology foresight is concerned only about factors at the first level, namely, the factors of science and technology and market needs. However, as a process of systematically identifying the long-term development trends of science, technology, economy and society, an effective technology foresight must be multi-dimensional, including a country's unique local resources, environment, technological advantages and disadvantages, human resource, social life and institutions as well as industrial structure and its position in the international division of labour. Namely, a comprehensive national level technology foresight exercise should consider those factors at the second level, viz. factors in the environment field. This is the main principle of the third generation of technology foresight.

From 1994 to 1999 Britain's technology foresight activities covered 16 areas: agriculture, horticulture and forestry; chemistry; construction; defence and aerospace; energy; financial services; food and drink; health and life sciences; information technology, electronics and communication; leisure and learning; manufacturing, production and business processes; marine; materials; natural resources and environments; retail and distribution; and transportation.[10]

In Sweden eight areas were chosen as the subject of the national level technology foresight exercise: health and medicine and care; biological natural resources, including agriculture, forestry, water usage, food, timber products, raw materials for bio-energy; community infrastructure; production systems; information and communications systems; materials and material flows in the community; service industries; and education and learning.[11]

The technology foresight activities of these two countries share one thing in common. They do not follow the traditional classification of disciplines in science and technology. They were organized around interdisciplinary themes rather than pure scientific fields. They clarified, firstly, that the aim of technology development is to provide services for social progress and economic development in the future. Secondly, they clarified that the priorities of technological fields are determined from different vantage points, such as science, technology, society, economy and the environment, in order to fit the socio-economic development aims of their country.

The mere inclusion of non-technological fields, like society, the economy and the environment, within the purview of technology foresight does not mean that the third generation of technology foresight has necessarily been reached. According to Bruce Don's analysis and evaluation, it is important that such inquiries should not be limited to the technological highlights of the above fields. Technology foresight should not only address related key technologies, peripheral technologies and applicable technologies pertinent to those fields but should also combine them from the perspective of commercialization and the formation of a system to solve problems (such as the need to increase competitiveness).

C. The Fourth Generation of Technology Foresight and Soft Technology

Soft technology is another paradigm of technology. An awareness of technology, in its broadest sense, may provide a theoretical basis for the fourth generation of technology foresight.

1. Technology Foresight and the Innovation System

Owing to our growing awareness of soft technology, our understanding of the technology innovation system has undergone a fundamental change in terms of space structure and innovation procedure. For instance, the innovation system, as broadly understood, was built by hard-tech innovations, soft-tech innovations, institutional innovations, hard industrial innovation (agriculture, engineering industry, equipment base service industry, etc.), soft industrial innovation (intellectual service industry, cultural industry, social industry, etc.) and so on. Future technology foresight must therefore be carried out in such a way that takes into account technological innovation in the broadest sense and in such a way that covers not only soft technology foresights but also includes interdisciplinary fields that involve a mixture of hard technologies and soft technologies.

2. Soft Technology and the Goals of Technology Foresight

Today, in the face of competition, in order to maintain innovative capability and to reduce risk, managers of enterprises needs to manage the 'interface' between their firms and customers, suppliers, partners, rule-makers and policy-makers. This will require new thinking and new methods and it presents an increasingly complex challenge. As a tool to help create a shared strategic plan, technology foresight can help reduce the uncertainty faced by managers and policy-makers. From the macro perspective, with the complexity of contemporary society, the range of issues that must be faced by decision-makers at the national level is growing quite wide. Decision-makers are increasingly in need of assistance from technology foresight to set priorities for such matters as adjusting resource distribution, arranging the structure of budgets and adapting to international competition.

Martin and Irvine have identified six goals of technology foresight: 1) to clarify the direction of science and technology policies (normally with an emphasis on the macro level of analysis); 2) to set priorities in policy-making (taking into account that resources are limited, while the number of fields requiring attention are rapidly expanding); 3) to obtain pertinent information in advance of technological trends being realized; 4) to reach a consensus on particular needs or opportunities (mutual understanding needs to be reached amongst scientific and technological experts, providers of capital and industrial users who apply technological innovations); 5) to win support and understanding for technological foresight from all stakeholders; and 6) to communicate and educate civilians, government officials, industrialists and various scientific and technological experts about critical issues, through the processes of technology foresight.

John Wood believes that technology foresight is, firstly, the process that enables 'business, the science base, the voluntary sector, and government' to work together to plan for the future. Secondly, he believes that technology foresight creates 'a culture of forward thinking' towards the future; and, thirdly, he believes that technology foresight is a process 'to inform decision-makers' and to assist them to pay attention and to learn to better apprehend and analyse facts while formulating policies.[12] Wood considers that 'foresight is a think and do tank'. It not only gathers 'knowledge and ideas about future possibilities, needs and requirements' but also analyses the position and situation of the nation. He considers it to be a vehicle for matching a country's vision of possible futures to its circumstances, strengths and potential capabilities and for measuring (and preparing to face) possible opportunities and threats it may be facing during the forthcoming five to ten years. It is obvious that depending on technological foresight about hard technology alone will not be sufficient to enable a country to deal with the above issues.

3. The Causal Analysis of the Failure of Technology Forecasting

Hasegawa Yosaku, Director of the Japanese Future Engineering Research Institute, has conducted a thought-provoking study of 'the failure of technology forecasting'.[13] Yosaku analysed several forecasting mistakes in the information field in Japan and drew the following three conclusions:

1) Non-technological factors, such as the economy, society, institutions and culture, were neglected in technological forecasting. For example, it was forecasted that the 'newspaper delivery and residents information system under the influence of informationalization [*sic*]' would be completed by the year 1985, but it had still not been completed by the year 2000. This was due to the negligence of such non-technological factors as institutions and national feelings that revolve around industries. It is rational to consider the forecasting results of information and communication technology from all kinds of technological perspectives. Nevertheless, even as recently as ten years ago it was not expected that the Internet and mobile phones would become so ubiquitous today. The failure to forecast the widespread adoption of the Internet and wireless telephone communications was due mainly to excessive focus on technology itself and to insufficient knowledge about the combined effects of the sharp

decline in the cost of information and communications equipment and social capacity. The relationship between cost and acceptance has always been a problem. One key factor that has affected the growth of wireless cellular technology has been the popularity of the worldwide 'mobile phone culture' with young people. Who could have predicted that such a phenomenon could be so influential? Thus, the problem of dealing with the social tolerance for the high cost of new technology is no longer a technological problem in the traditional sense — it is a socio-technological problem.

2) The widely accepted Delphi forecasting technique has limitations. The Heterodyne Trend method, furthermore, places too heavy an emphasis on mathematical analysis and tends to neglect the emergence and influences of new technology, as well as new applications and new complementary development surrounding the technology in question. Even the Expert Interview method is often ineffective, sometimes because of the limitations in the awareness of most experts but also because 'leading edge' opinions (which, by definition, are minority opinions) tends to be neglected in favour of majority opinions and are often simply rejected because they are at odds with dominant social and political preferences.

