Translation

This lengthy study by the government of the city of Shenzhen in southern China is an example of China's meticulous open-source research on international technology transfer institutions. The study's authors acknowledge that Shenzhen has a weak research base and relies heavily on technology transfers to grow its tech sector. The study proposes creating an "international technology transfer center" in Shenzhen, one that focuses as much or more on tech transfers within Shenzhen and within China as it does on importing foreign technology.

Title
A Study of Shenzhen's International Technology Transfer Model and Measures to Improve it
《深圳国际技术转移模式及对策研究》

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A Study of Shenzhen's International Technology Transfer Model and Measures to Improve it

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Introduction

In today's competitive global economy, scientific and technological (S&T) innovation has become the interface between social and economic demands and knowledge producers. Society is increasingly dependent on specialized technology and new institutional forms such as technology centers, networks, incubation bases and clusters. Implementation of S&T innovation policy requires education, training, recruitment, research and development (R&D), and cooperation, which are the main factors in the development of high-tech industries. As stated in the *National 12th Five-Year Plan on Science and Technology Development*, we must "promote construction of international S&T cooperation bases, regional S&T cooperation centers and cooperation demonstration parks, and foster a number of intermediary service institutions engaged in international technology transfer business; and we must actively promote private international S&T exchanges and cooperation." The trends now are integration of innovation resources through open innovation and internationalized R&D, integration into global innovation networks, and participation in global competition.

Given the structural adjustment and upgrading facing the development of Guangdong's industrial economy, there is a greater need to promote the transfer, adaptation, development and application of technology to drive and promote transition to the high end of the industrial value chains. It is necessary to put the factors for scientific innovation first, implement industrial restructuring and a forward-looking strategic layout, and achieve a paradigm shift for new types of industries. Seen in terms of experience in international S&T cooperation, integration of S&T resources is the direction in which S&T cooperation is heading. Technology transfer in particular can guide and promote the combining of innovation achievements with industrial capital, accelerate the pace of industrialization, and promote the commercialization of innovation achievements, thereby promoting the improvement and accelerated development of the overall innovation capacity of industry and achieving the rapid rise of S&T strength. As in other parts of the world, the need for international technology transfer centers comes from economic considerations. The need to establish an international technology transfer center originates in the underutilization and limited development of S&T in the Guangdong Province region.

To build the Shenzhen International Technology Transfer Center, Shenzhen must strive to maintain its S&T edge as benchmarked against international competitors, as well as establish international S&T transfer institutions in industrial, technology and engineering fields; and it must also establish links between academic institutions and R&D centers, and between potential funding and projects based on creativity and innovation. It must demonstrate successful practices in innovation aspects within a worldwide scope, and form networks linking research centers with industry, and potential funders and with owners of creative ideas and projects.

Primary tasks of the Shenzhen International Technology Transfer Center

1. Promote balance in the supply and demand of S&T innovation, based on considerations of regional cooperation and development requirements;
2. Consolidate the components of the knowledge-based economy and their relationships, develop network matching and new institutional forms, develop and disseminate key technologies, and promote social and economic development;
3. Raise the S&T innovation awareness of the public and private sectors;
4. Implement programs for planning or drafting government S&T innovation policies, and encourage more spending on S&T innovation programs using a results-based budgeting approach; and
5. Improve international cooperation on technical innovation.

Part One: Current State and Trends of International Technology Transfer

I. The meaning and categories of international technology transfer

1. Meaning of international technology transfer

The technologies that a nation requires come from internal and external sources. The former refers to technologies derived from the country's own R&D, while the latter refers to technologies derived from technologies introduced from other countries and regions. Since the beginning of technology production, technology has always been transferred and disseminated between regions or nations. Since 2000, as science and technology have developed, they have played an increasingly important role in human lives, especially in economic activity. Of course, the international transfer of technology has become a phenomenon of great concern to people, the main reasons being: First, the current revolution in new technology (the fourth technological revolution) has microelectronics technology at its core, with bioengineering technology, electro-optical technology, new materials, and new energy technology as main elements. This technology revolution has caused the traditional resource endowment-constrained international division of labor to develop into an international division of labor in which available advantages (可以优势) are the dominant factor. This international division of labor is not static or unchanging, but rather changes constantly with the establishment or loss of technological advantages. The transfer of technology in the new international division of labor pattern has accelerated the dissemination of S&T, and the rapid development of international technology transfer has strongly promoted to the development of national economies. Both suppliers and recipients of technology have obtained enormous economic benefits. As a result, technology today is becoming an increasingly powerful force driving economic development. Second, a nation's comparative advantages in natural endowment and in S&T are not set in stone. International flows of factors of production (生产要素) can not only change a country's comparative advantages in technology, but can also change, to a certain degree, natural endowment-based comparative advantages. Through investments in scientific research and education, and the introduction of technology, a nation can change its comparative advantage in S&T, or create comparative advantages, and it can also create new comparative advantages on the basis of existing comparative advantages. According to the principle of the division of labor and trade in comparative cost theory, whereby "areas of greatest comparative advantage and least comparative disadvantage are selected," the one with a relative technological advantage exports, and the one with a relative technological disadvantage imports. Relative advantages between nations are constantly changing with the development and exchange of technology. That is to say, the levels of S&T development among countries in the world are unequal, and even the most developed countries in the world may have blind spots in some areas. Nor is it possible to lead in all areas, and technological areas that are in leading positions may not always be in the lead. At the same time, even developing countries with lower levels of S&T development can be ahead of advanced countries in some fields. The acceleration of S&T and economic development through the introduction and export of technology is one of the underlying trends and strong currents of the international economy. In consequence, whether they are advanced or developing countries, none can pursue economic development without technology transfer. Third, today's extremely developed means of communication and convenient transportation create good conditions for international technology transfer, making the transfer of technology between nations more rapid and convenient, and transactions more frequent. Finally, science and technology are wealth shared by all of humanity, but it is only through transfers in the service of all humanity that they can fully play their enormous role. There is no doubt that as the globalization process unfolds, an increasingly important strategic choice is to draw upon the various pathways of international technology transfer to strengthen the international technical cooperation of one's own enterprises, region, and country, in the hope of using limited resources efficiently, highlighting core competitiveness for enterprises and regional economic development, and highlighting the strategic resource positions of one's country and region. It is precisely for this reason that the study of technology transfer is still growing in China and abroad. Exploring the implications and characteristics of technology transfer will help us recognize the fundamental laws of technology transfer, and thereby better serve the development of the economy.

1.1 Meaning and characteristics of technology

Before discussing technology transfer, we need to first clarify the target subject of transfer—technology. The word technology comes from the Greek word tekhnologia, which means the systematic understanding of an art or craft, and is the systematic exposition of its artistry.

However, when it comes to defining what technology is, people have a number of different interpretations. In different fields of study in particular, the meaning of the word technology is different: In sociology, technology refers to the scientific knowledge that people within a specific society and specific period of time use to solve problems faced in the society's development; in economics, technology is defined as effective combinations of factors of production (capital and labor); in S&T and engineering fields, technology refers to specific applications of scientific knowledge in production activities; and in the business literature, technology is regarded as a means of converting scientific knowledge into products.

The definition of technology in this report is: Technology refers to the systematic knowledge of people, in practical activities, for manufacturing a product, applying a process or providing a service. Technologies can exist in written form, and they can also exist in people's minds or in machines and equipment. Technology exists in fields such as production, management, sales, finance, accounting and scientific research, and it includes technical solutions, designs, practical experience, and skills.

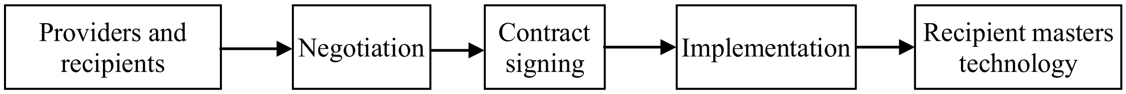
Characteristics of technologies: First, a technology is a good and has the properties of goods, namely, it possesses value and use value. As a result, technologies can circulate on international markets for goods, and under certain conditions are transferable or licensable. Second, a technology is knowledge that has been invented and created in, or gleaned from, actual practice by humans, and has been proven in production practice to be scientific, implementable, and able to generate economic benefits. Third, technology being knowledge, it can be imparted. People can master technologies through teaching and learning, and can use them in practice, in order to obtain desired economic benefits and achieve expected objectives. Fourth, technology is immeasurable, in that it cannot be measured using quantity, weight, area, volume, etc. Hence, the use value and quality of a technology itself can only be measured and identified using indicators such as areas of use, output, product quality, and the economic benefits generated.

1.2 Meaning of international technology transfer

The technology transfer concept, which was initially an important strategy for resolving the North-South problem, was proposed and discussed at the first United Nations Conference on

Trade and Development in 1964. At the conference, the import and export of technology between countries was collectively called technology transfer. In the UN Draft International Code of Conduct on the Transfer of Technology, technology transfer was defined as "the transfer of systematic knowledge for the manufacture of a product, for the application of a process, or for the rendering of a service," but does not include transactions only involving the sale of goods or only involving leasing. Technologies are a kind of intellectual product. They have different vehicles (载体), and they may exist in people's minds or they may be expressed in writing or coalesced within machinery and equipment. Consequently, technology transfer can be the buying and selling of a software technology, or the employing of technicians with mastery of the technology, or the purchasing of machinery and equipment containing the software technology. In other words, this definition specifies that the target of technology transfer is the software technology, whereas a pure transfer of hardware without any software technology does not fall within the scope of technology transfer. The definition does not make a specific interpretation of "transfer," however. Scholars in China and abroad have given various interpretations of technology transfer, which can be divided into seven perspectives according to their differences in emphasis: 1. The transfer and distribution of knowledge and know-how interpretation. This perspective holds that technology transfer is the transfer and redistribution of technical knowledge. There is the definition of Japan's Tatsuya Kobayashi, for example: Broadly speaking, technology transfer is the redistribution of human knowledge resources. 2. The application of technical knowledge interpretation. This views technology transfer as being the widespread application of technology within society. There is Dr. Frank Jinleis's (弗兰克晋雷斯) definition, for example: Technology transfer is the socialization of research results, including their extension domestically and abroad. 3. Geographical and domain transfer interpretation. Scholars holding this view believe that technology transfer is a geographical transfer and the transfer of the domain to which a technology belongs. For instance, as one American scholar has put it: When scientific technical information generated and used in one field is further improved or applied in another field, this process is called technology transfer. 4. Link transfer interpretation. This perspective maintains that technology transfer is a sequential development process where technical information goes through a series of stages and a series of links. Chinese scholar Lin Huiyue (林慧岳), for example, believes technology transfer to be the directed flow of technology and knowledge, and their vehicles, between the three links of invention, innovation and diffusion, in technological activities. 5. Technology vehicle transfer interpretation. This perspective holds that technology transfer is just the transfer of vehicles. 6. Cooperation of different agents interpretation. This actually defines technology transfer from an agent perspective, holding that technology transfer is the process of technological factors flowing between different agents, which process has two characteristics: First, there are different agents, and second, there is cooperation between agents. 7. Flow of technology goods interpretation. This defines the transfer of technologies from their properties as goods, and argues that technology transfer is the process of technological achievements flowing as goods between different owners. In fact, there is another perspective apart from these seven that is rather representative, and which can be called the digestion and absorption interpretation. This perspective maintains that technology transfer refers to the movement of technical knowledge and the machinery and equipment transferred with the technology, and also refers to the complete process of a technology's acquisition, absorption, and mastery in new environments.

Figure 1 A simple flowchart of technology transfer



As for technology transfer in the general sense, it refers to the process in which technology moves from providers to recipients. Its emphasis is on an interactive process between the provider and the recipient, and this process does not end until the recipient obtains the technology. It can also occur between different fields (see Figure 1).

2. Classification of international technology transfer

2.1 Vertical and horizontal transfer

Based on the direction of technology transfer, international technology transfer can be divided into vertical technology transfer and horizontal technology transfer. So-called vertical technology transfer refers to the transmission of a technology from researchers to developers, and then to producers (research ⟶ development ⟶ production). It progresses continuously along the stages of invention, innovation, and development, and is further commercialized at each stage passed through. Vertical transfer can be carried out within an organization, and can also be a transfer between, for example, a research institute and a manufacturer.

Mansfield (1988) argued that the purpose of technology transfer is to expand the effect of a given technology. He divided into three stages the process of expanding the effects of a technology: basic science technology, applied technology, and commercial production technology. A technology's effect is expanded sequentially in the three stages. Hence, so-called vertical transfer refers to where providers "graft" R&D accomplishments in basic S&T fields to the recipient's applied S&T, gaining opportunities to expand the effects of the scientific research accomplishments, or where providers apply applications of S&T accomplishments to the actual commercial production of recipients, causing them to form international productivity, and similarly serving to expand the effects. Furthermore, vertical transfer is not necessarily the transfer of technology from high to low, from top to bottom, or from developed countries to developing countries.

So-called horizontal technology transfer refers to the transfer of an established technology from one operating environment to another (one kind of operating environment ⟶ another kind of operating environment). As the technology has already been commercialized, the purpose of the transfer is to diffuse the technology so that it is applied to other areas. A company adopts this form of transfer when it wants to maximize the returns from a technology but is unable to sell the final product on the market. Transfers of technology from industrialized nations to developing nations are often horizontal transfers.

Mansfield (1988) believed that horizontal technology transfer was where a provider of a technology that has already been applied in practice transplants it directly to a technology recipient, and the technology is utilized on the recipient's side to carry out production. The implicit premise here is that the technology recipient did not previously have that technology, and the technology can be applied directly after it is obtained, which is a sort of "taking in" (“拿来主义”) doctrine.

Since in horizontal technology transfer the technology is typically not modified, slight changes are perhaps made only in order to adapt it to the recipient's local conditions or environmental protection requirements. If some alteration of the technology is desired, it is necessary to combine vertical and horizontal technology transfer.

2.2 Commercial and non-commercial technology transfer

International technology transfer can be divided into two types according to whether or not transfers are realized by means of market transactions. One type is commercial technology transfer, that is, compensated technology transfer where it is necessary to pay a certain fee. The other type is non-commercial international technology transfer, which is usually a kind of uncompensated technology transfer where it is not necessary to pay a transaction fee.

There are two important kinds of channels for international technology transfers carried out through markets:

2.2.1 Commercial technology transfer

International trade in technology carried out through technology markets. International trade in technology can be defined as the exporting or importing from an organization (private or public) of a technological component that meets a special need or market opportunity. That is, it is the act of buying and selling technologies by the technology supply and demand sides on general commercial terms, and is therefore also called compensated technology transfer or technology assignment. With regard to individual countries, their roles in technology trading are the engagement in technology exporting and technology importing activities, respectively.

International trade in technology is an important component of international trade, in which trading activity is carried out with technology serving as goods. International trade in technology is closely linked to international merchandise trade, and there is a mutually reinforcing relationship between the two.

In addition, there is also international technology transfer carried out by means of commercial contracts with technical components, including:

(1) Purchases of technical equipment.

(2) Carrying out foreign direct investment (including joint ventures) and establishment of factories with accompanying technology.

(3) Establishment of technology, equipment, or enterprise proxy agencies.

(4) Conclusion of technical or commercial consulting contracts.

(5) Manufacturing industry subcontracting contracts, processing trade contracts, etc.

2.2.2 Non-commercial technology transfer

Non-commercial international technology transfer refers to the transferring or diffusion of technology by means of government assistance, human resource flows, exchange of technical information, scholarly exchanges, technical missions, etc. Channels include the following:

(1) Technology transfer effects generated by transactions that are not for the purpose of technology acquisition, where the most important thing is that the technologies contained in the merchandise in international trade transactions can be diffused as a

result of trade.

(2) Technology exchanges, including:

- Obtaining technology through such paths as overseas visits, missions, study and work;
- Obtaining technology through international academic conferences, technology seminars, collaborative research, and the employment of foreign experts;
- Obtaining technology through observation and study at international exhibitions, demonstrations, and trade fairs;
- Obtaining technical information, etc., through access to professional literature, technical publications, and technical reports;

(3) Obtaining technology through public information sources, such as radio and television, the internet, and newspapers and magazines; and

(4) Obtaining technology through international technical assistance. The motivations for assistance include political, military, and economic objectives. In these kinds of circumstances, the provider-side government provides preferential or uncompensated technical assistance to the recipient-side government or enterprises.

3. Methods of international technology transfer

3.1 Import-export trade

3.1.1 The technological content of merchandise trade

In contemporary societies in which technology has become the main well-spring of economic growth, the technical content of production inputs is very important. Technology can come from two sources: in-house development or acquisition from outside the enterprise. External acquisition can be further divided into overseas acquisition and domestic acquisition outside the enterprise. In the absence of trade, immigrants with technology are the main pathway of technology transfer. When there is trade, on the other hand, the pathways for international technology transfer are expanded.

Goods are important vehicles of technology, and trade in merchandise becomes one of the important methods of technology transfer. Naturally, international merchandise trade involves countless goods, and the technology contained in various kinds of products differs in terms of the types, characteristics, levels, etc. The technology contained in ordinary bulk commodity transactions is more widespread, and the technology contained in consumer products is more often product usage technology. More important for technology transfer is the transfer of manufacturing and production technology. Therefore, international trade in new products and capital goods plays a greater role in technology transfer.

