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The Evolution of Technology

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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.

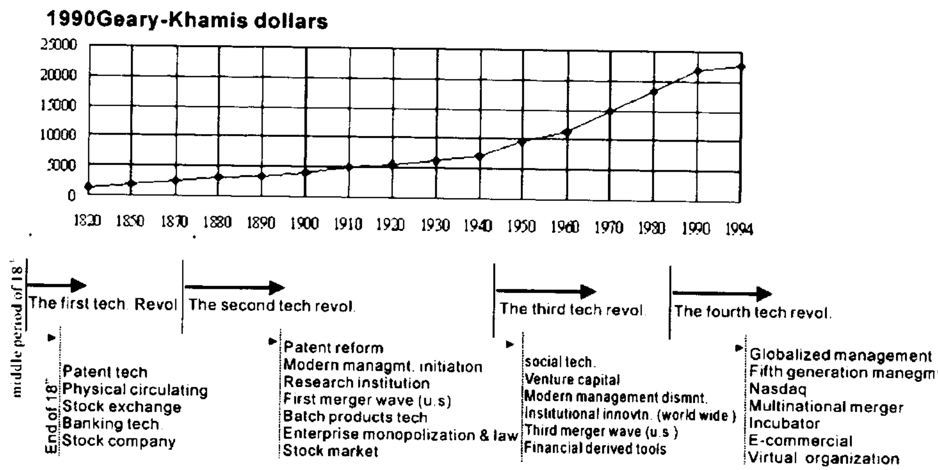
Table 1: Increase of Average Human Life Expectancy

Historical Periods	Average Life Expectancy (years of age)
Bronze Age (2000 B.C.)	18
Ancient Roman Period (500 B.C.–A.D. 400)	29
Renaissance Period (Fifteenth century–Sixteenth century)	35
Eighteenth century	36
Late nineteenth century	45
1920	55
1980	62.7
1985	61.74
1990	65.52
1992	65.9
1995	66.43
1996	66.71
1997	66.7

Sources: Statistics of the Bronze age (1920) come from *A Handbook of Population* by Liu Hongkang and Wu Zhongguan, from the Southeast Finance Economy University Press. The statistics of 1980–1997 came from the *International Yearbook of Statistics* (1998 edition) and the *International Yearbook of Statistics* (1999 edition) by Liu Hong, China, Statistics Press.

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



*Sources: JZY/CTISS/1997.10, statistics from:[26 27]

** Geary-Khamis dollars is the standard currency measured with the Geary-Khamis conversion factor.

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.

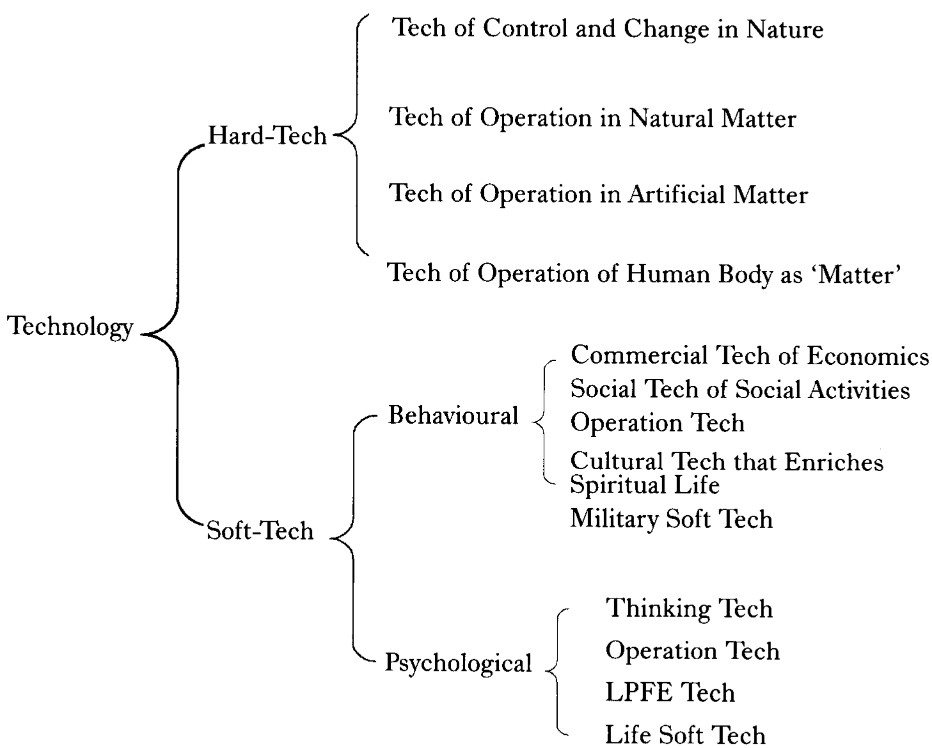
Technologies derived from sources other than the physical sciences and physical contexts are certainly different from traditional technologies; in this book they are applied to the field of soft technology.