3) Experts must be invited who pay attention to the non-technological subject matter of the social sciences and humanities when they are considering technology development; and experts in non-technological fields, who may nevertheless be able to understand the problems and difficulties of technology itself, along with techno-economic experts, need to be invited to participate in future technological forecasting exercises.

4. Powerful Tools for Strategic Planning

Technology foresight as a tool for strategic planning is itself a form of soft technology:

1) Strategic planning must be conducted as part of the innovation system, in the broad sense. Only the framework of the broad sense of the innovation system can systematically identify the long-term development trends of science, technology, the economy, the environment and society.

2) So-called 'strategic technologies' may realize great economic and social benefits for the community only through combination with soft technologies,

3) Soft technologies are also produce huge economic and social benefits, in their own right.

4) Institutional foresights actually act as measures and guarantees of the realization of future strategies.

From the foregoing discussion we can see that technology foresight is an activity that may not be conducted successfully through the independent efforts of natural scientists. It is also impossible to attain successful technology foresight by relying on forecasting of hard technologies alone. Successful technology foresight must combine soft technology foresight with hard technology foresight. This, of course, requires the full participation of both soft technology specialists and hard technology specialists.

5. Embryonic Development of the Fourth Generation Technology Foresight

The fourth generation of technology foresight has begun to emerge in some countries, in an embryonic form.

1) The framework for technology foresight in the United Kingdom from 1994 to 1999 included soft technologies, such as financial services, leisure and learning, manufacturing, production and business processes, materials, retailing and distribution.

2) Sweden's approach to technology foresight has included the following soft-technology fields, along with orthodox S&T fields: community infrastructure development, including housing, city planning, transportation systems, logistics, distribution and regional development planning; production systems; materials and material flows within the community; service industries, including media, leisure, trade, insurance and finance; and education and learning.

3) Japan's seventh technology forecasting exercise, in 2001, comprised 16 fields in six major systems. Among them, manufacturing and management systems and social infrastructure systems were juxtaposed with information systems, biological systems, environment systems and material systems. From the perspective of soft technology, Japan's technology foresight process has some striking features: social infrastructure fields, including city planning, construction, civil engineering, transportation and service industries, are included as important fields. Most remarkable was the fact that service technology was treated as a subject amenable to forecasting, based on the demands of the development of the new economy - including the intellectual service economy, e-commerce, and the knowledge-intensive society. Secondly, in order to follow the trend of 'softening and informationalization of the economy' [*sic*] the manufacture and management system was selected. The system consists of three fields, namely, manufacturing, circulation and management. They belong to, or are closely related to, soft technology. n the field of management, furthermore, a subject

that is traditionally seen as non-technological - that of institutions - is also taken into account.[14]

While these embryonic examples are encouraging, no cases of technology foresight in which soft technology foresight has been systematically integrated with hard technology foresight have yet been discovered by the author of this book.

D. Technology Foresight in Developing Countries

Developing countries have exhibited almost no presence in traditional technology forecasting activities. This is due mainly to the fact that most scientists in developing countries lag behind their counterparts in developed countries in science and technology and lack practical experience in the application of the most advanced technologies. Most information available to developing countries about frontiers in technology stems from the technology that developed countries have commercialized or issued publicly. Much of the leading-edge technical knowledge, of course, is not made publicly available. The vast majority of experts on future trends in science and technology who make presentations at annual meetings of the World Futures Society, for example, come from developed countries. This poignant fact raises the question as to what path developing countries should choose to catch up with, and surpass, developed countries in the domain of technology.

The chapters of this book that have dealt with the topic of technological competitiveness have illustrated, in a number of ways, that there is a big gap between developing countries and developed countries in R&D capability and in most advanced technologies. The critically important point to recognize at this juncture is that it is the macro-environment, especially the imperfect soft environment and underdeveloped capability in soft technology, which leads to the failure of developing countries to transfer advanced technology or to absorb advanced technology (by converting it into enterprise technology). This gives rise to unequal opportunities between rich countries and poor countries vis-à-vis new technology and it erects a strong barrier to improving industrial competitiveness in poor countries. Thus, foresight in soft technology is an indispensable component of technology foresight. Regretfully, however, technology foresight in most developing countries has neglected soft technology.

Many developing countries do enjoy advantages in some fields. However, they cannot expect to build long-term competitive advantage in those fields if their forecasting techniques focus only on fields of natural science and natural technology to the neglect of soft technology. If developing countries place excessive attention on cutting-edge hard technology that is 'hot' in developed countries, they will lose the opportunity to cultivate their distinctive strengths and will never be able to close the technological gap that currently stands in the way of their economic development.

Notwithstanding the popular icon of the 'leap frog' strategy, it is actually very difficult for developing countries to catch up with developed countries from the perspective of technology qua technology. This is because technological invention and technological innovation are not determined solely by hard technology. Even forecasting on such topics as industrial and technology policy, the environment, water, transportation and national life, which is conducted in developing countries, is rarely conducted under the same framework as natural science and technology foresight. As for intellectual service technology, social technology, management and institutions - in other words, topics that fall into soft technology categories - almost nobody in developing countries places stress on them as part of the content of technology foresight. Accordingly, it will be very easy for developing countries to commit the same error (described above) that Americans made in the area of critical technology assessment. Technology foresight professionals in the United States are currently engaged in a process of self-reflection about this issue. It would be a pity if leaders in developing counties were not able to learn from the previous self-acknowledged errors in technology foresight in America.

Developing countries could benefit by establishing a network for mutual sharing of information about markets, economies, societies, the environment and technology, and they could benefit by sharing this within an international coordination network. It would also help fulfil an essential condition for the successful conduct of technology foresight in developing countries.

In summary, soft technology, hard technology, markets, society, the economy and the environment need to be integrated together into a whole-systems framework. Only when that is done, and only when technology foresight is approached from the vantage of technology innovation in its broadest sense, can the process of technology foresight be made to fit the local or national situation of a particular developed country. In addition, only under those circumstances will it be possible to identify those technologies appropriate for producing tremendous economic and social benefits. Without such circumstances, and without such technologies, it will be difficult for developing countries to realize their goal of promoting national comprehensive competitiveness based upon their unique configuration of resources and conditions. Entering the fourth generation of technology foresight, as soon as possible, is therefore especially important for developing countries.

Notes

1. Jantsch, *Technological Forecasting in Perspective: A Framework for Technological Forecasting*, p. 15.

2. Martin and Irvine (eds.), *Research Foresight: Priority-setting in Science*, p. 109.

3. *ibid.*

4. Cetron, *Technological Forecasting: A Practical Approach*, pp. 4-5, 12.

5. Terutaka Kuwahara, 'Technology Forecasting - past, today and future', Seminar at the National Institute of Science and Technology Policy, Tokyo, 2001.2.8.

6. Tegard, International Conference on Technology Foresight, Tokyo, 2000.3.

7. International Conference on Technology Foresight, Tokyo, 2000.3.

8. Don, 'Changes in the U.S. Approach to Technology Foresight and Critical Technology Assessment', International Conference on Technology Foresight, Tokyo, 2000.3.