Generally speaking, there are two important aspects of technology transfer in relation to international merchandise trade: One is that, with trade in new products and capital goods, new technologies may be contained within the traded merchandise, and importing various new and different products or capital goods can result in the transfer of the technology within them. The second is that, in the flow of technical information in the trading process, when merchandise is exported to buyers with technical knowledge, product designs and production techniques are circulated, and the related technologies can also be understood and studied.

Importation is an important method for acquiring technology: In all countries except Japan, the share of technology acquired through importation has been increasing year by year. In terms of intensity, apart from the United States, Germany, and Japan, imported technology is more important than domestic technology. The percentage of technology purchased abroad is smaller among large countries than among small countries, with small countries relying on imports for more than 50% of technology acquired. The United States is the most important source of technology for all countries.

The continuous growth of the technical content in trade is related to the following three interacting factors:

(1) The degree of specialization of high-tech products is increasing, which is a necessary consequence of technological progress.

(2) Enterprises are expanding their markets through exports in order to recoup R&D costs, and the intensity of export competition forces them to increase the technology content of products, raise quality and lower costs.

(3) The internationalization of production has promoted intra-enterprise trade within international trade. Trade carried out internally between parent companies and subsidiaries is growing, and the internal technology transfers of enterprises often involve greater technology content.

Although the specific roles of each of these three factors are not very clear, they help in understanding why imports are more important for some sectors, as well as why there are different forms of technology transfer between different trading partners.

3.1.2 Import-export trade and technology spillovers (溢出)

Sometimes, technology transfers are the "by-products" of other economic activities. This is especially typical when technology is contained in imported (capital) goods. International technology spillover refers to where technologies are disseminated to other countries directly or indirectly (e.g., through trade), thereby allowing the producers of other countries to gradually master those technologies.

As practice has shown, adoption of overseas technology is a precondition for industrial development. Although a certain amount of costs will be paid due to copyrights and patents, there is still a "free rider" effect for the countries adopting an overseas technology, because they can avoid the innovation costs invested in their research. Theoretically, at least, this facilitates convergence in growth rates between technologically leading countries and free-rider countries (followers).

Coe and Helpman (1995) maintained that trade is a major pathway for technology spillovers, expressed mainly in four ways:

(1) International trade allows a country to use a variety of intermediate products and machinery and equipment, which may be different or complementary.

(2) International trade has provided pathways for studying production methods, product design, management models, and market conditions across national boundaries. These help promote the effective use of domestic resources and

adjustment of product portfolios for greater output per unit of input.

(3) International trade allows other countries to replicate technologies and adapt them for domestic use.

(4) International trade can boost the efficiency of a country's development of new technology or imitation of other countries' technology, thus affecting its entire national economy.

3.1.3 Advantages of acquiring technology through import-export trade

(1) It permits the fastest acquisition of existing technologies. One characteristic of production inputs such as equipment and software is that they have embedded technology. Technology is present in them in hidden forms, and the hidden technology in them is acquired at the same time as such equipment is acquired. That is to say, the process of importing the merchandise is simultaneously a process of obtaining technology. This process is often much faster than the technology trading process, however, because the technology trading process requires that an understanding be reached on all of the technical details before a deal is completed, whereas obtaining technology by importing products puts the understanding of technical details after the transaction is completed. Of course, obtaining technologies is not the same as mastering technologies, but if the importers or users of imported goods have the technical abilities that those technologies require, they can quickly master those kinds of technologies.

(2) Sellers may provide training. In equipment and software trading, it is often the case that the seller provides corresponding technical training to help buyers learn how to use the technology contained in the products. This is determined by a product's characteristics and by market competition. If buyers do not understand the technology, and the seller also does not provide technical training, the buyers will not purchase the equipment or software. Providing related technical training becomes a strategy and means of marketing and export expansion for the seller. Buyers, on the other hand, can learn and master the technology more quickly by means of the seller's technical training.

(3) The path to production and profitability is faster and less risky. Technologies that can be embedded in products are basically already mature, or at least the main problems in applying the technologies have been resolved, so technologies obtained by importing equipment and software can be put to use immediately. Moreover, since it is equipment and software containing the most advanced technologies that is imported intentionally, using those technologies can therefore improve production efficiency, increase output, and reap more profits. And precisely because those technologies are already mature, the technical risk is small, and economically they can reduce R&D costs and raise production efficiency.

(4) Imported equipment and software provide a basis for technological innovation at a higher level. If the introducing company has the corresponding innovation capacity, it can improve and innovate, and in general, the cost of such innovation is much lower than where internal development is relied upon for all technologies, because the formation of new technologies requires a large amount of risky investment with

typically low rates of success. Introducing technologies and mastering them means it is possible to save the cost of the previous R&D, and it allows an enterprise to have a high starting point for its technological innovation.

Introducing machinery and equipment means easy installation and faster commissioning and formation of production capacity, and the risk is smaller compared to purchasing patents or proprietary technology. There are also drawbacks to acquiring technology through merchandise imports, the main ones being: New equipment may not be suited to an enterprise's existing environment; purely introducing technical equipment cannot fundamentally improve an enterprise's technical capabilities. If the importing enterprise does not have the corresponding technical innovation capacity, or the enterprise cannot innovate in a timely fashion, then in order to keep up with changes in the relevant technologies, it may be forever updating its technology by importing equipment. The contribution of this kind of introduction method and structure to improving production capacity is great, but its contribution to improving technical levels is not significant.

3.2 Trade in technology: technology licensing and franchising

3.2.1 The international technology market

Technology has both public and private characteristics. As with production processes, some technologies have highly idiosyncratic components, and their privately owned components can be sold. It can be understood in this way: Apart from the introduction of shared technology in the public domain, technology is a kind of private property that can be traded as goods by means of technology markets. Like other goods in international markets, technologies as goods have value and value in use.

The value in use of a technology good is expressed as the utility for production or life brought about by the use of the technology. The application of technology can satisfy society's demand for the constant development of material production activities; application of technology can satisfy the demand to greatly improve labor productivity, save labor, reduce consumption of materials, and save materialized labor (物化劳动); and application of technology can satisfy demands of humans for fewer inputs and greater output, given the limits of the Earth's environment and conditions for human survival. The value of a technology good is expressed as the physical labor that is expended on or embodied in the technology good, and the mental and physical labor of researchers consumed in the course of developing the technology.

However, technology goods also have a number of other characteristics that differ from those of ordinary goods in international trade, leading to the emergence in international trade of a specific area—international technology trade (or international trade in technology). So-called international trade in technology refers to the buying and selling of technology internationally by technology suppliers and demanders according to general commercial principles. The act of providing technology goods to foreign buyers is technology exporting, and the act of purchasing technology goods from foreign technology providers is technology importing.

The narrow concept of a technology market is that of a place to carry out the exchange of technological achievements as goods. The broad concept of a technology market is that of a domain for the circulation of technological achievements, and is the sum of the technological achievement exchange relationships. The exchange relationships of technology markets are mainly relationships between the producers, operators, and consumers of technological achievements.

Technology markets are different from markets for ordinary physical goods in that they have a specific mode of operation and scope of business, and they involve technology development, technology transfer, technical consulting, technical services, and other related technology trading services.

The international technology market has greater incompleteness compared to international merchandise markets. Specifically:

(1) The international technology market is easily segmented, which is determined by international technology supply and demand relations. Technology development is done mainly for one's own production and use, and sales or transfers are not the main objective, so in technology trading, the buyers usually have the same kind of technology. That is why they are interested in relatively advanced technology in the first place, but international technology market participants must submit to technology class boundary restrictions. The difference in supply and demand objectives between technology and merchandise affects the completeness of these two markets. Generally speaking, merchandise markets are far more complete than technology markets. Because of the relative incompleteness of technology markets, international trade in technology is often established on the basis of long-term technical cooperation relationships, and technology trading contracts are generally long-term contracts with a high degree of continuity.

(2) Monopolistic features of the international technology market. The market for international technology transfers worldwide is still a seller's market at present, especially when it comes to developing countries. In fact, most of the technology transferred to developing countries comes from developed countries. The features of technological monopolies and the nature of traded goods limit the paths for acquiring technology. This gives rise to large differences in the bargaining positions of buyers and sellers compared to those in markets for other goods, even in highly monopolistic commodity markets.

(3) Buyers in the international technology market are in weak positions. The unfavorable bargaining positions of buyers stems from their having very little information about the technology they want to purchase. This is because technology trading and R&D activities are highly correlated, and the degree of technology information openness is frequently very limited. In technology transactions, moreover, it is difficult for buyers to compare the contract terms and conditions that sellers have granted other customers (since those are trade secrets). Hence, unlike in purchasing merchandise, the pricing of technology and the terms for purchasing technology reflect, to a great extent, the monopolistic nature of technology.

(4) In the international technology market, there are no automatic mechanisms for matching with related markets. In particular, there may be a disconnect from the development of markets for the circulation of investment goods and technical personnel matching the technology being traded. It may so happen that an appropriate technology can be purchased on the international technology market, but suitable people cannot be found to use it, or maintenance and repair is very difficult once the

technology is in use.

Despite its imperfection, the international technology market has developed rapidly in recent decades because of the important role that technology plays in economic growth and economic development. According to UN statistics, the volume of world trade in technology, which was only U.S. $2.5 billion in 1965, increased to $11 billion in 1975, exceeded $50 billion in 1988, was $260 billion in 1995, and reached $500 billion in 2000. The volume of international trade in technology has doubled every five years, on average. In terms of the speed of its growth, the trade in general tangible commodities pales in comparison.

3.2.2 Forms of international trade in technology: technology licensing

The main method of international technology trade in technology is licensing. Technology licensing is the transfer between different legal entities (licensor and licensee) of the right to use a technology. Licensing implies that some of the licensor's rights are transferred to the licensee. It usually refers to where a licensor grants a licensee the right to use a technology within a certain period of time and within a certain territory or scope. Technology licensing often occurs during the technology development and innovation process, although research has shown that technology licensing can also occur at the initial discovery and diffusion stages, or at the final stages of a highly developed technological innovation.

Licensing includes formal contracts that specifically stipulate the rights and obligations of both parties to the licensing. The licensee usually obtains access to the relevant technical knowledge (possibly including training), along with the right to use new processes, production, or services. The licensor often stipulates limits on the use of the knowledge or technology obtained. The licensor will usually try to control the diffusion and use of the new technology, at least within a certain time period or region. Apart from restrictions on the diffusion, publication, and sale of knowledge, the use of knowledge for other purposes, or the transfer of knowledge to other unauthorized parties, the licensor will also make restrictions as to markets, regions, sectors, quantity, and quality. The licensor will also make similar restrictions with regard to some special applications or groups. On the other hand, the licensor is responsible for providing the latest knowledge and new technology applications, and often must train and guide the licensee's personnel in how to use the technology.

3.2.3 Forms of international trade in technology: franchising

Franchising consists of a contractual relationship between two parties—the franchisee, whose business is often small, and the franchisor, whose business is larger. The former agrees to produce or sell a product or service according to an overall "blueprint" designed by the latter.

The franchisor provides overall recommendations and support, R&D, and marketing and advertising help. The franchisor grants the franchisee rights and a license permitting the franchisee to participate in the production and sale of the franchisor's products, or to use the business system developed by the franchisor. The franchisee usually pays an initial fee and continues to pay commissions and management service fees, usually based on turnover and the size of the markup allowed by the franchisor.

One feature of franchise operation is that the franchisee must self-finance, a model that separates the financing and distribution systems. Curran and Stanworth (1983) pointed out that the franchisee provides operating funds, and is a legal person that deals independently with the franchisor. That is, none of the franchise-operating enterprises using the same trade name are run by the business owner. The enterprises of the licensees are not branches or subsidiaries of the licensor, nor are they a free association of independent enterprises. They are all independently run enterprises responsible for their own profits and losses. The franchisor does not guarantee the franchisee enterprises that they definitely can make a profit, not does it assume responsibility for the profits and losses of its enterprises.

Another feature of franchising is that many of the franchisees are small-scale chain stores or service enterprises bound by the image and policies of the parent company. In recent years, there has been a more pronounced shift toward service businesses. Franchising may be full business model franchising, including aspects such as franchising of trade names, products or services, physical factories, operating methods, marketing strategies, quality control processes, communication systems, and business services. Trade name franchises and product distribution franchises are relatively numerous.

Franchising allows investors to obtain a successful business model, without having to "cross the river by feeling for stones" (“摸着石头过河”). Plus, the franchisor provides long-term follow-up support and assurance, multiplying investors' rate of success.

3.3 Non-market channels

A considerable part of technology flow takes place outside of technology transfer markets. Technology can be disseminated internationally through several non-market means, and may even be transmitted free of charge. For example, it may be through international collaborative alliances between different international companies or between organizations, migrations of people (skilled labor, research personnel, engineers), information flows (internet, journals, and exhibitions), education and training, technical assistance, etc.

3.3.1 Technical training and labor exchange

The use of any new technology requires having people who understand the technology to actually operate it. After a technology contract is signed or when technical equipment is imported, technical training will be carried out as part of the technology transfer, including in the following situations:

(1) The technology provider in the technology trade makes technical training party of the technology transfer content in order to stimulate demand, and provides the technology recipient training related to using the transferred technology. The technology recipient thereby studies and masters the relevant use and maintenance techniques.

(2) When a multinational corporation (MNC) carries out direct investment, in order to ensure the efficiency of its technology's use in the host country, it will also need to carry out technical training for the relevant personnel. This kind of training will be directed at all levels, and nearly everyone, from the simplest production-type operators to supervisory personnel, and from senior technicians to upper management personnel, will have the opportunity to receive training. Just as [American economist Michael] Todaro has said, MNCs provide a "package" of needed resources, including management experience, entrepreneurial ability, and the transmission of technical skills, to local enterprises in training projects and the "learning by doing" process.

(3) In order to save costs and improve efficiency, MNCs also entrust the processing

production of some product components to host country enterprises in the same industry and related industries. This also requires the transfer and diffusion of production technology to those processing enterprises, helping them improve and increase their technology level, and training their technical workers. This process thus drives the upgrading of the technology structure and product structure of the same industry or related industries.

(4) Technology providers provide various kinds of technical materials related to the technologies transferred, such as product instructions, technical manuals, brochures for business presentations, etc. These are interspersed with all sorts of relevant technical information, from which the personnel of technology recipients can derive clues and insights to further master the technologies.

(5) Under some circumstances, when the transferred technology involves technical know-how or proprietary technology, the technology provider must send technical experts to guide the use and maintenance of the technology. Proprietary technology is a kind of fuzzy knowledge, that is, it is difficult to explain systematically, using clear and formulaic language, or unsystematically. For example: knowledge closely connected to a particular market (or particular country), or expertise in the internal management methods of a particular organization. When the technical experts of providers of such technology come in contact with relevant personnel of technology recipients, proprietary technology of this kind may be transmitted.

(6) Employees at the MNC parent company have usually mastered some of the company's technical knowledge, so when the job positions of company employees rotate, that knowledge can be brought to subsidiaries.

(7) Another technology access method that differs from the above-mentioned knowledge flows directly linked to trade and investment activities is where people in technological latecomer nations go to technologically advanced nations to study or engage in research. Overseas students, post-graduate interns, workers, and visiting technicians from technological latecomer nations receive new knowledge and acquire technology in technologically advanced countries at universities, laboratories, or companies using new technology. Large numbers of students were sent from Japan, South Korea, Taiwan (中国台湾), and other places in the 1950s and 60s to study in advanced countries, especially the United States. They were often able to bring back many advanced technologies, laying a solid foundation for the economic take-off of those countries and regions.

In addition, with the international adjustment of industrial structure, the gates of countries are more open. Any country may have some technical personnel who choose to work in other countries, and many countries now employ many foreign technical experts. They too are a pipeline for international technology spillovers, and are also a form of international talent flow-based technology spillover.

3.3.2 Diffusion of technical information

Information is the vehicle for technology. Whether complete or incomplete, information about technology is an important means of technology transfer. In fact, most of the content of technology transfer and technology spillovers is completed through the transmission of information. Many information transfer links are included even in the various modes of technology transfer mentioned earlier. For example, when technology is transferred by importing technical equipment, people need to use information to understand the machine tools available and what they are used for, as well as the kinds of goods available in the market and their respective characteristics. In this process, people use information to understand technologies, and transmit technologies using information flows.

Similarly, technical information can be transmitted through trade journals, magazines and conferences. Technical information is acquired through international academic meetings, technological exchanges and collaborative research, S&T journals or mass media (including newspapers, magazines, and websites), various research reports, and so on. Worldwide, over 300,000 business and S&T-related books are published each year, along with 100,000 different periodicals in business and S&T areas, and innumerable patent papers and research reports of all kinds. Given such an enormous "mine of intelligence information," enterprises of different countries, and even their governments, have established business intelligence research centers to acquire valuable technical information.

The close connection between information flows and technology transfer has been further strengthened in the internet era. The development of information technology such as the internet and modern communications has led to new means of international technology transfer. With its unprecedented influence and penetrating power, information technology is inexorably changing the economic structure, production methods, and lifestyles of society. The significance of information technology applications for international technology transfer lies in this: Rapidly developing information technology has reduced temporal, spatial, and language barriers, accelerated the speed of international technology transfer, and improved international technology transfer efficiency.