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



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

	Category	Contents
1	Sources of Knowledge	*Scientific Knowledge and Non-scientific Knowledge *Knowledge of Natural Science and Non-natural Science *Innate Knowledge and Acquired Knowledge
2	Character of Knowledge	External Knowledge and Implicated Knowledge
3	Holder of Knowledge	Organization Knowledge and Individual Knowledge
4	Form of Knowledge	'Knowledge of why', 'Knowledge of what', 'Knowledge of how to do it', 'Knowledge of who', 'Knowledge of who can help', 'Knowledge of when', 'Knowledge of which place is the best.'
5	Level of Knowledge	Local Knowledge and International Knowledge

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

(primary / secondary / tertiary industries)

	1970	1980	1987	1990
USA	3/38/59	2.8/36/61	2.1/31.4/66.5	1.9/31.6/66.4*
Canada	4.4/36.5/59.1	4.2/36/59.6	3.0/33.6/63.4	2.7/31.8/65.5
France	5.4/40.1/54.5**	4.8/38.6/56.5	4.1/33.8/62.1	3.9/33.3/62.7
Germany	3.6/55.8/40.6	2.3/48.1/49.6	1.7/44.2/54.1	1.4/42.5/56.1***
Italy	8.5/45.2/46.3	6.1/41.4/52.5	4.4/36.5/59.1	3.5/36.5/60
Britain	2.7/44.2/53	2.2/42.8/55.0	1.9/37.1/60.9	1.86/35.8/62.9

Sources: *International Statistical Yearbook* by Gong Feihong: *1992, **1977, and***1991.

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

	Primary Industry	Secondary Industry	Tertiary Industry
1889–1899	25.8	37.7	36.5
1919–1929	11.2	41.3	47.5
1953	5.9	48.4	45.7
1955	5	38.3	56.7
1960	4.3	38.2	57.5
1965	3.7	38.1	58.2
1970	3	38	59
1980	2.8	36	61.2
1985	2.3	33.1	64.6
1987	2.1	31.4	66.5
1990	1.9	31.6	66.4
1994	1.7	22.45	75.85

Sources: 1) The statistics of 1970-87 are from the world statistics of the World Bank.
2) The statistics of 1953-65 are from the American Historical Statistics — calculated by the GDP structure (price of that year) from the colonial period to 1970 and edited by the American Census Bureau. The three industries include excavation, manufacture, construction and electric power.
3) The Abstract of American Statistics, ed. by the US Department of Commerce.

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]

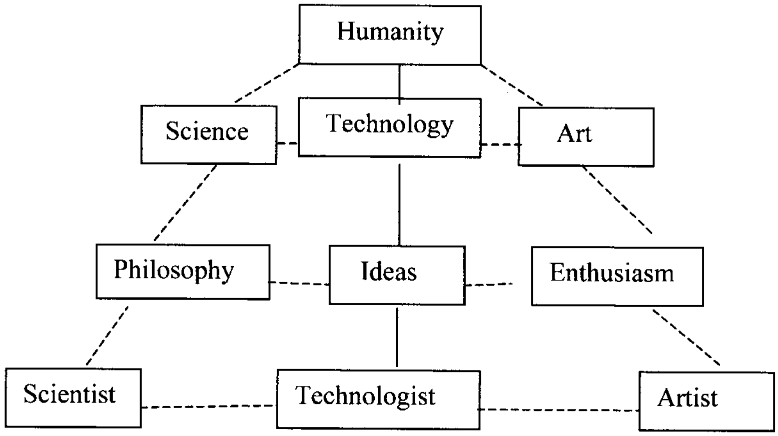
Since the middle of the nineteenth century, the dichotomies in the ways in which humanistic scholars and natural scientists look at the world have become wider. Humanistic scholars have tended to lack interest in natural science and technology and, therefore, have lacked knowledge of natural science 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



Sources:[53]

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.