9. Japan Monbusho National Institute of Science and Technology Policy, 2001.2.

10. Wood, 'Current Foresight Activities in the UK', International Conference on Technology Foresight, March 2000, Tokyo.

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12. Wood, 'Current Foresight Activities in the UK', International Conference on Technology Foresight', March 2000, Tokyo.

13. Hasegawa Yosaku, '30 Years of Future Technology Forecasting', *Technology and Economics Magazine*, January 2001 edition.

14. *The 7th* Technology Forecasting Survey, Science and Technology Trends Studies Center, Monbusho National Institute of Science and Technology Policy, July 2001.

Postscript: The Principles for Development in the Twenty-First Century - Harmony, Balance and Equality

As we move into the twenty-first century there is a good deal of exciting news about new discoveries and new inventions all around the world which will undoubtedly benefit human beings and develop a higher level of material civilization. However, the problems we are facing, such as the appropriate application of technology, social problems, the problem of human civilization, ethics and the future, are becoming more profound; and various international conflicts and crises are increasing. As early as the 1960s and 1970s people became aware of resource shortages caused by high-level industrial development and of global maladjustments in the natural ecological system. This awareness led to painful predictions regarding the necessity of ending the 'resource economy' and re-establishing a more human mode of development. What is more alarming is that human beings are losing a great deal when they pursue a high degree of material civilization. Along with material advancement has come a decline in spiritual civilization, indicated by such things as the preeminence of money, the growth of crime, moral degeneration, intolerance of differences between people and the destruction of the Earth and nature upon which we depend for our existence.

Human beings are now facing even more severe challenges. These include: conflict between economic growth and the environment; the conflicts between nations and between religions; the great gap between the rich and the poor; and the conflict between the development of science and technology, on the one hand, with society on the other (e.g. the relationships between research freedom, research orientation and the development of human society, especially the ethical and moral problems caused by research on human genes and the breakthrough of mammal cloning technology, the unreasonable use of nuclear technology, computer viruses, etc.). From increasing family violence to internationally organized crime and violence, human beings are now destroying the civilization, which they themselves created, in an even more tragic way ... with the help of high technology, which they also developed. There is a very wide spectrum of problems, ranging from the relationship between individuals and social interests, from national to global strategy, from domestic social relationships to international relationships and the economy, politics and national defence. Obviously, human beings are facing problems that now threaten their own mode of existence and development, as well problems related to sustainable development in resources, environment and ecology - which are not amenable to solution through the application of high technology alone or by the actions of politicians and governments alone.

In this context it is important for us to again consider the key principles of sustainable development:

1) The ultimate goal of sustainable development is the progress of the human race and the creation of a world of prosperity and peace, conducive to the development of material and spiritual civilization.

2) The socially productive activities of human beings, the development of the economy, technology and even political reforms are not the goal. Rather, they are but ways and means for achieving the goal of sustainable development. Among them, technology development and innovation are the means and method for social progress and economic development. This requires that we do not reverse the relationship between the means and ends and that we do not treat means and methods (technology, economy and politics) as ends in their own right. We must consider new modes at three levels (technology, economy and politics) when we design a new paradigm of development and new modes of development.

3) Good ecological environments and humanistic social environments are the result of sustainable development, as well as the essential conditions and prerequisites of sustainable development.

According to above perspective of sustainable development, we must succeed in balancing the development of three systems if we want to achieve sustainable development in our society: the natural ecological and resource environment, the humanistic-social environment and human social and productive activities. The process of implementing sustainable development actually requires activities centred on nature, society and people (especially on the process of coordinating human behaviours). The core types of coordination required (the coordination of behaviours between humans and nature, the coordination of humans and society, the coordination of humans and humans), together with the means of coordinating and controlling human behaviours (external behaviour and internal psychological activities), is the heart of what soft technology is all about.

The challenges of sustainable development create profound significance for the concept of soft technology. They also create profound reasons for studying soft technology. Important insights can be obtained by researching the new paradigm of technology, soft technology. Such research may deal with matters such as the rise of the new form of currency technology, complementary currency. Complementary currency is a key component of the new international paradigm of the cooperative economy. To achieve sustainable development a new kind of thinking mode and culture must be articulated and developed worldwide.

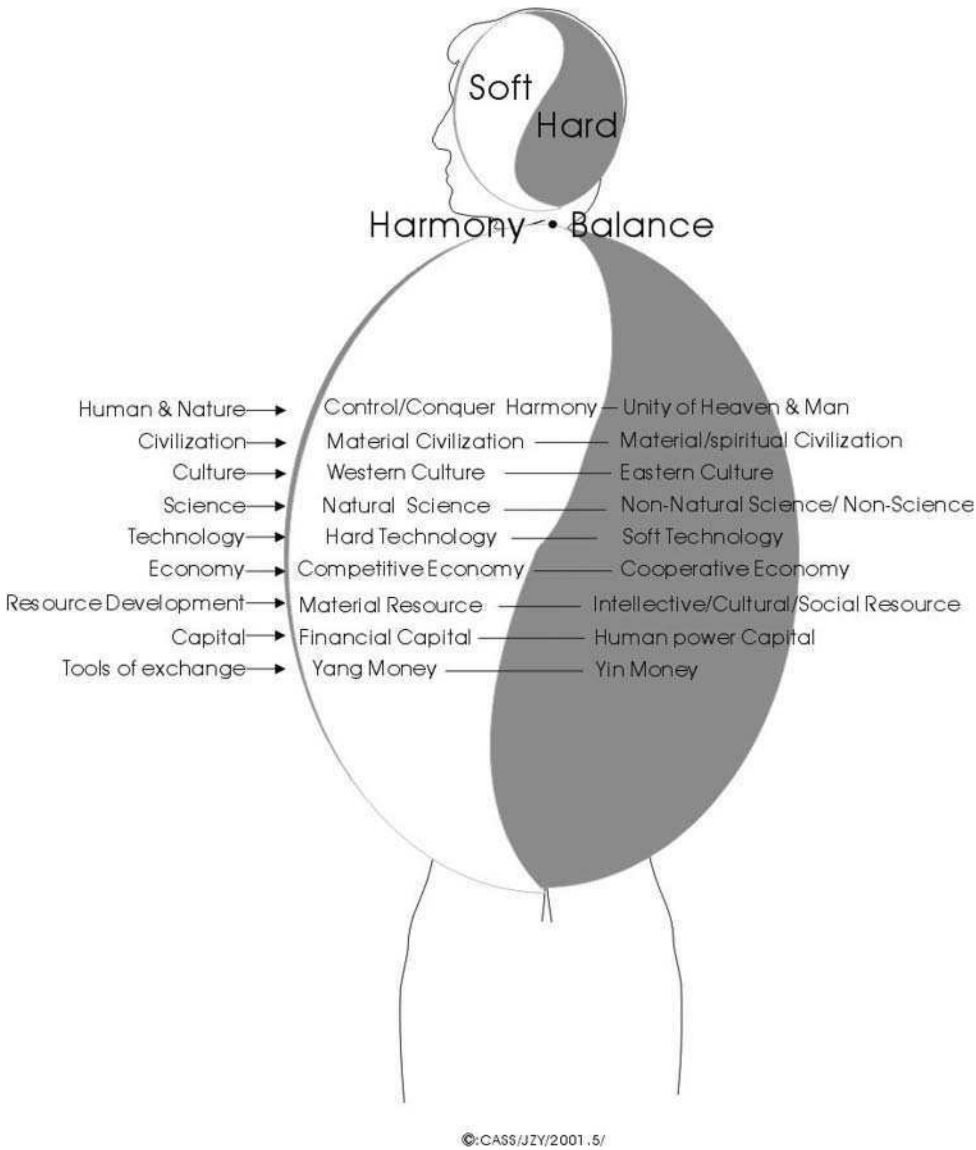
First, those who are well educated and the elite of every country, including the leaders, need to adjust their values and change their worldview. In other words, they need to work on the basis of common principles - harmony, balance, democracy and coexistence. These principles are suitable for dealing with problems related to economic development modes, pursuing new lifestyles, social civilization, multi-culture and culture innovation, the development mode of science and technology and the treatment of the relationships between different nations and religions, the relationship between the West and the East, and the relationship of humans, nature, society, etc. (see figure 11).