3.3.3 International technology cooperation

International technology transfer is often intertwined with various forms of international cooperation, which has gradually expanded into complex international economic and technical cooperation centered around technology goods. The main motivation for this is the internationalization of science and technology. International S&T cooperation and exchanges are continuously strengthening, and have entered a new stage of development in terms of quantity and quality, with coexisting trends of both competition and cooperation among countries in technological fields.

A strategic technology alliance refers to a form of union between enterprises that jointly, through close technological cooperation in R&D and technological innovation fields, and even in production and marketing fields, control the direction and speed of technology development, construct exclusive technical moats (e.g., by determining technology paths, controlling mainstream technology standards, implementing patent protection, etc.), and jointly seize and maintain competitive advantages. On the one hand, strategic technology alliances, formed mainly by enterprises in developed countries, share the expensive R&D costs of enterprises, avoid the risks arising from brutal market competition, pool each other's technological strengths, accelerate the unhindered diffusion of new knowledge within the alliance, and improve the competitiveness of the alliance's enterprises. On the other hand, the shared interests of strategic technology alliances have also obstructed the supply of new technologies to enterprises outside them, particularly to those in developing countries. Following the internationalization of R&D and the development of strategic technology alliances among enterprises, major MNCs have formed a complex technology network with global coverage using various technology linkages, and through this network, they keep control over global S&T resources in their own hands, thereby strengthening their monopoly position in technology supply and their bargaining power in transferring technology to enterprises in developing countries. This increases the costs that developing countries must pay when obtaining technology supplied from MNCs.

In the international direct investment process, joint ventures and cooperative ventures include the typical situations of international technical cooperation based on existing technology levels. Because the products of a joint venture require joint efforts to ensure their quality, and also ensure the advanced nature of the production technology so that it can continue to capture market share in international market competition, this common interest motivates both parties to develop and improve the technology together. Thus, during the investment process, both parties have to share the technical information used and transfer the technology through training. The cooperation of both parties on technology is an important factor in the success of investment projects.

II. Basic theories of international technology transfer

1. Internalization Theory

The main proponents of the internalization theory of technology transfer are the American scholars P.J. Buckley, M.C. Casson, and A.M. Rugman. They used internalization theory to analyze the internal market structure of MNCs, and further extended internalization theory to analyze the internal transaction market and technology transfers of MNCs. The internalization theory of technology transfer holds that the ownership attributes of technology determine that it cannot compete freely in the market like a commodity, and the incompleteness of the technology market inevitably leads to the internalization tendency of technology transfer. The theory argues that there is a two-way monopoly in the international technology market between buyers and sellers, and is thus an imperfectly developed market. Technology trading in an imperfectly developed market is not conducive to companies' pursuit of profit maximization. Technology itself is a special good with a proprietary nature for a certain period of time. For an MNC, technology is its core resource, and the internalization tendency of technology transfer has arisen in order for companies to maintain their monopoly advantages in production technology, management technology, and sales technology, strengthen their international competitiveness, and prevent the diffusion and loss of technology. The imperfection of the current patent system, the risk of technology transfer, and the pursuit of profit maximization have intensified the technology transfer internalization process.

In order to pursue profit maximization, moreover, MNCs will adopt foreign direct investment (FDI) methods based on their technological advantages. Using this approach, firstly, a company that establishes a trading market within the company can maximize the preservation of technology secrets and maintain its own technology monopoly, and secondly, it can maximize its use and development of potential production capacity, create economy of scale benefits from the company's integration, and enjoy exclusive access to the exceptional profits from its technological innovation. At the same time, internalization of technology transfer can avoid and eliminate various risks in technology transactions in external markets, and also allows adoption of differential pricing strategies based on the parent company's investments in subsidiaries, so that the determination of technology prices satisfies the requirement that it maximizes the company's overall profit. In addition, an FDI approach based on technological advantages also helps to reduce intervention from the host government, smoothly bypassing high trade protection barriers and improving the company's overall profitability.

The theory originates from the perspective of safeguarding the interests of developed countries and MNCs. With developing countries gradually lifting restrictions on FDI, once MNCs enter the host country market, their control of technology will not weaken, and the tendency toward internalization of technology transfer will continue to strengthen. Hence, for developing countries studying this theory and the behavior of intra-MNC trade, the need is to break through the economic and technological control of MNCs, choose the correct technology introduction strategy and favorable cooperation methods, and use the capital, technology, and management of MNCs in the service of their own economies.

2. **Product Life Cycle Theory**

The product life cycle theory was proposed by professor Raymond Vernon of Harvard University in the article *International Investment and International Trade in the Product Cycle,* published in 1966. The technology life cycle theory can be applied to the technology gap theory, and can further explain the specific evolution of technology gaps, as well as the impact of innovative technologies and their products on international technology trade. The technology life cycle refers to the fact that technology, much like all organisms, has a process of generation, development, decline and extinction, i.e., the technology life cycle. The theory argues that technological advantages and the achievements of technological innovation will eventually be reflected in products, and in the commercialized production of products and the economic effects of technology implementation.

The process of a technological innovation product in a country—from introduction into and domination of the domestic market, to product exports, export growth, export competition and export decline, until the beginning of the product's importation—can be divided into four main stages: new product monopoly stage, export growth stage, export competition stage, and export decline stage. The theory outlines the technology development cycle. In their foreign investment, MNCs basically follow the technology life cycle to determine the types of their investment. Amid today's rapid technology development, there has been a corresponding change in the technology life cycle pattern. In some high-tech fields, MNCs release their latest products in developing country markets rather than in the markets of their own countries, in the hope of monopolizing the huge overseas market. Essentially, however, MNCs choose technology transfer methods for different technologies and different life cycles.

3. **The Eclectic Paradigm of International Production**

The American economist J.H. Dunning organically combined FDI, international trade, and technology transfer, and used the eclectic paradigm of international production to analyze the mechanisms of international technology transfer. Dunning (1988) argued that, provided they have location advantages abroad and can control the technology patents for production abroad, enterprises will generally invest directly in foreign countries first. They tend to choose export trade when the location factors are not attractive, and they only choose technology transfer when the internal trading market does not have a certain scale and the location advantages are not obvious.

On the basis of the above choice theory, Caves (1974) summarized the two kinds of factors that determine MNCs' choice between FDI and technology transfer: (1) factors for choosing technology transfer, including obstacles to FDI (e.g., lack of economies of scale, insufficient market capacity, etc.), lack of basic prerequisites for FDI (e.g., insufficient stock of knowledge, high investment costs, unfamiliarity with foreign markets, etc.), short technological innovation cycle and risk factors; and (2) factors for not choosing technology transfer. The latter include high technology transfer costs, bargaining during negotiations, possible leakage of secrets due to the impact of product quality on reputation, etc. For MNCs, the cost of internal technology transfer is much lower than that of transfer between enterprises, so they generally do not choose inter-enterprise technology transfer.

III. Current state of international technology transfer in China

1. **Stages of international technology transfer in China**

China's introduction of foreign technology can be divided roughly into five stages.

1.1 First stage (1950-1959)

The background of China's economic development at this stage was reliance on imitation of the Soviet Union's development model and a one-sided policy in politics. Economic and technical cooperation was exclusively with the Soviet Union and the socialist countries of Eastern Europe, and complete sets of equipment (成套设备) and even entire production systems were introduced, including the management system, in order to introduce the advanced manufacturing technologies of the time. Statistics indicate that, from 1950 to 1959, China concluded 450 package project and project equipment contracts with the Soviet Union and Eastern European countries, of which 215 were signed with the Soviet Union, using U.S. $2.7 billion in foreign exchange. During the First Five-Year Plan from 1953 to 1959,[1] China spent a total of U.S. $3.8 billion to introduce technology.

The introduction of technology at this stage enabled China to transplant and establish many new industrial sectors, create a series of technological backbones, and narrow the technological gap between China and advanced countries. This produced significant positive effects on China's industrialization.

The technology introduced in this stage had the following distinctive features:

(1) The sources of technology were rather concentrated, being concentrated mainly in the Soviet Union and Eastern European countries;

(2) The technology introduced was mostly complete sets of equipment, and there was no straightforward importing of technology;

(3) The organizer of technology introduction was mainly the functional departments of the State and government, and it was often directly related to high-level government contacts. The funding needed for introduction was also almost entirely borne by the State.

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[1] Translator's note: The Chinese source text reads "1953-1959." China's First Five-Year Plan actually covered the years 1953-1957.

1.2 Second stage (1963-1967)

In this stage, China turned to Western developed countries to import complete sets of equipment and technology. The Soviet Union's unilateral breaking of contracts and withdrawal of experts in the early 1960s forced many projects to be interrupted, seriously affecting the introduction of technology. After some adjustment, consolidation, and improvement, China's national economy gradually recovered, and the introduction of advanced technologies from other countries and regions internationally was considered. Due to the impact of three years of natural disasters, when the national economy entered the adjustment period, solving the "food and clothing and other consumer goods" problems of the people became the primary problem, and the industrial structure of technology introduction also underwent important changes. The tendency in the 1950s to emphasize the development of heavy industry changed, and there was an increase in the introduction of technologies affecting the national economy and people's livelihoods, including classes of technology related to the textile industry and light industry. This large-scale introduction mainly focused on importing key sets of equipment and technologies from Japan, Western Europe, North America, and other countries and regions. Projects were mainly distributed among the chemical, synthetic fiber, metallurgy, petroleum, and machinery industries.

The introduction of complete sets of equipment still occupied the main position in this period, but attention was also paid to the introduction of individual equipment items and individual technologies. The scale of technology introduction was small, however, and there were fewer new and large-scale projects. Technology introduction was still focused on building production lines, and pure technology transfer projects were few in number. According to statistics, China introduced a total of 84 technologies in this period, at a cost of approximately U.S. $280 million.

1.3 Third stage (1972-1978)

In 1972, Sino-American and Sino-Japanese relations thawed in succession, and extreme leftist thinking domestically was partially corrected, setting the stage for larger-scale technology introduction from Western countries. In February 1972, Premier Zhou Enlai, after obtaining the consent of Chairman Mao Zedong, approved the *Report of the State Planning Commission on Importing Complete Sets of Chemical Fiber and Chemical Fertilizer Technology and Equipment* studied and proposed by Li Xiannian, Hua Guofeng, and Yu Qiuli, and new industrial technologies began to be introduced in a planned manner. During the year, China stepped up the pace of technology introduction. As instructed by Zhou Enlai, the State Planning Commission submitted the *Request for Instructions on Increasing Equipment Imports and Expanding Economic Exchanges* to the State Council, proposing a program for importing U.S. $4.3 billion worth of complete sets of equipment and individual pieces of equipment from abroad, i.e., the famous "Four-Three Program." Introduction projects included: Thirteen sets of large-scale fertilizer equipment, four sets of large-scale synthetic fiber processing equipment, three petrochemical systems, one alkyl benzene processing plant, 43 integrated coal mining units, three large-scale power stations, Wuhan Iron and Steel's “one meter seven” rolling mill, as well as turbine compressors, gas turbines, industrial steam turbine manufacturing plants, Spey aviation industry engines, etc. Such a large-scale importing of machinery, equipment, and technology from Western countries was unprecedented in the history of New China.

Contracts for the overall introduction projects involved in the “Four-Three Program” began to be signed and implemented one after the other in 1973, and follow-on projects were added as well, for a total contract amount of U.S. $5.14 billion. By the end of 1977, U.S. $3.96 billion in actual foreign deals had been made. At the same time, most of those introduction projects had been built and put into operation. Based on a summary of the relevant literature, although there were technological aging issues with some of the projects in the program, in general, it played an important role in promoting the renewal of China's industrial technology within the context of the "Cultural Revolution" at the time, and it also had important pioneering significance for the communication of Chinese enterprises with Western countries in terms of economic, technological, and cultural ties.

To summarize the first three stages of development, China's introduction of technology from abroad mainly relied on introduction of complete sets and key pieces of equipment, and internationally the license-based form of trade was very much lacking. From 1950 to 1978, China's software technology imports using the license-based trade approach accounted for only 2.3% of the total number of imported items; while introduction of complete sets of equipment accounted for more than 90% of the total number of items. In terms of the cost of imported technology, a cumulative U.S. $14.5 billion was spent on introducing technology from 1950 to 1978. Of that total, the amount for imported complete sets of equipment was U.S. $13.5 billion, accounting for 93% of all spending on technology imports, while spending purely for software technology was just over U.S. $100 million.

1.4 Fourth stage (1979-1999)

From the end of the 1970s, and after the mid-1980s in particular, China gradually changed its past approach of purely introducing complete sets of equipment and turnkey projects, and an introduction approach in which the introduction of manufacturing technology was predominant was proposed. According to statistics, around U.S. $30.2 billion in total technology introduction deals were completed in this period, a growth of 204% compared to the U.S. $14.8 billion in the first nearly 30 years since the founding of the PRC. The main features of technology introduction in this period were: 1. a marked increase in the scale of technology introduction; 2. a shift in the areas of technology, from production fields alone to a combination of production fields and daily life-related fields, so that in addition to introducing technology and equipment from abroad needed for economic construction, a large number of production technologies and production lines for consumer goods, represented by home appliances, were introduced; 3. a shift from the introduction of single sets of equipment to a combination of technology and equipment, so that design, manufacturing, and process technology was introduced along with the introduction of the required equipment; and 4. transition towards the stage in which the introduction of manufacturing technology would dominate.

According to statistics, the proportion of imported software technology among introduction projects rose to 46.3% in 1979-1983, while the introduction of hardware in complete sets of equipment fell to 53.7%; by 1984, these proportions had changed to 59.9% and 40.1%, respectively. This was a clear change compared to before 1979. From the mid-1980s, the concept of trading technology as a good was gradually established in China at both the policy level and enterprise operation level. The technology market gradually became active, and international and domestic technology transfer activities flourished.

From the early 90s in particular, there was a profound change in China's technology introduction, with several important features becoming apparent:

(1) Greatly increased scale of introduction. From 1991 to 1999, China introduced more than 30,000 technologies in major industries such as energy, machinery, and electronics, with the transaction amounts totaling U.S. $98.57 billion. The number introduced was more than 15 times that in the first 30 years following the founding of the PRC. The transaction amount of U.S. $98.57 billion was 219% of the transaction amount in the first 40 years.

(2) Diversification of introduction methods. In addition to traditional trading of equipment, there were also numerous methods such as technology licensing, technical services, cooperative production, investment in exchange for shares, compensation trade, etc.

(3) Increasing initiative in technology introduction After over 30 years of development, in some fields China had mastered technologies that were relatively advanced internationally, and also partially possessed independent development ability. At the same time, overseas, more and more MNCs were competing in various ways to export technology to China in order to enter the Chinese market.

(4) Increasing optimization of the technology introduction structure. The purpose of introduction gradually shifted from the introduction of individual production technologies to the introduction of technology to adjust the product structure, boost the value added of products, and strengthen innovation. Introduction of large-scale complete sets of equipment was gradually replaced by introduction of key technologies and equipment.

(5) Based on China's technology introduction statistics, hardware introduction was still proportionally higher in this stage, with the percentage of technology introduction that was primarily hardware equipment exceeding 50%.

1.5 Fifth stage (2000 to the present)

In this stage, many more significant changes in the introduction of technology have again occurred. Many kinds of technology introduction methods coexist, the trend is toward greater diversity of source countries and regions for introducing technology, there is relative concentration of industries in which technology is introduced, and foreign-invested enterprises and state-owned enterprises (SOEs) have become the main entities in China's technology introduction.

2. Features of China's technology introduction in the current stage

2.1 Coexistence of multiple technology introduction methods, clear increase in the software proportion

In the current stage, the traditional technology introduction pattern dominated by key equipment and complete sets of equipment has been broken and replaced by a new situation in which technology consulting and services, and various technology introduction methods such as patented technology, proprietary technology, and complete sets of equipment, are all interwoven. As shown in the following table, among the technology introduction methods in 2010, proprietary technology ranked first, accounting for 36.7%, followed by technology consulting and technology services, accounting for 29.2%. The introduction of traditional equipment had fallen to third place, accounting for only 10.6% of the total (Figure 2). This indicates that software introduction has gradually become the dominant component, while hardware equipment has taken a supporting position.

Figure 2 Statistical table of China's technology introduction methods in 2010

Technology introduction method	Number	Amount (U.S. $10,000)	Technology cost (U.S. $10,000)	Amount as percent of total (%)	Change from previous year (%)
Patented technology	494	190128.3	189586.4	7.4	4.4
Proprietary technology	2639	941133.9	913897.8	36.7	-1.6
Technology consulting and technical services	6809	747461.1	633845.8	29.2	13.2
Computer software	745	229583.0	227647.5	9.0	111.0
Trademark licensing	100	42225.2	42225.2	1.7	196.8
Joint venture and cooperative production	135	82229.8	81908.9	3.2	32.9
Complete sets of technology, key technologies, production lines	140	271622.7	39923.5	10.6	81.0
Other methods	191	59172.7	55632.3	2.3	151.2
Total	11253	2563556.63	2184667.32	100	18.84

Data source: Ministry of Commerce website

2.2 Increasing diversification of source countries and regions for technology introduction

Using contract amounts to measure technology introduction, it is still concentrated in certain countries and regions. The number of source countries and regions for China's technology introduction reached 71 in 2010. Among those, China signed 3,058 technology introduction contracts with the European Union (EU), with a contract amount of U.S. $7.82 billion, an increase of 21.6% year-on-year (YoY). Accounting for 30.5% of the total amount of technology introduction contracts, the EU is China's largest source of technology introduction. In the same period, the technology introduction amounts from the United States and Japan were U.S. $5.75 billion and U.S. $4.56 billion, respectively, accounting respectively for 22.4% and 17.8% of value, and putting them in second and third place (Figure 3). In addition, technology introduction from South Korea amounted to U.S. $2.1 billion, which ranked fourth.