Notes

1. Naisbitt, Naisbitt and Philips, *High Tech, High Touch: Technology and Our Search for Meaning.*
2. Joy, 'Why the Future Doesn't Need Us', *Wired,* April 2000.
3. Gan Tairoku and Hiromasa Naohiko, *On Technology.*
4. Hondasyuro, Technological Anthropology.
5. *ibid.*
6. Song Jian (ed.), *Essentials of Modern Sciences.*
7. Hondasyuro, *Technological Anthropology.*

8. *ibid.*

9. Jantsch, *Technological Forecasting in Perspective: A Framework for Technological Forecasting*, p. 15.

10. Williams, *A History of Technology*, vol. 6.

11. Website www.hazelhenderson.com

12. Yuhikaku, *Yuhikaku Dictionary of Economics*, p. 88.

13. *Concise Encyclopaedia Britannica*, vol. 4, p. 233.

14. *The Strategy for Technology Toward 2000.*

15. *Diction Resources*, p. 0658.

16. Dong Guangbi, *The History and Prospect of Chinese Science Modernization*, p. 59.

17. *Modern Chinese Dictionary*, p. 533.

18. Yuhikaku, *Yuhikaku Dictionary of Economics*.

19. Willoughby, *Technology Choice: A Critique of the Appropriate Technology Movement.*

20. Gui Shou, *Chinese Macro-economy Information Web*. 2000.11.3. http://www.macrochina.com.cn/info.shtml

21. 'The aim of Chinese software industry', *Science and Technology Daily*, 2002.11.29.

22. Gui Shou. 2000.11.3 http://www.macrochina.com.cn/infor.shtml

23. Jones, *Was an Industrial Revolution Inevitable? Economic Growth Over the Very Long Run.*

24. Jin Zhouying. *Technology Driving Force - The Principle of Harmony and Balance* http://www.skyrme.com/updates *I3UPDATE*, 1997.10; World Forum 1999 San Francisco, 1999.10; AI & Society MS 193, 2001.

25. European Patent Office. Ministry of Science and Technology International Cooperation of China ed. quote from Christoph-Friedrich von Braun,'The innovation War'Beijing, Machine Industry Press,1999.5

26. Maddison, *Monitoring the World Economy, 1820-1992.*

27. *The volume of historical economy statistical data for Soviet Union and the main capitalism countries (1800-1982).*

28. Federal Funds for Research, *Development and Other Scientific Activities*, vol. XXVI, p. 51.

29. Wei Yong, *Nature and Trends of Social Science.*

30. Misumi Jyuji, *Introduction of Social Technology.*

31. Helmer-Hirschberg, *Social Technology.*

32. State Science and Technology Commission. *Chinese Science and Technology Index*, pp. 246-68.

33. Kusaka Kimindo, *The New Culture Industry.*

34. *Encyclopaedia China. Sociology,* p. 409-18.

35. *The Comprehensive Dictionary of Chinese Language*, p. 1731.

36. *Encyclopaedia China. Sociology.*

37. Popenoe, *Sociology.*

38. Li Yining, *Economic Culture* from *A Probe into Cultural Economics*, issue 4.

39. *ibid.*

40. Ji Sha, *The Thinking for The Future Medicine.*

41. Liu Tianjun, 'Experimental Science and LPFE Science-A Comparison of the Methodology of TCM and West Medicine', *Journal of Basic Chinese Medicine Journal*, 1996.2, vol. 2-1.

42. Qiu Hongzhong, *On the Scientific Spirit and the Humanistic Methods of Chinese Traditional Medicine*. 2001.9.

43. Jin Zhouying, *Technology Driving Force The Principle of Harmony and Balance,* AI & Society MS 193, 2001.

44. Hondasyuro, *Technological Anthropology.*

45. Kurihara Siro, *Technology Philosophy for the Future.*

46. Jin Zhouying, 'To View Knowledge Economy from Another Angle'. *Science and Technology Daily,* 14 November 1998.

47. Yuhikaku, *Yuhikaku Dictionary of Economics*, p. 427.

48. Aoki Ryozo, *New Industrial Theory*, Japan Economy Wire Agency, 1987.5.

49. *The Comprehensive Dictionary of Chinese Language.*

50. *Concise Encyclopaedia Britannica,* vol. 7, p. 644.

51. Bernal, *Science in History*, pp. 338-9, 767-8.

52. Hondasyuro, *Technological Anthropology*.

53. *ibid*.

54. 'The Future of Entertainment Technology', *Nikkei Science*, February edition, 2001.