In the practice of science and technology development, for example, a fundamental shift is required. Namely, it is necessary to shift from emphasizing hard technology development aimed at improving efficiency and conquering nature towards emphasizing balanced development with human society (creating an environment which is reassuring and suitable for securing substantial and healthy living). It is also necessary to regulate the application and dissemination of hard and soft technology by applying the concept of sustainable development. Economic development also should shift from emphasizing competition and profits towards emphasizing green principles, cooperative enterprise, sharing and human-centred mutual beneficial business activities. The progress of human society should be in the direction of harmony between human beings and nature and in the direction of mutual respect, coexistence and democracy of all countries, nations and races.

The essence of Chinese traditional culture speaks directly to the challenges now facing us. For example, the ideas of 'emphasizing peace', 'man being centred' and of 'unifying humans and heaven' may be of significant theoretical and practical value through their contribution to the cultivation of sustainable development and as guiding principles for the future development of human beings worldwide.

The principles of harmony and balance, at different levels and through the different dimensions described in figure 11, are in line with the ancient Chinese philosophy and culture of 'Yin' and 'Yang'. In the words of the first sentence in *Questions: On the Changes of Yin and Yang* of the *Yellow Emperor's Inner-cycle*, 'the so-called "Yin" and "Yang" are the laws of heaven and earth, the discipline of the universe, the origin of immortality and death, the parents of change, and the mansion of gods and spirits'.[1] Soft technology may be thought of as the practice of technology in the spirit of 'Yin' and 'Yang'.

Figure 12: The Principles for Development of the Twenty-First Century



Notes

1 . Chen Shide, Wang Hongtu, Lu Zhaolin (eds.), *Collection of Explanatory for FAQ,* vol. 1, People's Hygiene Press, 1982.1, p. 68.

Appendix: Organizational Innovation and Virtual Research Institutes

The world has entered the Knowledge Age. Traditional organizational systems are experiencing difficulties maintaining competitiveness in this unpredictable world. 'Organization' itself has become the most important factor of competition. Organizational revolution is the first item on the agenda.

In this book I have thoroughly analysed the disadvantages of traditional Chinese research organizations, indicating that organizational innovation is a precondition for all kinds of creation and innovation. In this Appendix I will describe a new mode of research organization - the virtual institute - along with its background and significance. I will also discuss organizational change in China after its reform and opening up and provide examples of virtual institutes in both America and in China. Through summarizing China's experiences in implementing virtual institutes I will make a case for the idea that moving in the direction of the virtual institute is the way of the future and that the growth of virtual institutes may even be inevitable. Finally, I will discuss the outlook of virtual institutes and the challenges they will inevitably face.

A. The New Organization Mode Embodies the Features of the New Era

Since the world is entering the Knowledge Age, information technology is gradually turning the world into an information highway network. The development of technology has greatly accelerated the international flow of information, capital and commodities, and has sped up the rate of economic globalization. At the same time, the cycle of technological development and commercialization has become shorter and shorter. Consumers have more choices in the market. World competition for markets is consequently becoming fierce.

The pressures of external market competition increasingly influence the internal affairs of organizations, in fields such as technological innovation, perceptions and ideas about employment and the distribution of profits after the application of new technology, including new management technology. In the meantime, the effectiveness of companies' capabilities in fields such as technological innovation, intellectual property protection, product development, technology transfer and new venture development depend upon how well these organizational capabilities are coupled with appropriate organizational structures, flexibility, personnel management (including senior managers, intrapreneurship). The ability of an organization to match its capabilities to it organizational structures directly affects its competitiveness. 'Organization' itself has become an important factor in competitiveness. In the contemporary environment, traditional organizational systems are increasingly incompatible with competitiveness.

Today, no country is immune from the tidal wave of globalization and from the pressure to independently develop its economy, acknowledging that this must be done through connections with the global economy. China's recent wave of reformation and opening to the outside world, for example, has highlighted many of the inefficiencies and inflexibilities of the country's organizational systems. At first, central government administrative agencies began to be reorganized and simplified and many officials shifted to new posts, including positions in new companies. China's academic system then also faced organizational reform. A large number of researchers shifted the emphasis of their activities from pure research into technology transfer and commercialization - or, as it has often been described, 'jumping into the sea' (that is, taking the plunge). State-owned enterprises are now allowed to go bankrupt. Several million people employed in Chinese state enterprises have resigned their posts and have entered the labour market in search of a second career. All of these organizational changes have had a great impact on work life, family life and personal life. Meanwhile, it also has created greater opportunities and better conditions for individuals to choose directions for their lives. These have also led many people to re-think the meaning and purpose of their work in the realization that established Chinese organizational systems and organizational concepts had effectively been stifling creativity

At the same time, most Chinese people have realized that the established Chinese organizational 'units' may no longer provide cradle-to-grave security; climbing the ladder of rank, title and post in a unit is no longer the unique career goal; loyalty to a unit is no longer seen as being equal to loyalty to the country. Reasonable personnel flow and structural reorganization have been necessary to raise competitiveness for Chinese enterprises. Recent trends of reform in China have forced Chinese workers to face the reality of international organizational changes and have forced them to gradually move from a passive mindset to an active one in relation to their careers.

To sum up, organizational reform is the top item in China's new agenda as it faces the reality of the fierce competition that characterizes the new society, the economic environment and the new international context. We need to reconsider the definition of 'organization' and to discuss the following question: what kind of organizations are best able to adapt to changing market conditions and are most suitable for survival and development in a competitive environment? No matter from which country they come, enterprises in today's world are forced to experiment with a wide variety of organizational innovations, with a variety of labels, including: down-sizing; restructuring; re-engineering; changes in scope, scale and level, to absorb external resources; virtual organization; new forms of inter-organizational cooperation; and various types of mergers and corporate annexations. All of above phenomena reveal the contemporary importance of organizational innovation.