Figure 3 China's top 10 technology introduction countries and regions in 2010

No.	Country of region	Number of contracts	Contract amount (U.S. $10,000)	Technology cost (U.S. $10,000)	Amount as percent of total (%)	YoY change (%)
1	European Union	3058	781714.7	638062.9	30.5	21.6
2	United States	2010	574933.5	560474.1	22.4	-1.9
3	Japan	2473	455983.7	412654.1	17.8	21.8
4	South Korea	769	209547.9	204764.3	8.2	-16.0
5	Russia	31	174831.1	31261.1	6.8	2309.5
6	Hong Kong	1212	112351.2	98771.4	4.4	10.5
7	ASEAN	447	50959.4	45808.0	2.0	85.0
8	Switzerland	160	47726.7	40917.7	1.9	55.7
9	British Virgin Islands	80	43711.6	43711.6	1.7	20.0
10	Singapore	356	39188.6	34048.6	1.5	107.3
	Total	11253	2563556.63	2184667.32	100	18.84

Data source: Ministry of Commerce website

2.3 Relative concentration in technology introduction industries

In 2010, the communication equipment, computers, and other electronic equipment manufacturing industry had the largest amount of technology introduced among industries. The industry introduced a total of 1,061 technologies, with a contract amount of U.S. $5.84 billion, an increase of 25.01% YoY and accounting for 22.8% of the total contract amount of technology introduced nationwide. In the same period, technology introduction by the transportation equipment manufacturing industry amounted to U.S. $3.84 billion, an increase of 0.36% YoY and accounting for 14.97% of the total. The electricity and heat production and supply industry's technology introduction amounted to U.S. $2.27 billion, accounting for 8.87%. These two industries were in second and third place (Figure 4).

Figure 4 Statistical table of China's top 10 technology introduction industries in 2010

No.	Industry	Number	Amount (U.S. $10,000)	Technology cost (U.S. $10,000)	Amount as percent of total (%)	YoY change (%)
1	Communication equipment, computers, and other electronic equipment manufacturing	1061	584066.5	575615.7	22.8	25.0
2	Transportation equipment manufacturing	2104	383652.6	379683.5	15.0	0.4
3	Production and supply of electricity and heat	113	227425.4	43003.6	8.9	213.6
4	Chemical raw materials and chemical manufacturing	475	142850.3	115591.5	5.6	25.3
5	Special equipment manufacturing	591	123249.8	120674.1	4.8	64.2
6	Real estate	1363	100036.5	99926.8	3.9	59.8
7	Computer services	310	91841.2	91841.2	3.6	-16.1
8	General equipment manufacturing	519	83920.7	74719.9	3.3	66.4
9	Crafts and other manufacturing	507	83251.6	83251.6	3.3	494.9
10	Recycling and processing of waste resources and scrap material	49	54234.4	52587.1	2.1	-73.6
	Total	11253	2563556.63	2184667.32	100.0	18.84

Data source: Ministry of Commerce website

2.4 Foreign-invested enterprises and SOEs are China's main technology importers

With the acceleration of economic globalization and the rapid development of China's economy, especially after China's accession to the WTO, the investment environment has been continuously perfected. More and more MNCs have shifted the focus of their investment to China, and are gradually ramping up their technology exports to investing enterprises in China. In 2010, the amount of technology introduction by foreign-invested enterprises was U.S. $15.37 billion, an increase of 16.63% YoY, and accounting for 60% of the total amount of technology introduction nationwide. The total amount of technology introduction by SOEs was U.S. $6.27 billion, up 13.2% YoY and accounting for 24.5% of nationwide technology introduction. In the same period, the total amount of technology introduction by private enterprises was U.S. $2.14 billion, up 8.3% YoY and accounting for 55.6% of nationwide technology introduction. Overall, foreign-invested enterprises, especially wholly-owned enterprises, are increasingly becoming China's main entities for technology introduction.

Figure 5 Statistical table of China's technology introduction in 2010 by type of enterprise

Type of enterprise	Number of contracts	Contract amount (U.S. $10,000)	Technology cost (U.S. $10,000)	Amount as percent of total (%)	YoY change (%)
State-owned enterprises (SOEs)	2070	627267.0	324649.8	24.5	13.2
Collective enterprises (集体企业)	105	26737.3	7178.9	1.0	575.0
Foreign-invested enterprises	6452	1536516.0	1502511.1	59.9	16.6
Private enterprises (民营企业)	1638	213764.3	195859.8	8.3	55.6
Other	988	159272.0	154467.8	6.2	10.3
Total	11253	2563556.63	2184667.32	100	18.84

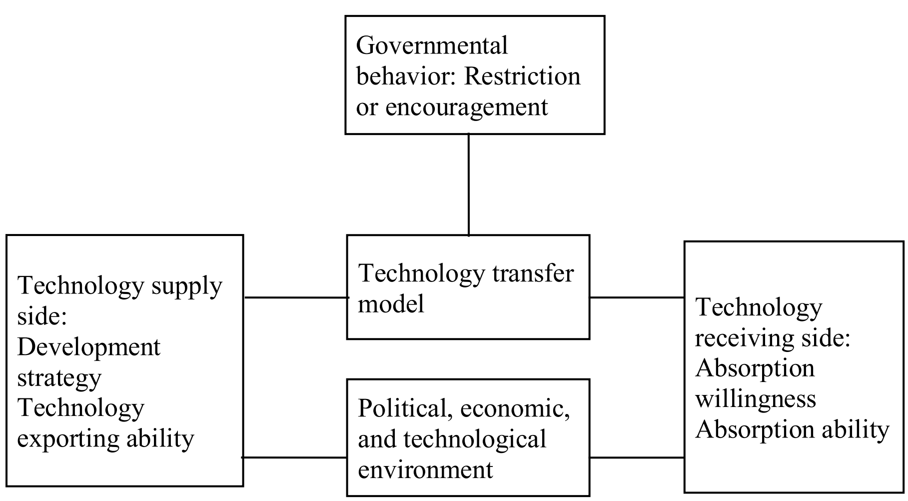
Data source: Ministry of Commerce website

IV. IV. Factors affecting China's international technology transfer

1. Methods of international technology transfer

The factors affecting international technology transfer are multi-level and multi-faceted (Figure 6). In addition to the technology supply and demand sides' willingness to cooperate, as well as the supply capacity of the supply side and the absorption capacity of the recipient side, one must also include the governmental behavior of the technology recipient country and the timing chosen for the technology transfer, i.e., the influence of factors such as the political, economic, and technological backgrounds.

Figure 6 Analysis of the pathways and influential factors in China's international technology transfer

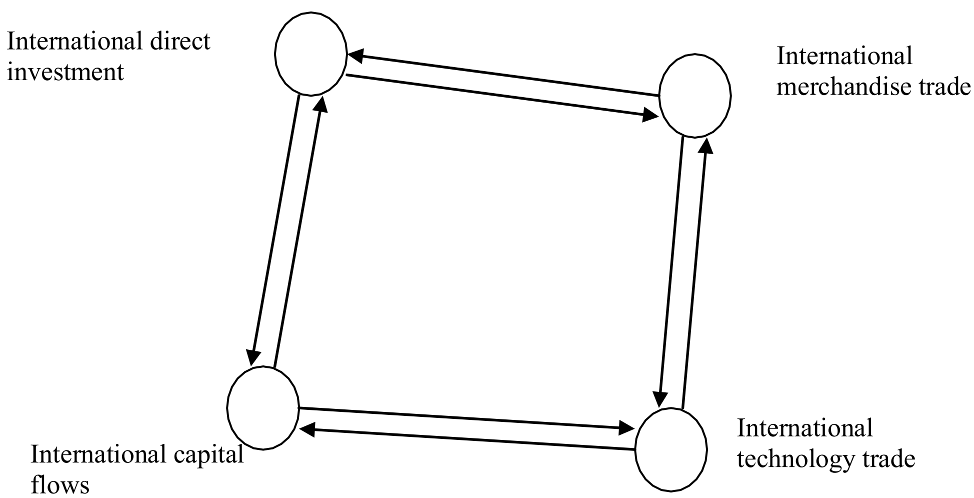


Globalization places new requirements on the technology supply and demand sides' willingness to cooperate, the governmental behavior of technology-receiving countries, and the timing of technology transfer, bringing new challenges for technology transfer policies.

2. Economic globalization and international technology transfer

Globalization in the broad sense refers to the progressive formation of the global market economy, integration and reorganization on the part of nations and other political forces, and a significant strengthening of ties and interactions between countries, under conditions of accelerating transnational flows of goods, capital, production, technology, information and other factors of production. Economic globalization is clearly the most important element in the concept of globalization in the broad sense. Different people have different understandings even about the meaning of economic globalization, and there are many definitions of economic globalization. However, economic globalization is generally viewed as a kind of expansion of economic activities across national boundaries, which has deepened the interdependence of national economies and has led to a constant increase in the scale, and a rapid expansion of the scope, of international economic cooperation and trade. This in turn has prompted greater openness among national economies, greater reliance on markets, and a certain degree of integration of the world economy.

Figure 7 Interrelationships among main aspects of economic globalization



Economic globalization is the communication of economic ties between countries through the world market system (Figure 7). Not only has international trade in goods expanded unprecedentedly and the flow of capital grown a hundredfold, but FDI, trading of labor and technology, information dissemination, personnel flows, international tourism, and other fields have all grown rapidly. These fields are mutually promoting and combined with each other, forming a comprehensive, wide-ranging, multi-channel, complete, and well-developed market system. This world market system and market framework links the economies of countries closely together and allows for a wide range of economic relationships between them.

Economic globalization has led to increased interdependence among countries at different levels, a high degree of interpenetration among national economies, and close links between FDI, trade, finance, technology transfer, and labor mobility.

In the context of economic globalization, by making full use of technological and economic development imbalances among countries, international technology transfer integrates the resources of the international technology market, transforms technological innovations into achievements of various stages, and achieves regional migration in various ways, so as to promote technological innovation and the industrialization of technologies.

2.1 Economic globalization has accelerated technology transfer

The past practice of internationally advanced MNCs was to limit the use of the most advanced products and technologies they developed to within their home countries, and only transfer them to developing countries once they became mature or even outdated technologies. Developing countries would always lag behind if they depended on external technologies. Under the conditions of economic globalization, however, this traditional approach has changed. The main manifestations are:

(1) Since the speed of technological development has greatly accelerated, and the depreciation of R&D and manufacturing investments is rapid, enterprises that develop new technologies at great expense must apply them to the maximum extent within a short period of time for them to recover their investment and for the new technology to be profitable.

(2) In some important industries, the main feature of industrial organization is changing from vertical integration to a horizontal type of division of labor. In contrast to vertical integration, firms within a horizontal division of labor more often need global markets so that they can share R&D costs and maintain enterprise scale.

(3) The number of enterprises at the same technological level increases, competition is fierce, and whoever can occupy the market with the fastest speed and largest scale can win. For these reasons, technology-inventing enterprises will strive to achieve globally synchronized use of certain new technologies or inventions to serve their global production goals. Although technology-introducing countries do not "control" the core technologies, they nonetheless can use advanced technologies within their borders more quickly and manufacture advanced products.

2.2 Economic globalization has strengthened indirect international technology transfer

In terms of technology transfer methods, apart from the trade in technology, economic globalization also gives developing countries technology transfer opportunities through capital inflows. For the host country, MNC investment has a kind of "basket" effect. In addition to the inflow of foreign capital, the investing MNCs have to carry out transnational business activities such as production, sales and R&D in the host country, which inevitably leads to technology transfer. As a result, overseas direct investment by MNCs promotes the diffusion of advanced technology, labor skills, and organizational management skills in the host country.

2.3 Economic globalization has expanded the channels for international technology transfer

Economic globalization has made international trade and investment activities more frequent, and the flow of related entrepreneurs and technical experts back and forth between countries is also conducive to the transfer of technology, especially certain technical components involving skills and techniques, which are usually not the subject of technology trade. Thanks to the coming and going of technical experts and managers, information flows develop more quickly and technology is transferred more effectively.

In sum, economic globalization has provided more opportunities for international technology transfer and has brought about changes in the scale, speed, methods, and channels of international technology transfer. It has further led enterprises to formulate new technology strategies and governments to adjust their technology policies, and ultimately led to unprecedented changes in the scale and pattern of international technology transfer as a whole.

3. Complexity of international technology transfer

One issue facing international technology transfer is the growth and complexity of technology itself. Under some circumstances, technology has the attributes and characteristics of a commodity, but overall, technology is not a standard commodity. In consequence, international technology transfer is much more complex than commodity trading.

Much research by the Organization for Economic Cooperation and Development (OECD) and J.H. Dunning has shown that transnational technology transfer is a kind of systematic transfer of technology spheres, the scale and structure of which should match the technology gap between the technology supplier and the technology recipient. They hold that a prerequisite for foreign investment in another country or region is that the supplier's technology is ahead of that of local enterprises in terms of product production or management. The internal structure of technology transferred between developed countries is very simple, and it is usually manifested in certain specific production techniques. In contrast, the internal structure of technology transferred between developed countries and developing countries is very complex. The transplantation of any hardware technology must have corresponding software technology or media-ware (媒质件) technology, and organizational management must also be matched with the production technology. But for developing countries, due to long-established concepts that emphasize technology over management, technology recipients frequently overlook the transfer of organizational management technology. At the same time, the environment required for transferring management technology is more complex, and there are many uncertainties regarding the effects of cultural conflicts and synergies on its transfer, which makes the transfer of management technology just as difficult as the transfer of production technology.

In addition to the complexity feature of new technologies, international technology transfer must also take into account two other factors that affect the feasibility and transferability of technologies: One is the state of the intellectual property system, which must protect the interests of all parties involved in international technology transfer. If the IP protection system is missing or imperfect, large numbers of technology imitations or illegal leaks may arise, leading to the loss of technology. In addition to losses on the part of technology transfer participants, it is possible that the technology supplier may refuse to continue with the technology transfer out of concern for the security of the technology. The second factor is the structural characteristics of the national technology system, that is, the participants in international technology transfer are required to consider specifically the impact of the transferred technology on the country's technology development, based on the country's strategy and priorities for technology development, and whether it is conducive to further innovation.

4. **Willingness and ability of technology providers to export technology**

The technology supplier is the inventor, owner, or proprietor of the technology, and is the party that owns or possesses it. The technology supplier, by virtue of its monopolistic and legally protected status with respect to the technology, exercises control over the technology and decides, based on its own interests and preferences, whether to implement the technology's diffusion, whether to verify its diffusion, where to diffuse it, and which diffusion method to use.

The two basic characteristics of technology suppliers are willingness to export and the ability to export. Technology transfer can only occur when the technological capability of the supplier is greater than that of the recipient, and the supplier's willingness to export the technology can be fully or partially aligned with the needs of the recipient. Factors affecting technology transfer on the technology supplier side

(1) Collaborative intentions of the parent company, as determined by its development strategy;

(2) Product development prospects in the recipient's market;

(3) The parent company's technological ability.

(4) The parent company's estimation and judgment of the technology recipient's social, political, and economic environment;

(5) The timing chosen for technology transfer and the technology chosen to be transferred.

(6) The integrated, synergistic transfer of the product's production technology and organizational management technology;

(7) The choice of technology transfer method (technology trade, direct investment—joint venture or full ownership, etc.).

In terms of technology exporting ability, MNCs have become the main suppliers of technology for international technology transfer, for the following reasons:

(1) MNCs are the main source of investment in S&T development;

(2) MNCs are the main owners of the world's S&T achievements;

(3) MNCs have abundant economic power;

(4) MNCs are the main players in the internationalization of production, and have the requisite transfer channels.

Willingness to export technology is related to the MNCs' production and technology strategies. Corporate strategies are holistic, long-term, and fundamental plans for business competition. In the development and application of technologies, MNCs in developed countries generally complete the innovation stage of technologies and further industrialize them at home, while taking legal measures to protect their technological innovation achievements in markets worldwide. At the technology maturity and diffusion stage, those technologies may be transferred to foreign subsidiaries for production, or transferred to enterprises of other nationalities for collection of licensing fees. High value-added refinement may remain within the home country, but when necessary, the R&D stage can also be extended abroad as well. This has become a common technology strategy adopted by MNCs.

A key factor in determining the foreign technology transfer of MNCs is technology substitution, that is, the replacement of old technology with new technology. With the continuous advancement of S&T, there has been a dramatic shortening of the technology life cycle, especially for new and advanced technologies. On the one hand, this requires multinational companies to continuously develop new technology to replace existing technology. On the other hand, it also pushes MNCs to transfer existing technology in order to extend the technology life cycle and obtain more economic benefits.