B. The Defects of Traditional Organizations of Science and Technology in China

In general, all Chinese organizations - including government, industrial and academic institutions - were largely stable throughout the four decades of China's planned economy. From R&D to production and the sale of products, everything was carried out according to planned standards, guidelines and indicators. The word 'risk' was almost unheard of for both individuals and organizations. Outside competition was rare and mostly shut itself off from the international market. Organizational structure was like a pyramid.

People within Chinese organizations during that period answered only to their superiors within their own institutes and, appropriate for the environment of the time, were guaranteed lifetime employment. At that time, every Chinese person worked in a stable organization, called a 'unit'. A unit could be a government organization, association or enterprise. Unless one made a serious mistake or was transferred to another unit, owing to the 'need of the organization', he or she could remain working in one until the day of their retirement. During this time, medical care, housing and nursery-care were all provided, along with guaranteed retirement benefits. This system was known as 'the iron rice bowl'. In that period, people were not rich but life was stable and secure. At the same time, because of this egalitarianism and ignorance of the outside world, people felt in balance, which made the organizations stable. In this kind of system, any reform was difficult. Job change and transfer to other units was also difficult. In some old enterprises and research institutions it was common to see three generations of one family working in the same 'unit'.

Under the aegis of its planned economic system, the gap between China and international standards was even greater in the domains of organization and management than it was in the domain of technology. Bridging the organizational and management gap is even more difficult than bridging the technology gap. In this context, the organizational reform of scientific institutes in China is very important. The impact and shock of globalization on the organizational context of scientific work is greater in China than in other countries. The organizational context of Chinese research institutes, under the stable, planned, established system, had (and largely still has) the following characteristics:

1) Research organizations are duplicated at the central, industrial and local levels and also in the military. Research work is also duplicated across organizations, thereby wasting manpower, money and resources. By the end of 1995, there were 5,856 independent R&D institutes in China, employing 1.03 million people. However, divisions and subjects are not integrated, research efficiency is low and they often exhibits little creativity. Intellectual property is scarce. The level of research is often low and there is a great deal of redundancy between projects. Each institute, whether big or small, has a complete set of logistics systems and social security functions, thereby resulting in a heavy burden of non-research staff management and budgeting. The 'big pot' system formed over the past several decades, the evaluation standards of research achievement which lack of relevance to the market value and a weak social security system all form obstacles to organizational reform and to the optimization of the use of personnel in the research system. The 'contract system' for research institutes that has carried over in recent years as a reform step also exhibits detrimental effects.

2) All research institutes are organized according to traditional discipline categories. Research staff are also organized in such a way that people with the same disciplinary background are grouped together by the government in the same division or unit, no matter how recently or long ago they graduated from their studies. This does not fit well with the current trend towards interdisciplinary, integrated and comprehensive approaches to research.

3) Research institutes are not very different from government organizations and industrial entities. Even those local institutes or substrate-level institutes have a top-down administrative organization with a kind of class structure. This system promotes bureaucracy and is harmful to staff creativity.

4) The management of scientific research projects tends to be conducted in the same manner as the administration and management of other types of organizations. For example, under the established system for managing cooperative research projects:

- Resources and budgets are strictly controlled within departments, under the notion that 'rich water should not provide irrigation for others' and are treated as the sole possessions of the department from which they emanated. Each department or unit tries to keep the major parts of projects entirely within their own organization, using only their own people whenever possible. It is difficult to collaborate with outstanding researchers from outside their own organization, thereby negatively affecting the level of their research.

- Cooperation across units or departments first of all has to be formalized as administrative cooperation. In order to maintain organizational balance and to provide support for different sections under their control, administrative leaders normally end up in charge of research projects. Lower-level section leaders draw up the membership list for projects. Rank and title, rather than competence, determine the placement of people in projects. The bigger the project, the more stratified the team. The number of actual researchers in a research group for a project is often very small and frequently they are even be in the minority! Project participants are often appointed to represent the interests of their own unit, above the interests of the project. The group leader often has no actual power of command. When a decision is needed to resolve a research problem it is often necessary to call meetings with leaders from different units. This creates great inefficiency.

When a project is finished the names of participants are normally listed in an order that provides differential credit for individuals and their units. The decisions about who gets credit, and in what order, normally cause much internal fighting, both openly and behind the scenes. There are also discouraging problems related to awarding prizes. Administrative interference in cooperative projects tends to cancel out part of the benefits of cross-sectoral or interdisciplinary cooperation in research.

- Participants in research projects selected under the system of administrative interference are frequently not the experts most suited for the job, let alone the people who are likely to be interested in the project. Many take on the work for their own unit's task, simply for the sake of a title. It is difficult to have them produce any thorough inquiry or meticulous basic research.

- In general, when funding is over, researchers are dismissed, even if the research needs to continue. Research has to stop because there is no money or when the home unit wants its staff back. With the constant changes in personnel and research organizations for the same type of projects, it is hard to train advanced researchers.

- Standards for evaluating the qualifications of researchers and for evaluating the quality of the research results are very vague. This results in many strange phenomena. State-level projects have the twin problems of administrative interference and power distribution. The strange cycle turns out to be something like the following: apply for a major project under the name of famous experts, find several responsible units as contractors, organize the experts for certification and high evaluation, apply for award, and then look for another major project.

> Some soft scienceresearch actually looks 'soft'. Provided you have funding, you can research anything. Anyone can do it; research quality becomes lowered. Taking over other people's research achievements, or even plagiarizing them, often takes place.

The above-mentioned problems in managing research projects in Chinese research institutes are related not only to the type of organizational management employed, nor are they generated only by the institutes themselves. Rather, they stem mainly from the science and technology management system and the old organizational concepts that flourished under the former planned economy.

C. Virtual Institutes: A New Mode of Research Organizations

International competition today is centred on economic competition, and economic competition is dominated by competition in high technology. Virtually all governments in the world realize that only by strengthening technological innovation, possessing their own intellectual property and grasping high-tech resources can they take the initiative in international economic competition. Technologically advanced countries therefore adopt various policies to protect their intellectual property rights and to achieve market monopolies through technology monopolies. R&D institutes - as the main agencies of producing, accumulating and spreading knowledge and technology - hold the primary responsibility for providing technological sources for the technological innovation system. The capability and efficiency of research institutes is therefore the most important basis for economic growth and the core of competitive power for a nation.

Organizational innovation is one of the main prerequisites for other innovations. This has special significance for research institutes. In the Chinese context there is a pressing need to study the best structure, management methods and functions of organizations so as to establish a healthy research atmosphere and create a new culture for research institutes.

1. Virtual Organizations

In discussions of organizational innovation, people often talk about virtual corporations, virtual offices, virtual department stores and virtual banks, etc. Efforts have been in place to establish virtual organizations for quite some time. In 1988, the Englishman David J. Skyrme described the necessity of 'virtual working' in modern societies. Recently, he also developed 25 work principles for network organizations.[1]

However, in a sense, virtual companies have a longer history. In the past several decades, Japan has widely applied virtual production and organizational forms with Japanese features to operational modes of enterprises and groups to cooperation between big medium, and small enterprises and to manufacturing industries. This phenomenon is possibly one of the unrecognized reasons for Japan's great industrial and economic success. The organization of China's state-level engineering projects has exhibited the features of virtual organization but has been implemented and managed with inappropriate administrative methods. The projects have not enjoyed the advantages of modern virtual organizations because they lacked certain essential features of what we might call 'virtual management' techniques.

In recent years, virtual corporations have attracted increasing attention as a comparatively mature organizational innovation mode and the concept of the virtual corporation is still developing. In March 1994, Michael Malone and Bill Davidow wrote[2] an article entitled 'Welcome to the Age of Virtual Corporations':

The Virtual Corporation, a mere theory on a scrap of paper three years ago, has now become a common phrase in daily business life... Similar corporations temporarily join together into meta-enterprises. Manufacturers, suppliers, distributors, and even customers are linking together in enduring relationships built on mutual trust... The Virtual Revolution is the defining business transformation of our generation.

The Taiwan *Economic Daily* has described virtual corporations as being able to fulfil functions such as production, sales, design and finance, etc. but without having internal organizational capabilities to carry out these functions. That is to say, the virtual enterprise retains only its necessary key functions and relinquishes or 'virtualizes' the remaining functions, owing to its limited resources or insufficient competitiveness in those functions. The virtual company must use every means at its disposal to borrow strength from the outside to increase its competitive edge. The target of this borrowed strength might be upstream suppliers, competitors or customers. Whatever form it may take, the guiding principles of the virtual corporation are that it breaks past the conventional limitations of enterprises and extends its scope by using a strategy called 'integration of external resources'. This differs from the formerly popular strategy of 'selection of internal resources'. In general, the virtual corporation is a type of dynamic union of enterprises for responding quickly to market changes. A good example is the American company CIM Engineering Corporation, which organized several software and manufacturing companies into a virtual corporation. Using their technology and patents, CIM created the world's first high-speed PCMCIA voice card.

What would happen if we applied the idea of the virtual corporation to research institutes? Research institutes are a type of collective in which research activities are organized according to certain research goals and systems. They should provide an environment in which researchers can make best use of their individual creativity and collective wisdom. The application of the concept of virtual organization with respect to research institutes - the virtual research institute and the virtual research centre - will comprehensively challenge the definitions, boundaries and forms of our research organizations. Research institutes tend to have defined research goals and defined research content. In a virtual research institute, various research resources and functions are organized into a new 'flexible institute', involving close cooperation across time and space. The virtual institute can involve experts from different fields, different communities and different departments and employ researchers from all over the world - in addition to entrepreneurs, government officials and even users from different fields. The institute can also operate regionally and internationally. Its research scope and scale can be adjusted according to demand.

The virtual institute transcends the boundaries of traditional research institutes. It can infiltrate and extend the functions of different institutions. It can integrate a large quantity of internal and external resources. Theoretically, there are no limits to the scope, resources and options of a virtual institute. The virtual institute is thus able to achieve organizational flexibility at a low cost. Functions other than key research functions, such as supply support, can be relegated to outside organizations for greatest efficiency.

Though the work mode of the virtual institute is somewhat similar to that of conventional project groups, the virtual institute itself is more compact and retains the same functions of an institute. It is not a temporary collective group that will be disbanded upon completion of the project. It is a union where researchers trust each other and have a common understanding of the goals; they share common knowledge and working conditions. All this is directed at achieving high levels of success in long-term research by making optimal use of limited resources.

In short, the purposes of the virtual institute are as follows:

- To organize research resources in such a way that the institute can deal appropriately with change at a minimum cost and with maximum speed;

- To attract researchers by offering them mutual exchange, flexibility, the integration of wisdom, new concepts of institutional culture, open policies and glamorous research goals;

- To promote the principle of combining team spirit with individual creativity so as to increase competitive edge and create new conditions for future development.

Entovation International, Ltd. (Wilmington, Massachusetts, USA)[3] is perhaps a representative example of a virtual institute. Under the leadership of the founder and chief strategist Debra M. Amidon, its global innovation research and consulting networking links 48 countries and 2,000 experts throughout the world. During the past year alone, their new ideas, presentations and writings about knowledge innovation and knowledge management have been heard throughout more than ten countries, forming the worldwide ENTOVATION Network and Knowledge map.

The Millennium Project - the global futures research conducted by the American Council for the United Nations University - was organized through international networks of three hundred futurists, scholars and policy-makers in 60 countries who worked for UN organizations, corporations, governments, universities and NGOs, interconnecting global and local perspectives through the Project's nodes throughout the world. The reports of the millennium project provide a context for global thinking and the potential for the improved understanding of how humanity may work together as we enter the new millennium. This project was selected to be among the one hundred 'best practices in the world' by an independent panel on behalf of UNCHS (Habitat) and it was the winner of the Dubai International Award in 1998. During its five years of operation, the Millennium Project operated as an international research organization, supported by several foundations and companies. However, its designers, directors, operators and full-time members were just two experts - Jerome Glenn and Theodore Gordon.[4]

Of course, the virtual institute is just one of the organizational structures appropriate for the knowledge society and we should not expect it to be a panacea for solving all the problems of research organizations. However, at the level of grassroots organization there is no question that moving in the direction of the virtual institute is appropriate. Organizational reform is a prerequisite for the reform of the scientific system.

2. Background and Significance of the Virtual Research Institute

Virtual organizations are the result of social progress and they will only be able to realize their true potential when the conditions are right in the society at large. When the society has matured, in terms of its economic-informatization level and socialization level (including social security and welfare functions, ideas about work and various modern social systems), virtual organizations will then be accepted as a popular and official form or organization. Some of the features of those social conditions are as follows.

1) The age of collaborative innovation. In the international and information era of the twenty-first century the costs of creativity and of adopting new technology are rising. Uncertainty and high risk are important factors in the research processes of science and technology. Promoting pre-competition technological cooperation has become a necessary means by which companies may reduce the risks and costs of their R&D. As the American Debra Amidon has commented, the twenty-first century is the age of Fifth R&D Generation and the core strategy of the Fifth R&D Generation is collaborative innovation.[5]

2) An environment that integrates intellectual endeavour through various fields of cooperative and interdisciplinary research. Alongside its increasing complexity, the increasing integration of fields is a defining characteristic of contemporary high technology innovation. All parties involved in high technology development must rely on the integration of different technologies and upon interdisciplinary cooperation. Technological integration or knowledge integration involves not only technology, however, but also the integration of minds. Virtual institutes gather people from different fields and technological backgrounds and organize teams according to specific goals and systems to create superior environments for interdisciplinary research and for the integration of knowledge and intellect.

3) The age of breaking away from the boundaries of the old research system.In a knowledge society the differences between basic and applied research, and between science and technology, tend to blur. The distance from research, development and application to the market has become considerably shorter than was the case in the past and the different stages of technology development have become harder to distinguish from each other.

   The traditional division of institutes by academic disciplines and the rigid separation of research, development and production from commercialization - as was commonly found in China and other countries - are now obsolete. Virtual institutes combine researchers, producers and users into one system. They also enable mutual exchange and mutual extension of activities between their members, they break the boundaries between systems, they encourage the development of new ideas and they make it easier to overcome the obstacles to knowledge transfer between traditional organizations. By these means they speed up the application and dissemination of new technology.