5. Technology acquisition needs and technological ability of technology recipients

A technology recipient is the receiver and user of a technology. It is the party that uses the technology acquired from outside in order to engage in a production or business activity or to serve a certain purpose. The technology recipient is the other end in a technology transfer project. For a technology recipient, the willingness to acquire technology and the ability to accept technology play crucial roles in technology transfer: The former is its willingness to acquire the intrinsic technology for enterprise development; and the latter is its ability to absorb the transferred technology based on the enterprise's process technology. Obviously, the technology recipient's choice as to the level of technology to be introduced should match its technical innovation ability. Factors include the technological ability of the local recipient company, and the collaborative intentions of the local recipient company as determined by its development strategy.

6. The role of international technology transfer intermediaries in international technology transfer

International technology transfer intermediation refers to providing a medium for the transnational transfer of technology, the commercialized application of technological achievements beyond national borders, and the international diffusion of knowledge. Technology intermediaries play linking, bridging, organizing, and coordinating roles, and promote the transfer, diffusion, and commercialization of technological achievements through special technical services, thereby creating corresponding economic and social benefits.

The main role of technology intermediaries is to use their well-honed business skills and abundant market experience to provide intermediation services throughout the international technology transfer process, from technology selection and assessment to technology contract signing and contract implementation, and to play an organizational role to match the technology supply and demand sides. They not only transmit information between the market's supply and demand sides, but also actively participate in the market and coordinate relations for the two sides, thereby promoting the successful realization of international technology transfers.

It should be noted that the portion of all technology transfers accounted for by technology transfer intermediaries is not large, as most technology transfers are associated with large companies, which usually have their own dedicated personnel for technology licensing or technology transfer and do not need to rely on the matchmaking of technology intermediaries.

Comparatively speaking, the importance of technology transfer intermediaries is greater for small enterprises. However, the key to whether small enterprises acquire technology through technology intermediaries is the cost-benefit ratio. If going though technology intermediaries means more cost savings and greater benefits, enterprises will tend to acquire technology through technology intermediaries.

V. Evaluation of China's international technology transfer effectiveness

China's technology introduction since the 1980s has been quite striking. It has also obtained considerable foreign technology, a large amount of which has been in the form of technology embodied in machinery and equipment, while there has also been technology in text and graphical forms, as well.

1. The positive impacts of international technology transfer on China's technological progress

1.1 Strong promotion of the national economy's construction and development

In the short space of 50 years, China has gone from a country with a very weak industrial base and very backward industrial technology, to an industrial power (工业大国) that has captured the world's attention, The manufacturing industry in particular has become an important world manufacturing base. This is directly related to the importance China attaches to the introduction of technology, as well as to digestion, absorption, and innovation after its introduction. The introduction, digestion, and absorption of foreign advanced equipment designs, manufacturing technology, and engineering application technology has allowed some of China's industries, and some of its large equipment R&D, design, and manufacturing technology, to cross into the world's leading ranks. It has also greatly improved the equipment localization rate, and some industries have now become firmly established domestically. In the case of China's large thermal power generation equipment, for example, the digestion and absorption of introduced technology has allowed the technological level of large thermal power units to enter the world's advanced ranks, and the localization rate of thermal power equipment to go from 50% for the first units to more than 95%.

1.2 Faster improvement of China's industrial technology level

By introducing advanced technology and high-precision processing equipment from abroad, updating and upgrading products, and carrying out digestion and absorption based on the introduced technology, independent innovation (自主创新) capacity has been built, which has substantially improved the product development ability of enterprises and the overall technical level of industries. Take, for example, China's shipbuilding industry, which adopted foreign design and joint design methods, and has introduced more than 50 key marine equipment manufacturing technologies by purchasing patented technology, license trading, etc. Through a major national "end-to-end" technology development project for digestion and absorption of introduced technology, in which some 191 technology development, 47 technology introduction, and 44 technical transformation tasks were completed, China's marine equipment technology rapidly approached the international advanced level, so that ships built in China could enter the international market. All kinds of ships have now been exported to more than 50 countries and regions in the world, including Hong Kong, Japan, Germany, the UK, Norway, and the United States. In the case of textile machinery, through the digestion and absorption of introduced technology and independent innovation over the past two decades, a vast array of new-generation spinning equipment has been developed, such as automatic winding machines, shuttle-less looms, and combing machines, and new types of combing machines have gradually gone into mass production, greatly promoting improvements in the level of equipment in China's textile industry.

1.3 Continuous strengthening of technical exchanges and cooperation between domestic and foreign-invested enterprises

With the competitiveness of domestically funded enterprises (内资企业) increasing, MNCs have not only come to regard such enterprises as competitors, but have also started to seek all-round cooperation with domestic enterprises, jointly establishing long-term strategic partnerships. In the area of technology cooperation, MNCs and domestic enterprises have formed various forms of strategic alliances in recent years, such as the strategic alliances established by Sanyo and Haier, and Philips and TCL, the cooperation between Lucent and Konka in developing mobile phone technology, and the joint expansion of internet business between Lotus and TCL. Through technical cooperation, MNCs and domestic enterprises have achieved resource sharing and complementary advantages, which has helped domestic enterprises join the global R&D systems of MNCs, and achieve R&D economies of scale. Secondly, MNCs have combined their technology investments closely with the development of China's related supporting industries, enlarging technical support for supporting enterprises. For example, Michelin of France, in order to improve the technical level of supporting enterprises, has established a network of suppliers in China with international standards and competitiveness, participated in the planting and processing of natural rubber in Yunnan and Hainan, cooperated with Sinopec to improve the quality of chemicals for tires, and provided technical assistance to wheel manufacturing enterprises in Shandong, Guangdong, and other places. Technical exchanges and cooperation between domestic and foreign-invested enterprises can provide the impetus for China to digest and absorb advanced technologies, and provide a broad stage for boosting independent innovation capability.

1.4 Exploration of paths for digestion and absorption of introduced technology and for innovation

In their initial exploration through digestion, absorption, and innovation of technologies after they are introduced, China's industries have found some successful practices. For example: Based on introduced technology, China's shipbuilding industry carried out digestion and absorption, and successfully set out on an innovative re-export (再出口) path of "introduce one, export one, innovate one," allowing China to become the third largest shipbuilding country in the world. The communications industry, meanwhile, successfully took a leapfrog development path by introducing advanced technology and equipment from a high starting point, while at the same time adopting independently developed communications equipment close to the world-leading level.

2. Effectiveness of international technology transfer

As an economic activity, it is necessary to evaluate the effectiveness of international technology transfer and judge whether it is successful or not. The objective of assessing technology transfer lies in evaluating the effects that technology transfer has had or will have.

The successful implementation of a technology's international transfer requires certain necessary elements, including:

(1) A good technology. A so-called good technology means that the technology can bring the recipient of technology transfer advantages in terms of economic benefits, that is, increase labor productivity by using the technology, thereby increasing productivity and revenue. It must be noted, however, that the concept of applicable technology is often more useful. The technologies being transferred are not necessarily the most advanced or the most productivity-enhancing technologies, but those technologies should be the best suited to the technological conditions and capabilities of the recipient.

(2) There is demand for the technology. Demand for a technology is influenced by many factors, including the applicability, legality, and completeness of the technology, as well as the price and cost of the technology transfer. The transferred technology's acceptability and level of use must also be considered. Technological latecomer countries have a general demand for technology, but whether there is a need for a specific technology must be considered from multiple perspectives.

(3) Both sides of the technology transfer have technical experts who are competent in the particular technology transfer activity. The supplying side's technical experts can effectively transfer the relevant technical knowledge and technical equipment to the receiving side, while the receiving side's technical experts can effectively receive the relevant knowledge and information of the technology, and can make full use of the effectiveness of the transferred knowledge.

In terms of the actual process of international technology transfer, as with domestic technology transfer, more factors are involved. Generally speaking, successful active technology transfers all have the following features:

(1) The technology transfer should be active. Earlier in history, technology transfer was passive, in large part due to the imperfection of technology markets. Transfer pathways were also inadequate, and support structures conducive to technology transfer were lacking. Knowledge was usually obtained only through experience, without written records or public statements. Even when technology was later written down, knowledge was still difficult to transfer because of the underdevelopment of technology markets. Access to technology often seemed somewhat elusive, with a good deal of serendipity to it. With the constant development of technology markets, active technology transfer has gradually replaced passive technology transfer. Active technology transfer refers to technology transfer carried out with both the supplying side and the receiving side having initiative for the transfer of technology. The technology supplying side is willing to transfer externally a technology it controls in order to increase the benefits of the technology, and the technology receiving side hopes to increase its productivity and benefits through access to the technology. There may also be a technology intermediary between the two, but the important thing is that both parties have agency with respect to the technology transfer. As a result, both parties involved in the technology transfer, as well as technology intermediaries, will provide timely information on technology supply and demand to interested technology developers and users, provide timely responses and evaluations regarding possible problems with a specific technology, convey supporting information not yet published in the formal literature or reports, and enable technology intermediaries to grasp trends in user demand. Active technology transfer is more purposeful than passive technology

transfer, and it costs less in comparison with the results.

(2) Technology transfer is carried out by humans, and is a cooperative activity. Successful technology transfer hinges on the obligations performed by both parties in the transfer. This point is critical, because it ensures that the experience of innovation producers is fully utilized. In any technology transfer process, the relevant people will fully play their roles. They must be highly accountable and, of course, they must have access to two key resources, i.e., the recipient must have access to the necessary funds, and the supplier must have technology that is available for transfer.

(3) The technology transfer is selective, and obtains substantial support. The transfer results will be most effective if the technology transfer is focused on the core process aspects. At the same time, technology transfer should focus not only on the quantity of transfer, but also on the method and effectiveness of transfer. In other words, in addition to being concerned about the measurable input and output amounts, one should also pay attention to indicators of process aspects.

(4) Organizations, institutions, and policies that are appropriate and beneficial to technology transfer This means that the institutional and even human barriers to technology transfer are relatively small, and that policies can be used to promote the transfer of technology.

3. International trade and technology spillovers

In an open economic system, a country's technological progress depends on domestic R&D investments, and the R&D behavior of other countries will also affect the country's technological progress, directly or indirectly, through various transmission channels. Recent research has shown that among the 34 OECD countries, the main contribution to productivity growth has not come from domestic R&D activities, but from foreign R&D. Even for an economically developed country like France, foreign R&D can explain 87% of its productivity growth (Eaton and Kortum, 1999).

Externalities of this kind, in which foreign R&D activities affect a country's technological progress directly or indirectly, are called international technology spillovers. With the development of transportation, information, and communication technologies and rapid increases in the level of economic integration, the impact of international technology spillovers on a country's productivity is growing. For a developing country such as China, the main drivers of sustained economic growth in the future will come mainly from technological progress, and technological progress will not only come from self-innovation and accumulation, but will also depend to a large extent on digesting and absorbing the existing technologies of all mankind. Scientifically and rationally utilizing international technology spillovers from all kinds of spillover channels is therefore of great significance for China's achievement of technological catching-up and economic takeoff.

3.1 International trade and technology spillovers

Recent empirical studies on international technology spillover channels in academic circles focus mainly on exploring spillover channels such as international trade, inward FDI, and technology spillovers. Coe and Helpman (1995) made a pioneering study on technology spillovers from import trade and gave a basic econometric model of international technology spillovers (abbreviated as the CH model). They argued that an economically open country can import intermediate goods from other countries, and hence its productivity will depend not only on its domestic R&D capital stock, but also on the R&D capital stock of other countries. Thus, domestic productivity, TFP, is a function of both domestic R&D capital stock and foreign R&D capital stock:

$$\ln TFP = \alpha^0 + \alpha^d \ln DRD + \alpha^f \ln SF + \varepsilon$$

Where TFP denotes a country's total factor productivity, DRD is its domestic R&D capital stock, α^0 is a constant term, α^d denotes the elasticity of TFP with respect to domestic R&D capital stock; SF is foreign R&D capital stock, and α^f denotes the elasticity of TFP with respect to foreign R&D capital stock. Coe and Helpman (1995) used import shares as weights to construct foreign R&D stocks, and employed a panel dataset of 21 OECD countries and Israel. Their empirical findings show that R&D investment in trading partner countries increases domestic total factor productivity, and its effect strengthens as a country's trade openness increases.

Other scholars such as Sjoholm (1996) and Keller (1997) have also concluded that import trade is an important transmission channel for international technology spillovers. In terms of empirical studies of the technology spillover effects of China's international trade, a study by Fang Xihua, Bao Qun, and Lai Mingyong (2004) showed that R&D investment in trading partner countries has contributed significantly to the improvement of China's total factor productivity through the import trade transmission mechanism. Using the Global Trade Analysis Project (GTAP) model, Huang Lingyun and Xu Lei (2009) found that eight regions including North America can all promote technological progress in China's industrial manufactured goods sector through international trade technology spillovers.

3.2 Foreign direct investment and technology spillovers

The "technology spillover effect of FDI on the investment host country" has received widespread attention since it was proposed by MacDougall in the 1960s, becoming one of the hot research topics in economics. FDI is divided into inward FDI and outward FDI. Academic research on FDI and technology spillovers has mainly focused on the international technology spillover effect of inward FDI, i.e., exploring the technology spillover effects on the host country of FDI flowing into the host country. Related empirical studies have mainly focused on three aspects: 1. whether international technology spillover effects of FDI exist; 2. what kinds of factors influence the international technology spillover effects of FDI; and 3. the mechanisms of the international technology spillover effects of FDI.

3.2.1 Do the international technology spillover effects of FDI exist?

As to whether the technology spillover effects of FDI exist, scholars have mainly explored the technology spillover effect on the host country of inward FDI flowing into the host country. They have found that the technology spillover effect on host country enterprises of inward FDI flowing into developed countries generally exists, but their conclusions on the technology spillover effects of FDI flowing into developing countries are inconsistent. The findings of Kokko and Zejan (1994), Sjoholm (1999), and others on the inward FDI of developing host countries support the existence of technology spillover effects of inward FDI. However, Aitken and Harrison (1999) and others do not support the inward FDI technology spillover hypothesis. Domestic scholars have also carried out empirical studies on the impact of FDI inflows to China on China's technological progress, and have reached inconsistent conclusions. Guo Qingbin and Fang Qiyun (2009) empirically analyzed the effect of foreign R&D on China's technological progress using co-integration analysis and an error correction model, and found that FDI-based spillover effects have promoted China's technological progress; however, Bao Qun's (2003) study showed that the technology spillover effect of foreign firms was not significant and the technological progress effect of inward FDI had considerable volatility.

3.2.2 Factors influencing the international technology spillover effects of FDI

In terms of the factors influencing technology spillovers, the key points considered by scholars have been technology gaps and absorption capacity. Kokko (1994) argued that the level of spillover depends on the complexity of the technology and the technology gap, while no evidence was found for the existence of spillovers in those industries where MNCs use highly complex technologies. Kinoshita's (2001) examination of the Czech Republic found that the presence of foreign capital generates positive spillovers for R&D-intensive local firms. This shows the importance of firms' absorptive capacity in capturing technology spillovers. Using empirical evidence from China's manufacturing sector, Chen Taotao, Fan Mingxi, and Ma Wenxiang (2003) showed that the "technology gap" is one of the most direct and important factors influencing the intra-industry spillover effects of FDI in China. By building an endogenous growth model based on the expansion of intermediate product categories, Lai Mingyong, Bao Qun, Peng Shuijun, and Zhang Xin (2005) confirmed the role of technology absorption capacity in determining the effect of technology spillovers. Their empirical results show that the relative lag of human capital investment in eastern China had restricted its technology absorption capacity, while the key to increasing the technology absorption capacity of central and western China is to enhance the openness of the economy.

3.2.3 Technology spillover mechanisms of FDI

In research on the spillover mechanisms of FDI, scholars have tended to explore the mechanisms of FDI technology spillover in simultaneous equations in which the productivity of foreign and domestic enterprises are determined simultaneously. If the coefficient on the variable indicating the presence of foreign capital is positive, it indicates that FDI technology spillovers originate from demonstration and imitation effects. Driffield's (2001) empirical findings for the UK show that the higher the productivity of foreign firms, the faster the productivity growth of domestic firms. This suggests that competition between domestic firms and MNCs is an important mechanism for the occurrence of productivity growth in domestic firms. Kokko's (1996) study of Mexico also found that competition is an important mechanism for generating spillover effects. Econometric analysis by Xiaoying Li, Xiaming Liu, and David Parker (2001) using Chinese manufacturing data for 1995 showed that the demonstration-imitation effect is an effective mechanism for collective and private enterprises to obtain technology spillovers from FDI. Chen Taotao's (2003) empirical evidence also showed that sufficient competition is an effective mechanism for generating spillovers.

3.3 Outward FDI and technology spillovers

In addition to the technology spillover effects that inward FDI may bring for the host country, some scholars have also noted that outward FDI can also bring international technology spillovers to the host country. Outward FDI allows enterprises to take advantage of proximity to local technological resources in order to monitor, study, and acquire advanced and applicable technologies. At the same time, foreign branches of FDI-making enterprises make technology transfers and diffuse the latest and most advanced technologies to the home country through reverse technology flows, which improve the overall technology level of the parent company, other subsidiaries, the home country industry, and the home country. This is the reverse technology spillover effect. Branstetter's (2000) empirical study of Japanese enterprises investing in the United States showed that their direct investment in the United States enhanced the technology level of those enterprises, thus demonstrating that outward FDI has a reverse technology spillover effect. Using panel data, Braconier (2001) examined the spillovers on R&D of Sweden's inward and outward FDI, and found that inward and outward FDI together was positively related to domestically acquired technology spillovers. The results of Potterie and Lichtenberg (2001), who examined trade, outward FDI, and inward FDI separately, suggest that only outward FDI can generate technology spillovers. For small countries, technology spillovers from imports are larger than those from outward FDI, while the opposite is true for large countries.

Some Chinese scholars have analyzed and tested the reverse technology spillover effect of China's outward FDI. Zhao Wei, Gu Guangdong, and He Yuanqing (2006) used the linear programming (L-P) model to demonstrate that China's outward FDI can promote the productivity growth of the home country. Wang Ying and Liu Sifeng (2008) conducted an empirical analysis of the reverse technology spillover effect of China's outward FDI from 1985 to 2005, and the results showed that there was a reverse technology spillover effect of outward FDI. However, Zou Yujuan and Chen Ligao's (2008) study found that the effect of outward FDI on total factor productivity was not very evident.

There have been relatively few comprehensive studies of import-export trade, FDI, and technology spillovers in the domestic and international literature. Xu and Wang (1999) were first to test the spillover effects in a CH setup of trade, inward FDI, and outward FDI using data from 13 OECD countries for 1983-1990. Their findings showed that trade in capital goods is a significant spillover channel; outward FDI also leads to technology spillovers, although its level of spillovers is low; and there was no evidence that inward FDI brings significant technology spillovers.

VI. Trends in international technology transfer

1. The role of MNCs in international technology transfer is prominent

According to the Internalization Theory proposed by Peter Buckley and Mark Casson in 1976 and further developed by Canadian scholar Alan M. Rugman in 1981, due to the existence of market imperfection and rising transaction costs, firms are unable to ensure that they profit from the buyer-seller relationships of external markets, which also leads to many additional costs. Therefore, they establish internal markets, that is, they form intra-firm markets within multinational companies that enable them to overcome the risks and losses caused by external markets and market imperfection. As explained by Teece (1977), the main purpose for the existence of MNCs is to internalize the market in order to avoid as much as possible the higher technology transfer costs in technology trading. Amid the enormous progress in transnational technology trade, the position of MNCs is becoming more and more important. According to statistics, the world's technology trade amounted to U.S. $500 billion in 2000, and MNCs control and transfer much of the world's technology, with technology trade within MNCs accounting for 60%-70% of world technology trade. They have leveraged their strong technological strength and abundant capital to become the main bearers of today's international technology transfers, and the monopolists of the world technology market. This phenomenon has now attracted great attention from theorists, and a number of scholars have emerged at home and abroad to analyze the phenomenon of technology transfer by MNCs in depth, producing many valuable results.

2. **Technology transfer's systemic and pluralistic nature**

In the information age, new technologies are typically characterized by their complexity and systemic nature. On a macro level, "systemic nature" refers to modern S&T being closely linked with economics, politics, culture, and the military, and reflecting the overall S&T development capability of a country. On a micro level, the systemic nature of modern technology is mainly reflected in the R&D and use of new technologies being dependent on personnel, equipment, financial resources, and many other supporting factors. This systemic nature of modern technology is what determines the increasing complexity of international technology in the transfer process, with a clear pluralistic feature being apparent: First, the systemic nature of modern technology makes it difficult to separate new technologies and make adaptive transformations. This objectively requires the technology-introducing party to consider various aspects such as equipment, software, and talent when introducing a new technology, so as to ensure the digestion and absorption of the introduced technology. Second, the systemic nature of modern technology often causes the technology introduction to be accompanied by the culture, customs, and values of the home country (technology exporting country), and this pluralistic feature makes international technology transfer more complex.

3. **Government's role in international technology transfer will weaken**

Due to rapid technology development and fierce competition, governments attempt to intervene in technology transfer in various ways. The governments of technology-exporting countries try to control the exportation of technology for strategic, national defense, and foreign policy reasons, while technology-importing countries use various channels to try to provide a good platform for the importation and digestion of technology. However, looking at current trends in the world economy, the process of economic globalization has weakened the boundaries between countries in economic and cultural respects, and the liberalization of trade and investment is increasing. This reality will greatly limit government intervention in international technology transfer, and the role of government will evolve from direct control and participation to the provision of services. For governments in developing countries, that means striving to improve education, improve internet-based infrastructure, establish efficient information service systems, improve financial services, and so on. Naturally, since trade in technology is not the same as general merchandise trade, each developing country still intervenes directly in the introduction of some major projects owing to macro-objectives such as protecting its economy and promoting its industrial restructuring and technological upgrading. South Korea's government, for example, has been directly engaged in the introduction of technology for large-scale projects in the state-run sector. But in a perfect market economy, the main entities in trade should be the market entities (enterprises), and only by giving full play to their role will a rising overall level of technology introduction "lift all boats."

4. **The role and status of international technology transfer are increasingly prominent**

As the industrialization histories of many latecomer economies (South Korea, Japan, Taiwan, etc.) have proven, import substitution and technology catch-up strategies are effective ways to promote one's technological development and achieve industrialization. However, the industrialization of these countries (regions) occurred in the middle of the last century, and both import substitution technology catch-up strategies survived in a highly protected market environment with relatively low external dependence on technological development. Half a century later, though, the entire international environment has undergone radical changes. The most striking change is the economic globalization trend, which has penetrated every corner of the world, and all countries are transitioning toward more open market economies. In the midst of rapid S&T progress, increasing liberalization of trade and investment, and increasing internationalization of production, it is impossible for any country to rely entirely on its own strength to securely keep pace with technological development. Looking just at the situation of developed countries, nearly 70% of the newly added GNP in developed countries over the last decade has been associated with the transfer of high-tech achievements. With societies developing towards informatization (信息化) and high technology, countries positioned downstream in high-technology industries, including some emerging industrial countries and many developing countries, must, out of economic development necessity, use huge amounts of capital to purchase the technological achievements of developed countries, and use the introduced technology to promote their industrial structure upgrading and economic development.

5. **The uneven distribution of international technology transfer will be difficult to change in the short term**

In the international technology market, the distribution of technology transfer is extremely unbalanced, with the vast majority of technology trade occurring between developed countries. According to statistics, technology trade between developed countries currently accounts for over 80% of the world's total technology trade, while technology trade between developed countries or regions and developing countries accounts for only 10% of the world's total technology trade. Less than 10% of technology trade is between developing countries. As mentioned above, a characteristic feature of modern technology is its systemic nature, and technology is often intertwined with local economic and cultural factors, social customs, etc. Developed Western countries have very similar levels of overall technology development, and their economic systems and cultural customs are also very inclusive. They all have abundant capital and technology as well, and their market and investment capacities are larger. For these reasons, it is easier for them to provide smooth channels for pluralistic technology transfer, thereby achieving cooperation, exchange, mutual penetration, and competition in technology R&D. On the other hand, there is a certain gap between developing countries and developed countries in terms of economic and technological development levels, and there is also a large gap in education and talent structures, which objectively creates obstacles to the flow of technology. Although there is a high degree of similarity in economic and technological levels among developing countries, the low level of technological development also restricts the transfer of technology. From a long-term perspective, since the economic development level and state of technological progress of developing countries are unlikely to improve in a short period of time, the above-mentioned gap between developed and developing countries is not only impossible to narrow in the short run, but is still tending to widen. Therefore, the current high concentration of international technology transfer among developed countries will persist.

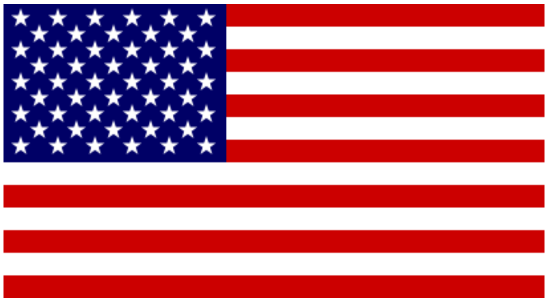
6. **Protectionism in international technology transfer is intensifying.**

On one hand, countries have implemented protection measures with respect to international transfer of high technology and strictly control the outflow of advanced technology. A multi-polar pattern of technology competition among developed countries is forming, and the contradiction of control and anti-control between developed and developing countries is deepening. On the other hand, global flows of talent are accelerating, and competition for talent is becoming more intense. The shortage of talent in developing countries is especially serious, and the brain drain phenomenon has become widespread. In addition, the influence of political and diplomatic factors on technology transfer is growing, and technology transfer and technology diplomacy are becoming important activities in the international political arena. This is particularly evident in the field of high technology.

Part Two: Typical National Models of International Technology Transfer Institutions

I. The United States

1. Basic information on the United States



Population: 312 million (ranked third)
GDP: U.S. $13.2383 trillion (ranked first)

The scale of IP in the United States has grown steadily: Patents increased from 280,500 in 2000 to 440,400 in 2011; trademarks increased from 624,000 to 787,800; and industrial designs increased from 24,600 to 83,400. GDP also increased, from U.S. $11.1581 trillion in 2000 to U.S. $13.2383 trillion in 2011, the highest in the world (Figure 8). R&D represented 2.74% of GDP in the United States in 2011.

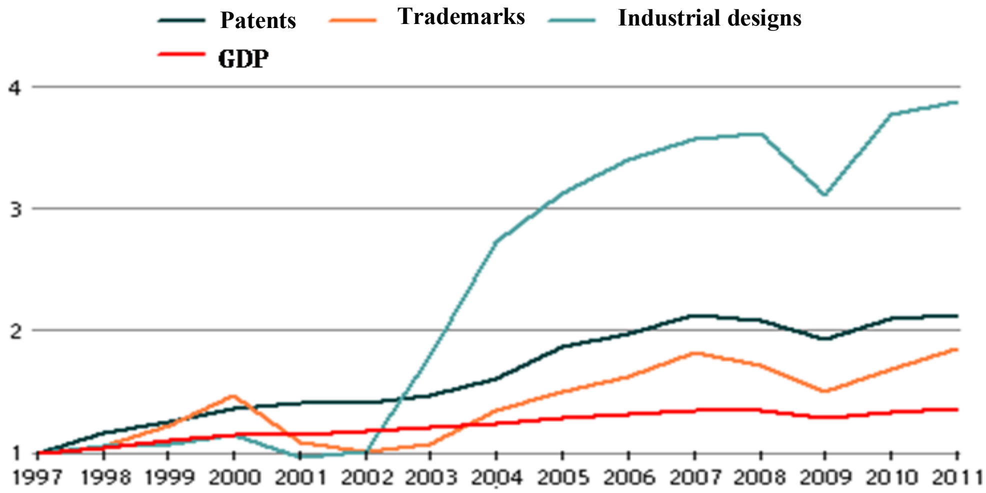
Figure 8 Intellectual property and GDP in the United States

Year	Patents	Trademarks	Industrial designs	*GDP (USD trillion)*
2000	280,456	624,017	24,578	11.1581
2001	290,467	459,416	20,677	11.2801
2002	291,639	428,800	21,573	11.4863
2003	302,779	458,047	38,348	11.7795
2004	332,233	573,929	58,539	12.1894
2005	384,136	641,233	67,168	12.5643
2006	406,859	691,790	73,153	12.8984
2007	437,920	777,715	76,982	13.1444
2008	429,602	732,964	77,922	13.0972
2009	398,485	637,742	66,916	12.6352
2010	432,911	716,276	81,294	13.0170
2011	440,433	787,762	83,428	13.2383

Data source: World Intellectual Property Organization

Growth in intellectual property (IP) filings in the United States has outpaced economic growth since 2003, with industrial design filings in particular growing much faster than patent and trademark filings (Figure 9).

Figure 9 Comparison of IP filings and economic growth in the United States

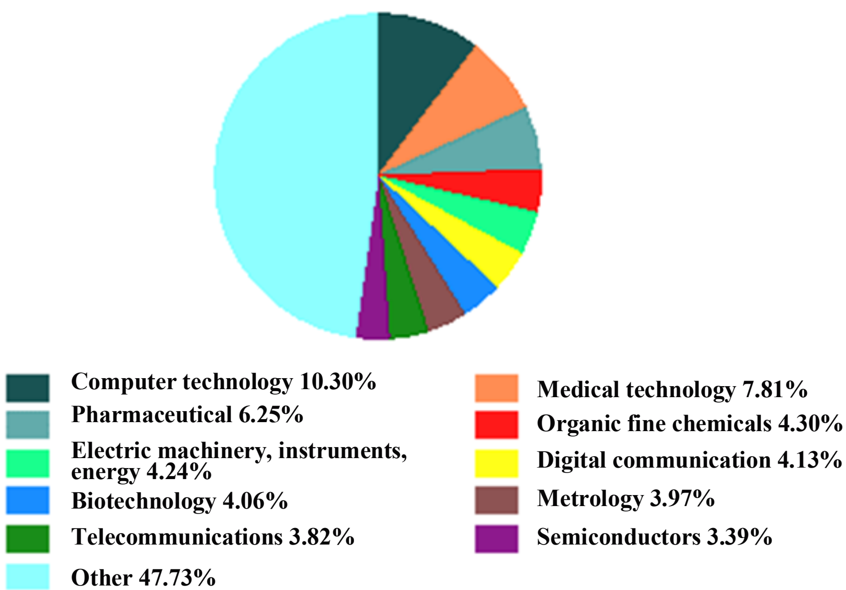


Note: Set equal to 1 in 1997

Data source: World Intellectual Property Organization

Among patent applications from 1997 to 2011, the highest share was in the computer technology field, with 10.30%, followed by medical technology (7.81%), pharmaceuticals (6.25%), and organic fine chemicals (4.30%) (Figure 10).

Figure 10 Technical fields of United States patent applications



Data source: World Intellectual Property Organization

2. National Technology Transfer Center

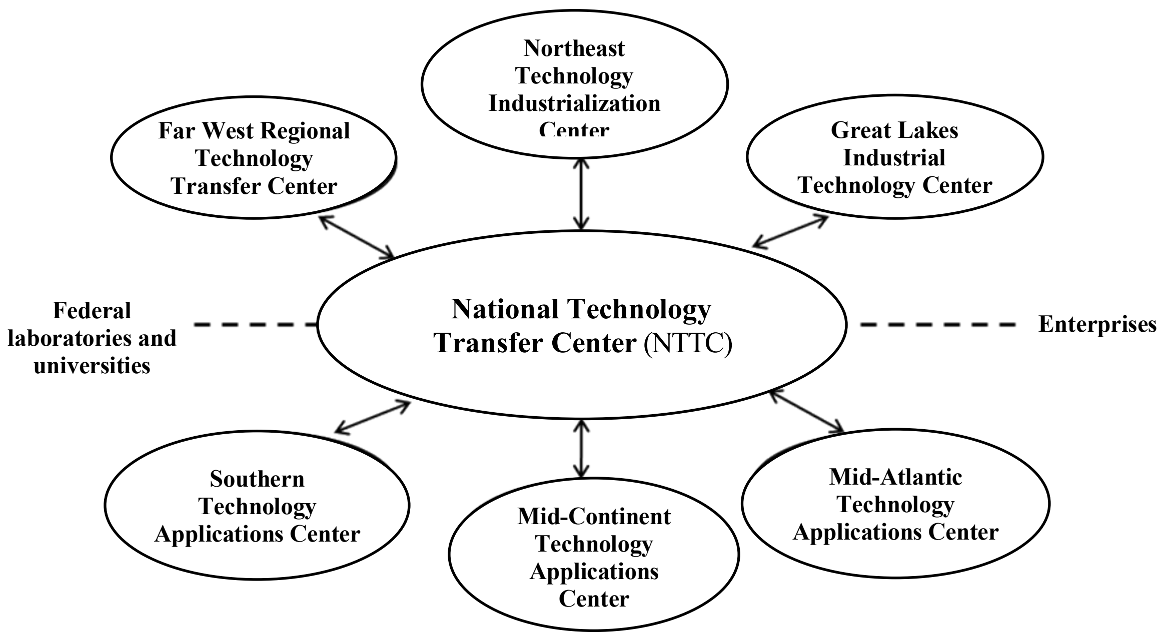
- A government research institute technology transfer model

2.1 Overview

The National Technology Transfer Center (NTTC) is a national nonprofit technology transfer institution (TTI) established with the approval of the U.S. Congress in 1989 and headquartered at Wheeling Jesuit University. Its aim is to maximize product development opportunities by enabling industries in the United States to join forces with federal laboratories and universities that have the technology, facilities, and research personnel. With operations in Wheeling, West Virginia and Alexandria, Virginia, the NTTC has evolved into an organization dedicated to developing partnerships between industry, academia, and government. For more than two decades, the NTTC has provided federal agencies and other clients many essential services for the commercialization of technology. Its funding comes mainly from NASA, the Department of Energy, and the Small Business Administration.

2.2 Organizational structure

Figure 11 Organizational structure of the NTTC



To establish partnerships with companies, the NTTC relies on six NASA-funded Regional Technology Transfer Centers (RTTCs)—the Far West Regional Technology Transfer Center, the Northeast Technology Industrialization Center, the Great Lakes Industrial Technology Center, the Southern Technology Applications Center, the Mid-Continent Technology Applications Center, and the Mid-Atlantic Technology Applications Center (Figure 11). Each RTTC has an independent technology information search system that provides a full range of technology transfer and commercialization services.