4) The flexibility of virtual institutes facilitates flexibility in traditional organizations. One of the problems of traditional organizations is their inability to make quick decisions in the face of ever-changing markets and opportunities. An ideal organization should be able to readily respond to surrounding changes. However, because modern technology develops so quickly, it is impossible for new organizations to be created for each change in demand or products. It is not feasible to continuously establish new institutes to adapt to ever-changing research requirements created by the emergence of new topics and concepts. The core of an organization is people. Unreasonable organizational adjustments and personnel exchange usually results in huge, invisible costs. It is also very difficult to quickly transform an existing organization into a larger or more comprehensive one. This problem is compounded by the fact that the bigger an organization becomes, the weaker its ability to deal with change becomes.

   Because a virtual institute is not a hierarchy, its reorganization does not affect the social status or welfare benefits of its researchers. The establishment and dissolution of a virtual institute does not follow the traditional procedures for determining management, so the 'human' obstacles become fewer than is the case in traditional organizations. A virtual institute can accordingly make swift changes, at minimal cost, to changes in external demands; and it can increase or reduce staff according to the task at hand, guaranteeing a free flow in its activities and achieving the best distribution of its resources.

5) A collective body that encourages people to learn from each other and share common knowledge. In modern times the amount of extant knowledge increases rapidly, as does the need for people and organizations to keep up to date with new knowledge. An increasing number of jobs require knowledge as their foundation. The worker who relies only on what he or she learned in school will be left behind. For employee training and the updating of knowledge, we must rely on on-the-job training and actual work experience. An employee's ability to apply new knowledge cannot be determined just by looking at his or her age, education, qualifications, title, rank or position. Virtual institutes encourage people to share their common culture and to be open to the entire society and the world.

   Virtual institutes provide a basic infrastructure for ongoing study and research. They may become an organizational base for retraining, a place where people share knowledge and a medium for life-long learning. Work no longer means only the means by which people make a living and a place where people make that living. Rather, work is an important vehicle by which people may seek greater self-realization and pursue happiness. Updating knowledge is expensive in rigid organizations and, as a result, stagnation through 'inbreeding' easily happens.

6) A network-style parallel organization and the new concept of 'leadership'. One of the greatest dangers facing an organization with the passing of time and with the growth of its achievements is that the expansion of authoritarian leadership proceeds to such an extent that the organization gradually becomes a bureaucracy. In such cases leaders resist democratic initiatives, preferring instead to make autocratic decisions. The core of modern organizational reform is to simplify management procedures, that is, reduce hierarchy, shorten information channels and quicken the pace of decision-making. A virtual institute is a network-style parallel organization. As the most basic research unit, it no longer contains any internal hierarchy, enabling it to prevent deterioration and bureaucracy.The leaders of research institutes should, therefore, change the emphasis of their leadership style from that of a 'director' to that of a 'facilitator, coach, mentor, advisor and indeed a peer in the exchange of knowledge and experience'.[6]

7) As a combination of a relaxing environment and team spirit, leadership must not only give rein to individual creativity but also insist on team spirit. As society develops and people's ideas change, the connotation of this principle evolves. This is the eternal subject for organizational innovation. For research work, it is not sufficient only to have strict discipline. As in composing music, a free environment is necessary for enthusiastic thinking, as well as a concentration of energy to complete the task. Researchers in virtual institutes avoid the binding of traditional organizations. They are not protected or pressured by others. They will discover their own ability in a completely new environment and find a place suitable for themselves. However, the process of technological innovation becomes more and more complex; any major invention or creation cannot be removed from the team. A virtual institute is not a paradise for individualism. It survives on team spirit. The purpose of this type of institute is to seek a balance between the close alliance and the relaxant environment to fulfil the task that no individual can fulfil alone. As David Skyrme put it, 'Organizations today need a balance of the highly innovative and the tightly coordinated.'[7] As for the form of team activities, besides a face-to-face exchange, many depend on advanced communications technology to achieve the goals of research, without regard to time or place.

In brief, a research virtual institute meets the needs of innovation. The trend towards virtual institutes is an inevitable part of social development.

D. The Development of Virtual Research Institutes in China

Since China commenced carrying out it policy of openness and reform, there have been many brave attempts to seek new ways to organize and manage research projects. We can divide these attempts into two basic types.

First, there are interdisciplinary research organizations and academic associations for which changes in administration must be led by government or must involve intervention by government. When their task is fulfilled, the group is dismissed. If the result is a success and the scale becomes large, these institutes are often contaminated by the virus of big companies, big units or big institutes. For instance, once the institute has been approved by the pertinent government administrative organizations, the leader of the institute is appointed by the administration. Soon, hierarchical management departments and administrate structures emerge. The new institute then gradually adopts the mode of traditional institutes.

Second, there are a variety of civil or private institutes in the broader society and there are a number of independent research bodies and associations backed by certain universities or institutes. Many of them have the features of a virtual institute. As the institutes pass through their initial stages of growth they often become hindered by traditional concepts and their further development process becomes difficult. However, the virtual institute is becoming a new force in research and is winning more and more attention.

The State Plan for Key Projects in Science and Technology, started in 1982, was a good experience for state organizations and carried out key projects in industrial technology. The State's success in extracting petroleum gas and in taming the mouths of the Yangtze and Zhujiang rivers is a good example. As a further example, the central government approved a project for the management of low-yielding fields on 5.5 million hectares of land in the 43 counties of the four provinces of the Huag-Huai-Hai area. In this project, the Chinese Academy of Science (CAS) organized 2,000 people from 23 institutes and sent them to grassroots work sites together with technicians from colleges, universities and other organizations concerned with agriculture, water conservancy and meteorology. The boundaries between various departments were broken; manpower, technology, finance and other resources were assembled to solve the variety of problems encountered in the project. Eighty-five items of technology transfer were achieved within five years and brought about obvious results in the economy, society and ecology. Organizing researchers from multiple subjects, and from across departments, to carry out the projects in a reasonable way is not merely a means to solve scientific problems but is also an effective way for China's industry to increase its ability to compete with the world.

The State High Technology R&D Plan (863 Plan), starting in 1986, attempted new approaches to the management of high-tech R&D projects. Under the guidance of the government, responsible units and experts from all over the country were selected and entrusted with responsibilities based upon the optimum allocation of their knowledge, experience and skill. These experts organized nearly 2,000 cross-department teams. The experts were academicians, professors and young technicians. They worked together in the same team regardless of the titles or positions they held in their original units. These teams provided the organizational experience of the virtual institute under the auspices of central government. Another example was the project team for underwater robots, which was organized on the basis of cross-department cooperation by the Shenyang Automation Institute, the Metals Institute of CAS, the Changchun Institute of Applied Chemistry, the Institute of Acoustics (Beijing), 702 institutes of China's Shipping General Corporation and Shanghai Communication University. For over ten years, cooperation of the above organizations has formed the basis of the virtual team for the development of underwater robots. The team has had to work across subjects, departments and regions; it also trained China's first high-level interdisciplinary group in this field. The first 300 metre and the 1,000 metre robots were developed for the first time in China; and the team finally also succeeded in making the world's first 6,000 metre underwater robot. These researchers worked together for a long period but they did not leave their original institutions, where they retained a strong foundation for research and technological support. Though it was somewhat different from the virtual institute discussed above, the experience of the underwater robotics team has profound significance for the reform of scientific management and the training of interdisciplinary researchers in China.