The NTTC studies commercial and government markets, and provides the technologies its clients need. Its team includes experts in all kinds of fields, including IP management, engineering, computer information, database development, market analysis, professional technical writing, publication distribution, graphic design, business and manufacturing consulting, financial analysis, and training.

In addition to working with major federal TTIs, the NTTC is actively involved in university and corporate research. Enterprises from *Fortune* 500 companies to small and medium enterprises (SMEs) have all allowed the NTTC to accumulate technology transfer experience in a variety of fields. Today, the NTTC covers more than 4,000 technology market segments. It has trained 6,832 technology transfer professionals, distributed more than 40,000 government technical support packages, and searched for 1,582 specific commercial technologies for the government.

2.3 Business services

The NTTC's scope of business is very broad, and it has promoted some of the most revolutionary technological developments the world has ever seen, bringing enormous benefits to the American people.

2.3.1 Technology and market assessment

Technology assessment is one of the main functions of the NTTC, which provides in-depth assessment and analysis of government, university, and privately held technologies, including screening, technological competition intelligence, patent searches, identification of competing products, technology performance ratings, and improvement of current technologies.

Technology matching is a service that the NTTC has given particular emphasis in the past few years. In response to client requirements, the NTTC's technology analysts search for available technologies to satisfy a variety of technology needs. In some research, this is conducted on an investment portfolio basis, and the NTTC searches a range of available technologies in pursuit of solutions, regardless of origin.

Software evaluation involves developing a technical description, as well as identifying the novelty of the technology, the various stages of the technology's development, the value of the technology to the customer or the U.S. government, whether IP actions are required, and whether the software relies on third-party software. The purpose of software evaluation is, together with the technology assessment, to make recommendations for the next steps in IP protection. The NTTC has now reviewed over 700 federal-level software programs.

Patent portfolio analysis and categorization. Many federal organizations and universities have developed large portfolios of technologies. In order to keep these products up to date, many organizations have had the NTTC carry out analyses of their investment portfolios for technology commercialization, in which the NTTC identifies new technology, and thereby determines what United States patent category the technology falls under, etc.

Market research. When assessing the commercialization potential of a technology, a very important first step is to examine the validity of the technology. Once the technical capability of a technology has been proven, market opportunities can then be looked for. At the NTTC, it is very important to identify market structures and competing products, and predict favorable conditions and restrictive situations. Market research can identify and attract potential partners, and use federally funded research to negotiate agreements. The NTTC has now analyzed thousands of technologies of the federal government, universities, and industries.

Partnership development. Successful R&D or technology often requires a partnership, especially when the technology needed by an individual company has reached a certain stage. Since 1989, the NTTC has built an excellent platform between industry, academia, and government agencies, where licenses can be issued and agreements concluded. Its partnering business includes identity verification, examination of qualifications, technical support, and agreement signing.

2.3.2 Technical information services

Information technology support. The NTTC can provide a series of services, from website development to construction of databases, and including the four categories of software analysis, design, development, and testing. The IT support staff are experts in user applications and server applications ranging from ASP, ASP.net, VB.net, Visual Basic, and JavaScript, to HTML design and development, Activex Data Object/Open Database Connectivity (ADO/ODBC) database driven applications, Crystal report design, SQL server installation, database driver programs, etc.

Integrated knowledge management services. The Knowledge Integration Toolset (KITS) developed by the NTTC is a knowledge management system with enhanced search functions. The NTTC initially developed this project for NASA, and now provides information to industry, academia, and federal agencies, simplifying their offsite data source issues. KITS refines search functions integrating databases, website data, document repositories, and other data sources. The system is also scalable, so it can incorporate any number of additional databases and any amount of website data. Customers using KITS can store different indices in various databases, create personalized knowledge bases to store information such as websites, perform data analysis by defining customized categories, generate the results required for specific data sources, etc.

2.3.3 Public relations services

Publication of related materials. The NTTC and NASA have published 70 studies on aerospace technology and technology transfer functions. Over the past decade, the NTTC's *Innovation* magazine has publicized many of the NTTC's technological innovations, including aerospace technology innovations and space technology innovations; and technology transfer development has been promoted by NASA projects and procedures, and NASA's Small Business Innovation Research (SBIR) program, events, and awards. Since 1993, some 1,358 newsletters related to federal technology transfer have been published.

Press release writing. The NTTC also issues some other press releases, introducing the success stories of its federal clients, and serving as an effective tool for promoting and marketing government and university technology. Services provided include: publication writing, editing, and design; editing project management; development of marketing materials, and carrying out public relations activities.

2.3.4 Training

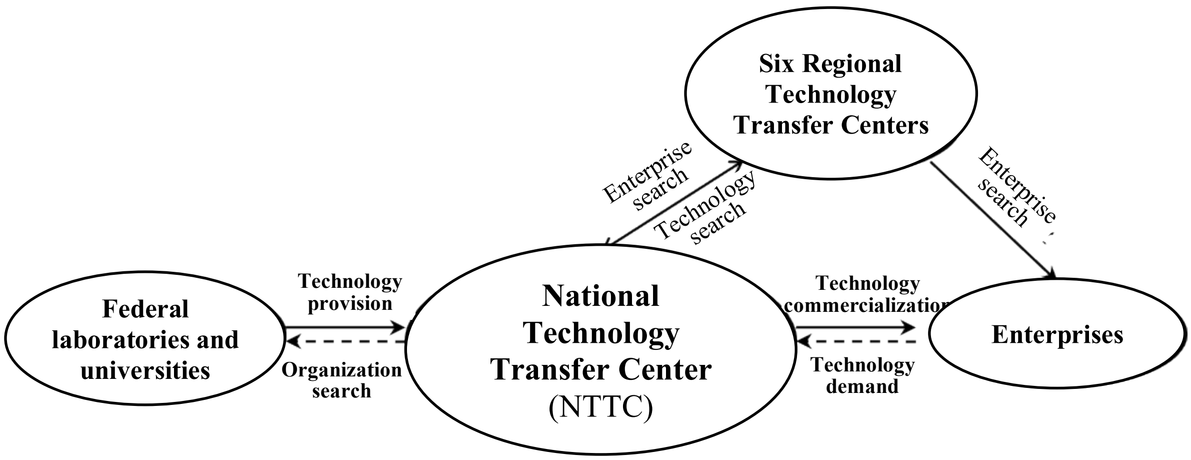
Technology transfer training covers numerous fields of study, such as IP law, engineering, technology, commercial markets, R&D, product sales, and international law. The NTTC has taught 450 training courses to 6,832 professionals. Global curriculum education is also available at its sister organization, the Center for Educational Technologies (http://www.cet.edu/).

2.4 Operating model

In its operating model, the NTTC plays a two-way information exchange role. Technology information from federal laboratories and universities is registered with the NTTC's Technology

Database Center, and NTTC searches for suitable technology transfer targets through the six Regional Technology Transfer Centers and its own business network. When enterprises have demand intentions, the NTTC builds technology transfer cooperation relationships between research institutions and enterprises to promote the commercialization of technologies. At the regional level, it effectively achieves the transfer, adaptation, development, and application of technologies (Figure 12).

Figure 12 Operating model of the NTTC



The service network of the six Regional Technology Transfer Centers (RTTCs) is divided as follows:

1. Far West Regional Technology Transfer Center (FWRTTC): The FWRTTC is responsible for the regions of Alaska, Arizona, California, Hawaii, Idaho, Nevada, Oregon, and Washington, and is an engineering research center located in the College of Engineering at the University of Southern California in Los Angeles. The FWRTTC uses telematics (远程信息) services to centralize information from hundreds of federal databases, and its staff work closely with enterprises to identify expertise and other resource conversion opportunities. The FWRTTC provides many customized services for collaboration between NASA and enterprises, such as NASA online resource workshops, NASA Tech Opps, and links to various kinds of funding and conferences.

2. Mid-Atlantic Technology Applications Center (MTAC): The MTAC is located within the University of Pittsburgh in Pennsylvania. Its primary areas of responsibility are Washington D.C. (District of Columbia), Delaware, Maryland, Pennsylvania, Virginia, and West Virginia. MTAC designed TechScout, a specialized matching system to help in the two-way positioning between enterprises and technologies. MTAC has close working relationships with Goddard Space Flight Center and Langley Research Center, which have improved the competitiveness of many enterprises.

3. Mid-Continent Technology Applications Center (MCTTC): The MCTTC is responsible for the regions of Arkansas, Colorado, Iowa, Kansas, Missouri, Montana, North Dakota, Nebraska, New Mexico, Oklahoma, South Dakota, Texas, Utah, and Wyoming. Located in

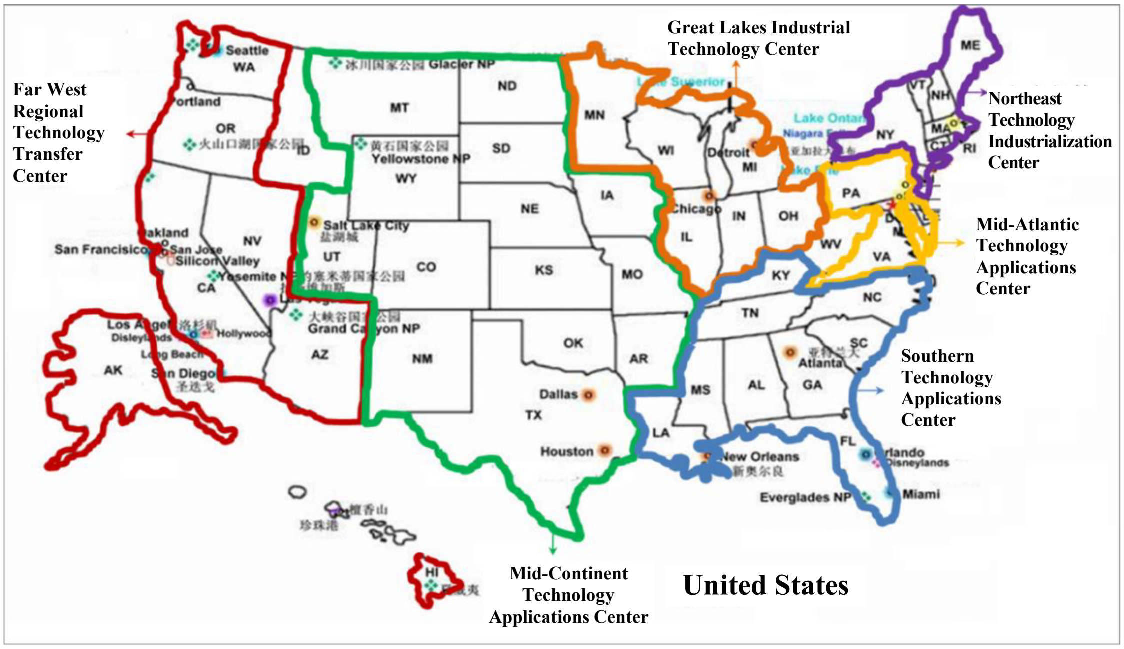
College Station, Texas, the MCTTC is under the direction of the Department of Technology and Economic Development (技术与经济发展部), which is responsible for engineering services in Texas. The MCTTC provides a link between enterprises and federal laboratories, and reports directly to Johnson Space Center. The MCTTC focuses mainly on technology commercialization in the high-tech and manufacturing industries.

4. Great Lakes Industrial Technology Center (GLITeC): GLITeC is mainly responsible for the regions of Illinois, Indiana, Michigan, Minnesota, Ohio and Wisconsin. GLITeC is managed by the Battelle Memorial Institute and is located in Cleveland, Ohio. GLITeC primarily uses its regional divisions within the six states to access and use NASA technology and expertise, particularly at the Glenn Research Center. Each year, over 500 enterprises turn to GLITeC for new market and product opportunities. GLITeC provides technical problem solving, product planning and development, and technology commercialization support services.

5. Center for Technology Commercialization (CTC): The CTC is a non-profit organization based in Westborough, MA. It is responsible for the regions of Connecticut, Massachusetts, Maine, New Hampshire, New Jersey, New York, Rhode Island, and Vermont. With seven satellite offices under its umbrella, the CTC has developed strong relationships with Northeast industries. Thanks to the CTC’s operations, NASA has expanded its collaboration with regional contractors and NASA site centers in the Northeast.

6. Southern Technology Applications Center (STAC): The STAC's primary regions of responsibility are Alabama, Florida, Georgia, Kentucky, Louisiana, Mississippi, North Carolina, South Carolina, and Tennessee. The STAC is located within the University of Florida and works closely with the Marshall Space Flight Center, Kennedy Space Center, and Stennis Space Center. All nine southeastern states have experienced economic growth as a result of the STAC. The STAC has also established three NASA centers and the NASA Southeast Science and Technology Consortium for better transfer of NASA technology and expertise.

Figure 13 The six NTTC service regions



The NTTC has overcome the obstacle where, under normal circumstances, some enterprises are not active in R&D. Utilizing national and regional interventions to remedy this situation, it has become a foundation for technology transfer. By linking all the relevant parties (i.e., suppliers and business users, R&D institutions, universities, and international markets), the NTTC provides support to regional S&T innovation and international technology transfer activities, acting as an authoritative organizer of technology brokerage services to promote access to, and use of, modern technologies.

Through the NTTC's free "Gateway" service, individual enterprises seeking technology can carry out one-on-one personalized service with the customer services of the federal laboratory system, and keep abreast of federally funded research and development projects or other information. "Gateway" provides users direct links to a variety of resources, including technical reports, technologies or facilities at NASA or other federal laboratories, etc.

The NTTC also operates a NASA website called NASA TechTracs (http://technology.nasa.gov), which provides a catalog of NASA technologies and case studies of successful technology commercialization. The "TechFinder" search tool on this site allows users to search for technologies and successful technology transfers, as well as to consult additional information. All NASA technology information is submitted to the TechTracs database, which is used as a means of tracking technology commercialization potential.

Because the NTTC has experts in multiple fields, these experts provide in-depth assessment and analysis of the technology holdings of government, universities, and individuals, greatly reducing the riskiness of corporate investments and effectively helping in the refinement and successful transfer of technologies.

Since their establishment in 1992, the six RTTCs have provided technical and operational support to thousands of clients each year, contributing to the building of S&T at the overall national level, creating complementarities and synergies in S&T innovation-related activities, and enabling resource sharing for major regional technology projects.

2.5 Main technology transfer projects

2.5.1 Mine Security and Health

The Coal Impoundment Location and Information System has become a means of detecting coal impoundment locations in West Virginia, alerting residents to emergencies and related evacuation plans, improving safety, and providing up-to-date information on coal impoundment waste lawsuits. Coal impoundments are a fundamental need for the coal mining industry, storing water and waste generated during the mining process and reducing potential hazards that could endanger citizens, wildlife, and the environment.

2.5.2 Missile Defense Program (MDA)

The Ballistic Missile Defense Technology Applications Program commercializes technology from select U.S. companies and universities funded by the Missile Defense Agency, giving a second life in the commercial marketplace to technology originally developed for use in defense in the United States.

2.5.3 NASA projects

The NTTC has cooperated with NASA since 1989, and their IP portfolio management and technology cooperation partnership has continued to develop. Smoke detectors, computerized (CT) scanners, global positioning systems (GPS), and cordless drills are some of the common technologies that originated from NASA. The NTTC enables the commercialization of federally funded technologies, linking SMEs with NASA for collaboration on technologies and products.

2.5.4 Health Technology Project (OHTP; 健康科技项目)

This project was established to assist healthcare organizations in adopting advanced federal and commercial technologies to improve quality of care, patient safety, and clinical outcomes. Through research grants and contracts, the OHTP has supported a variety of health IT projects to effectively design, develop, and deploy health IT related projects for federal, industry, and non-profit organizations.

2.5.5 Small Business Innovative Partnerships Program (SBIPP)

The SBIPP helps SMEs with development research, commercializing technologies that can improve the quality of life of Americans. Many SMEs are bridging technology and product gaps by partnering with NASA programs.

3. Federal Laboratory Consortium (FLC)

- Government research institute technology transfer model

3.1 Overview

The Federal Laboratory Consortium (FLC) was established in 1974 and certified by the Federal Technology Transfer Act of 1986 to promote and enhance technology transfer nationwide. So far, over 300 federal laboratories and centers and their affiliated departments have become FLC members. These laboratories are distributed mainly within the system of laboratories belonging to the Departments of Commerce, Defense, Energy, Transportation, and

Agriculture, the Environmental Protection Agency, and NASA. The consortium supports the technology transfer efforts of its members and potential partners, and has created a value-adding environment for them. The FLC is a nationwide network of federal laboratories that provides strategies and opportunities for linking the technologies and expertise of laboratories to the market. The *Federal Technology Transfer Act* was passed by Congress in 1986. This law requires most federal government research organizations to join the consortium, and positions the FLC as a technology transfer management organization of the National Science Foundation.

3.2 Organizational structure

The FLC's membership is composed of federal laboratories, and consists of Agency Representatives (ARs) and Laboratory Representatives (LRs). The FLC membership rules stipulate that if more than one laboratory from a federal agency is a registered member, their ARs will be appointed by a senior representative of the federal agency at the next-higher level. ARs represent the high-level interests of the higher-level federal agencies, and serve as links between the FLC and the agencies. ARs cooperate with federal laboratories, assist the FLC's leadership, make recommendations on the priority goals of agencies, and support achievement of FLC's mission. LRs, on the other hand, are appointed by each federal laboratory member and are FLC staff members. The LRs represent the individual laboratories in technology transfer and related activities, and assist the FLC in providing technical assistance. ARs and LRs participate in amending the FLC's association bylaws, policies, organizational procedures, etc., when voting in FLC national or regional elections.