The Centre for Technology Innovation and Strategy Studies (CTISS) is an example of an attempt to develop a true virtual research institute in China. It was set up in 1995 in Beijing. In the Centre's statement of establishment, it was declared that 'the Centre will make use of the support it receives from academic communities, various enterprises and government departments and its broad relations with these institutions, adopting the form of virtual organizations or network structures, gathering scholars, experts and managers from different fields and departments, to organize a research force consisting of members from both social and natural sciences'. Through its own actions the Centre seeks to explore a new mode of operating for scientific organizations.

During the last seven years CTISS has fulfilled or has taken on many aspects of key state projects and has conducted international joint research projects in the fields of high-tech development strategies, resource exploitation strategies, future forecasting, scientific plan evaluation, etc. It has also published high-quality research reports and academic papers. The Centre has the following features:

- It is a virtual institute established on the border of official research institutes. It is not an organization of 'one group of men with two signboards' that has recently become common in China, where most of the researchers on a team come from one single institution.

- It is a research team with resources from both the social sciences and natural sciences.
- It is a multi-fan-style body with a small centre and large network.
- It has fuzzy boundaries for free cooperation.
- It tries to create and improve the new culture of virtual research institutes.
- It encourages its members to have concurrent posts.

Although China has made quite a bit of progress, as mentioned above, there are still a lot of issues facing the country related to the development of virtual institutes. Unless the following changes take place it will be difficult for virtual research institutes to thrive:

- Chinese society has recognized the new organizational mode.
- The authoritarian management structures of research institutes are removed.
- The leaders of the grassroots level research institutes are no longer appointed as commanders of research projects.
- Knowledge itself has won the recognition and respect from society that it deserves and knowledge workers receive rewards appropriate to their true value.
- The level of socialization of the social welfare and security system has increased.
- The 'informatization' of society has enabled convenient circumstances under which people may work efficiently in a variety of different locations (i.e. informatics has progressed to the point where teams of people may work together effectively, even through they may be separated by geographical space and different time zones).

- Effective rules and norms of behavior have been established for people holding concurrent jobs.

- The system of grading people for professional titles has been reformed.

- Objective standards have been implemented for evaluating research results (especially the results of soft sciences and soft technology).

- Conditions have been created whereby virtual institutes are able to maintain long-term and healthy relations with traditional research institutes.

E. Discussion

1.Long-term Influences

1) Apart from some basic scientific institutes, and a few special research organizations, most of the applied science institutes in the future will not remain intact for the long-term (i.e. for periods of several decades). It is also impossible for these institutions and organizations to live on state allocations only. Private institutes, virtual institutes or teams with a core consisting of academic experts or young researchers who are interested in studying new thinking, new concepts and new technology, will become the dominant type of institute in the future.

   Support can be gained from certain institutes, universities or enterprises but virtual research institutes must be fully independent. They can form vital academic groups across the boundaries of countries, regions, departments, enterprises and subject fields that can be established, developed, expanded or dismissed as practical needs change. These efforts will accelerate the revolution of science and technology in the sense of a great interdisciplinary assembly.

2) Electronic information networks may facilitate sharing between individuals and organizations. This sharing function, in turn, assists the dissemination of knowledge and the development of society, making it impossible for human beings to be compared with computers for their speed and accuracy in processing quantitative information. However, as for qualitative or ambiguous information processing and judgement, humans are stronger than machines. With regard to critical decision-making, people, and human factors (including the role of human 'sixth sense'), can never be replaced by machines or technical systems. There are two kinds of infrastructures that need to be fulfilled for the comprehensive development of society, the economy and technology: first, the informational infrastructure based on electronic networks; and, second,

human relationship networks, involving both people and organizations. Virtual institute systems are necessary for forming and improving the 4latter of the two basic conditions.

3) Energetic cells yield continuous creativity. The virtual institute is a new way to facilitate organizational innovation. Virtual research institutes are not meant to replace official institutions. On the contrary, most virtual institutes will operate on the borders of official, established, institutions. Virtual institutes that are successful in their work, and that are good at regulating themselves in the context of fierce market competition, will survive and thrive. The principle of the 'survival of the fittest' will lead to virtual institutes with the ability to cope successfully with change and to maintain creativity in their work. The existence and eventual development of thousands of these virtual institutes will help to provide a bottom-up renewal of traditional research institutes. Virtual institutes help accelerate the metabolic processes and increase the 'immunity' to attacks from organizational 'viruses' of traditional institutes. Together with these virtual institutes, virtual universities and virtual enterprises, China's virtual institutes join the country's innovation movement and help to create numerous opportunities for knowledge creation and the creation of technological enterprises.

2. Fierce Challenges

1) Conceptual change is one of the greatest challenges facing any group of people. China has not yet created the mechanisms for adequately investing in 'human beings'. Most people have trouble accepting even the mere concept of the virtual institute, let alone engaging in serious study of the essence of virtual organizations. Even virtual institutes in China, whose achievements are worthy of praise, find it difficult to apply for government projects without 'borrowing' the name of another prestigious established research organization or of one of the state-owned research bodies. When people talk about 'virtual' organizations, many - including those who advocate organizational innovation and the concept of 'advanced organizations' - still pay undue attention to matters of organizational scale, administrative rank and formal power. Their immediate consideration tends not to be how many results the users or markets might adopt. Rather, when looking at the virtual research institute, they simply say, 'Oh, yours is empty!'

2) Virtual institutes need to challenge authorities, superstructures and bureaucracies. 'Organizations' consist mainly of human beings. Significant changes to organizations (including changes to research institutes) frequently arouse people's sensitivities and evoke opposition because the changes touch everyone's interests as well as the authority structures in each department.

Therefore, misunderstanding is natural and innovations often meet with resistance.

3) In order to maintain its research orientation a virtual institute needs an appropriate level of funds. Virtual institutes cannot rely on state allotments. To follow the road of consistent research, virtual institutes need to solve the centrally important problem of finding funding support. If virtual institutes do not want to become 'scientific' labour hands, they must work hard to win the trust of users by producing excellent results and by obtaining somewhat stable support from relatively stable users of their research.

4) It is necessary to develop new concepts for evaluating research achievements. This should be combined with the reform of scientific research systems and personnel management within research organizations in China. The traditional system of grading professional titles must be thoroughly changed for the purpose of freeing promising researchers from the ties of 'titles' and to encourage them to engage in creative research activities in a substantial way. China has a long way to go in developing virtual institutes. However, nobody can stop the trend of this development. The virtual research institute is an organizational revolution started by the revolution of technology.

Virtual research institutes are an example of an institutional innovation in soft technology. Virtual research institutes are also the essential 'soil in the ground' from which the future 'trees' of soft technology will grow.

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