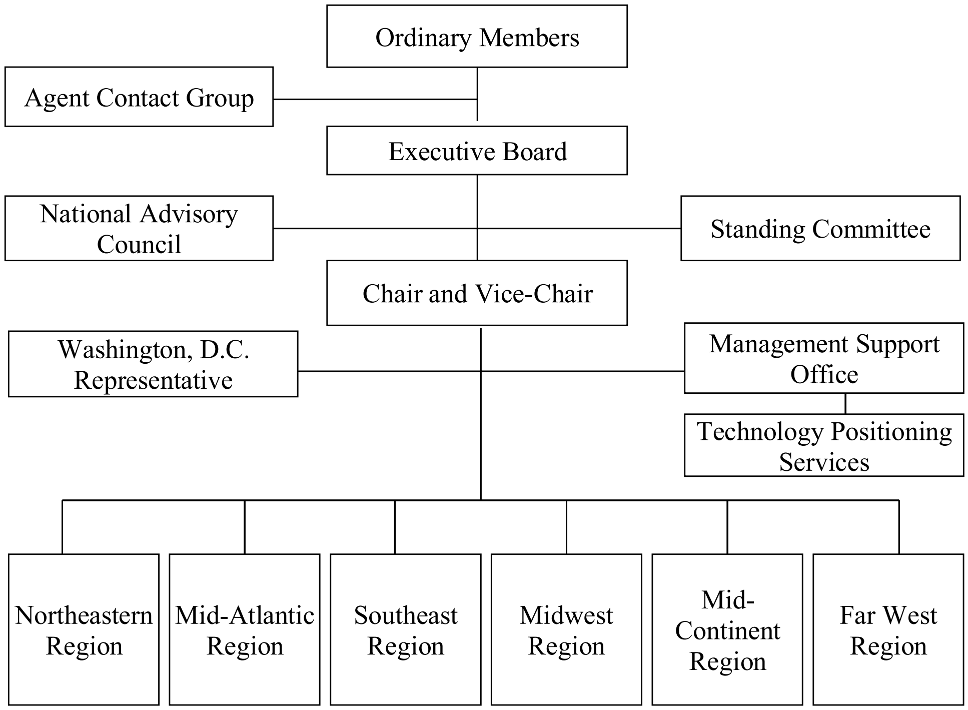
In order to manage its affairs and services more effectively, the FLC is divided into six regional branches: Far West, Midwest, Mid-Atlantic, Mid-Continent, Northeast, and Southeast. Each FLC laboratory member comes from one of these regions. Regional coordinators and deputy coordinators are elected by each region to carry out local business.

The Executive Board is the FLC's governing body, and it has four nationally elected positions: Chair, Vice-Chair, Finance Officer, and Recording Secretary. In addition, it includes representatives of host institutions, six regional coordinators, and up to six standing committee chairs. The Executive Board determines the FLC's policies and direction and sets the annual budget.

The National Advisory Council (NAC) is the Executive Board's advisor and includes the FLC's user groups (industry, academia, national and state governments, and federal laboratories). The NAC Chair and the FLC's Washington, D.C. representative may serve as ad hoc members of the Executive Board. The Washington, D.C. representative is nominated by the technology transfer community and provides the Executive Board information on legislation and policies.

The bulk of FLC's work is planned and executed by committees, which include the Awards Committee, Communications Committee, Education and Training Committee, Legal Committee, National Advisory Committee, Planning and Policy Committee, Planning Committee, and State and Local Government Committee. Committee chairs are elected and appointed by the Executive Board and report to the Executive Board on behalf of each committee.

Figure 14 Organizational Structure of the FLC



Data source: 2011 Annual Report to the President & Congress

3.3 Main functions

The FLC's primary technology transfer mission is to promote U.S. economic growth and job creation through the transfer and commercialization of technologies developed at federal laboratories. Collaboration between federal laboratories and non-federal laboratories allows research achievements to be used in technological innovation and new product development in a timely fashion. Efficient technology transfer activities ensure taxpayer investment in basic research, while the development, refinement, use, and diffusion of new technologies benefit the general public. Innovations in new products, medical treatments, services, and other areas contribute to substantive economic growth. Successful collaboration with non-federal entities yields benefits in multiple areas:

3.3.1 Stimulates the flow of ideas between government and other research sectors

3.3.2 Attracts and retains talented federal laboratory researchers

3.3.3 Accelerates the development of products and services and reduces costs

3.3.4 Supports further research by generating more licensing revenue

3.3.5 Rewards the innovation achievements of federal researchers through patent sharing

3.3.6 Creates numerous kinds of new and efficient products for healthcare, defense, homeland security, and other economic sectors that rely heavily on federally developed technology

3.4 Operations

Figure 15 FLC R&D projects in the last three years

Government agency	*2008*	*2009*	*2010*
Department of Homeland Security (DHS)	23	23	36
Department of Commerce (DOC)	2390	2386	2399
Department of Defense (DOD)	2596	2870	3248
Department of Energy (DOE)	711	744	697
Department of the Interior (DOI)	170	248	436
Department of Transportation (DOT)	23	22	22
Environmental Protection Agency (EPA)	112	112	67
Health and Human Services (HHS)	453	457	447
National Aeronautics and Space Administration (NASA)	1	1	1
Department of Agriculture (USDA)	252	259	287
Department of Veterans Affairs (VA)	221	623	895
Total	**6952**	**7745**	**8535**

Data source: 2011 Annual Report to the President & Congress

According to data submitted to the President and Congress by the Federal Laboratory Consortium, in the 2010 fiscal year (FY 2010), The FLC entered into 8,535 collaborative R&D projects between federal laboratories and with external partners. The Department of Defense (DOD) and the Department of Commerce (DOC) had the first and second highest numbers of collaborative R&D projects among government agencies, with 3,248 and 2,399 projects, respectively (Figure 15).

Figure 16 New inventions and patents of the FLC in the last three years

Government agency	*2008*	*2009*	*2010*
Department of Homeland Security (DHS)	10	32	7
Department of Commerce (DOC)	40	41	34
Department of Defense (DOD)	1018	831	698
Department of Energy (DOE)	1460	1439	1616
Department of the Interior (DOI)	7	4	5
Department of Transportation (DOT)	3	3	1
Environmental Protection Agency (EPA)	9	8	5
Health and Human Services (HHS)	437	389	363
National Aeronautics and Space Administration (NASA)	1324	1412	1722
Department of Agriculture (USDA)	133	154	164
Department of Veterans Affairs (VA)	164	150	168
Total	**4605**	**4463**	**4783**

Data source: 2011 Annual Report to the President & Congress

In FY 2010, the FLC disclosed 4,783 new inventions among federal government agencies. Of those, NASA and the DOE had the first and second highest numbers of new inventions and patents among government agencies, with 1,722 and 1,616, respectively (Figure 16). The FLC also licensed 13,542 federal laboratory technologies. Of these, DOE and NASA had the first and second highest number of government agency technology licenses, with 6,224 and 3,901, respectively (Figure 17).

The FLC has earned approximately U.S. $144 million in licensing revenue from federal technology transfers (Figure 18). Although the FLC's collaborative research projects, new inventions, and licenses have all grown in the last three years, licensing revenue has seen declines year by year.

Figure 17 Licenses issued by the FLC in the last three years

Government agency	*2008*	*2009*	*2010*
Department of Homeland Security (DHS)	18	63	458
Department of Commerce (DOC)	29	40	41
Department of Defense (DOD)	365	432	397
Department of Energy (DOE)	6196	5752	6224
Department of the Interior (DOI)	19	21	28
Department of Transportation (DOT)	5	2	3
Environmental Protection Agency (EPA)	37	40	37
Health and Human Services (HHS)	1675	1584	1941
National Aeronautics and Space Administration (NASA)	3912	4181	3901
Department of Agriculture (USDA)	328	329	343
Department of Veterans Affairs (VA)	153	163	169
Total	**12737**	**12607**	**13542**

Data source: 2011 Annual Report to the President and Congress

Figure 18 Licensing revenue of the FLC in the last three years

(Units: USD thousands)

Government agency	*2008*	*2009*	*2010*
Department of Homeland Security (DHS)	0	0	0
Department of Commerce (DOC)	293	336	237
Department of Defense (DOD)	16057	16439	13424
Department of Energy (DOE)	49318	43496	40642
Department of the Interior (DOI)	79	89	80
Department of Transportation (DOT)	18	44	17
Environmental Protection Agency (EPA)	1038	849	536
Health and Human Services (HHS)	97609	85059	80923
National Aeronautics and Space Administration (NASA)	2802	3144	3850
Department of Agriculture (USDA)	3978	5383	3646
Department of Veterans Affairs (VA)	141	202	167
Total	**171333**	**155041**	**143522**

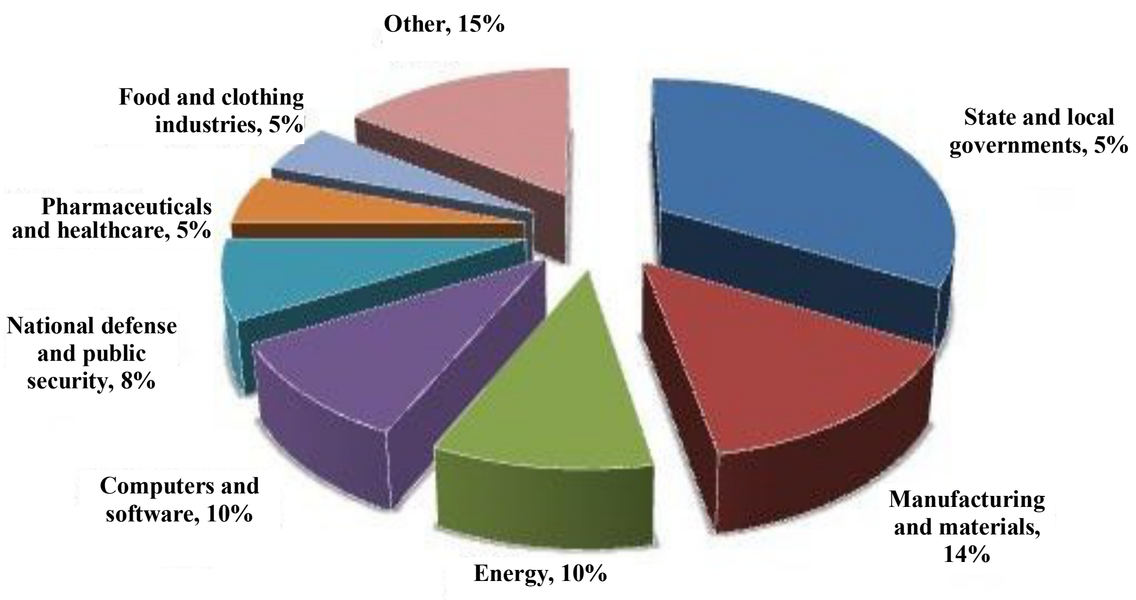
Data source: 2011 Annual Report to the President & Congress

3.5 Achievements and impact

The FLC actively promotes technology transfer and encourages multilateral cooperation among organizations. For example, the FLC recently presented the Federal Law Enforcement Training Center (FLETC) and the Naval Air Warfare Center Training Systems Division (NAWCTSD) with an Institutional Collaboration Award for their collaboration and efforts in the use of force training systems. Cooperation between the FLETC and the NAWCTSD led to the invention of a prototype simulator that enhances the training, performance and safety of law enforcement personnel throughout the United States. The NAWCTSD developed the system with DOD technology and law enforcement expertise from the FLETC, and it has been put into use at numerous locations.

The more than 200 requests for technology positioning services the FLC received in 2011, apart from government agencies, came mainly from the manufacturing industry, energy companies, and the computer software industry, accounting for 14%, 10%, and 10% of the requests, respectively (Figure 19). The FLC coordinates technical and commercial resources, and facilitates communication and cooperation between federal laboratories and technology-applying agencies and enterprises.

Figure 19 FLC technology positioning requests in 2011 by category



Data source: 2011 Annual Report to the President & Congress

4. Stanford University Office of Technology Licensing (OTL)

- University research institute technology transfer model

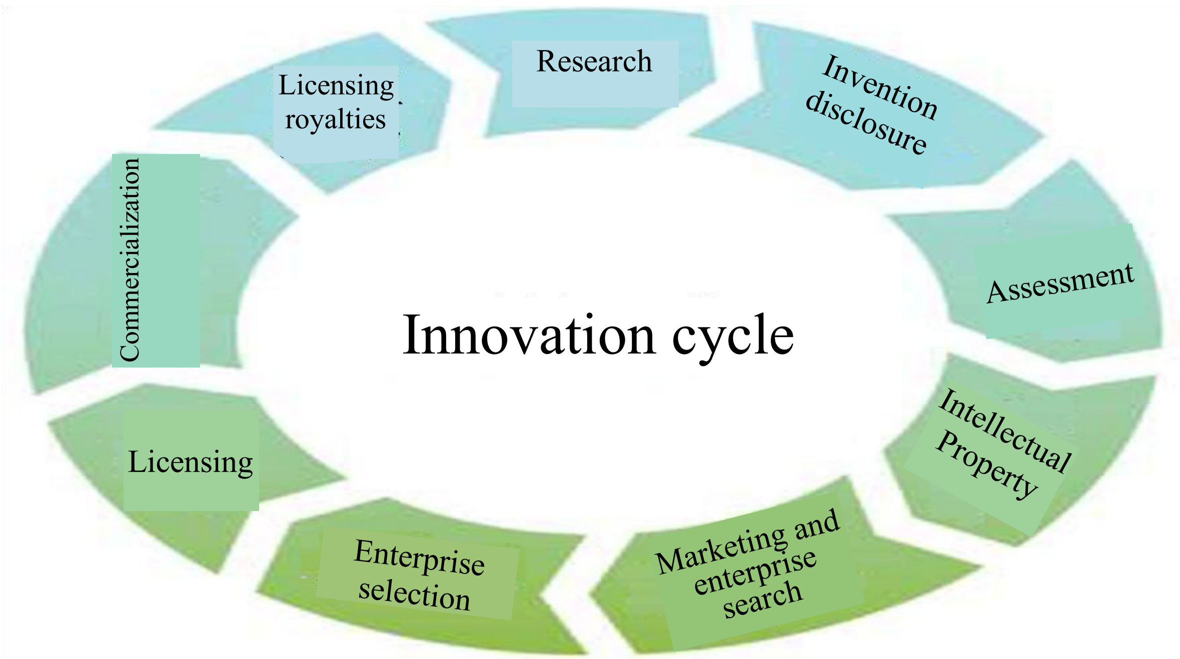
4.1 Overview

Stanford University's Office of Technology Licensing (OTL) was established in January, 1970, and at first consisted of just one manager, Niels Reimers, and one secretary, Sally Hines. The OTL has helped Stanford University resolve financial difficulties in its invention licensing activities. In the first nine months of its existence, the minimum technology licensing revenue negotiated by the OTL exceeded all of its office expenses, including salaries. In its first year, it generated U.S. $55,000 in revenue from just three agreements. The OTL specializes in managing the patenting and licensing of Stanford University's inventions, using third parties to do so, and this has become the standard model for technology transfer by universities in the United States. The OTL's objectives are to facilitate the transfer of technology from Stanford University, apply it to social development, and generate revenue to further support the University's research and education.

4.2 Operating model

The OTL has a standardized technology transfer process (Figure 20).

Figure 20 The OTL's technology transfer process



Data source: OTL

4.2.1 Disclosure

The inventor submits an "Invention Disclosure Form" online and obtains the relevant patent, marketing and financial information (e.g., invention participants, sponsors and publications, etc.), which is then recorded on file by the OTL.

4.2.2 Distribution management

After the OTL receives disclosure records, the invention will have a case file number and be managed by a technology manager, who will be solely responsible for the entire process thereafter.

4.2.3 Assessment

The technology manager will have a preliminary discussion with the inventor on the manufacturing feasibility, novelty, potential application prospects and market for the invention, though not all inventions will be transferable commercially. If an invention can be transferred, then an initial licensing strategy will be produced right away. Different inventions require different licensing strategies. For example, for a basic new scientific instrument that is likely to find broad applications, the OTL will usually license on a non-exclusive basis. In contrast, if an invention needs substantial investment from an enterprise, the OTL will license it on an exclusive basis. An exclusive license creates the incentive for enterprises to invest venture capital. Licensing strategies involve assorted market risks, and at times it is necessary to sign confidentiality agreements.

4.2.4 Patent application

Technology managers decide whether Stanford University will patent inventions based on the existing information. Since patent application fees are high (U.S. $6,000 to 10,000), the OTL does not apply for patents for all inventions. Therefore, if there are already interested prospective enterprises, that will be very beneficial. The filing and execution of patent applications are usually done by an outside patent law firm. The technology manager will select one based on the professional level of the lawyers, their experience with similar cases, and the inventor's preferences.

4.2.5 Marketing and license negotiations

While the patent application is underway, the technology manager will begin licensing negotiations with potential companies. The technical manager will contact interested companies and give them the opportunity to participate in the invention's assessment. If a company shows strong interest, then the technology manager will prepare a licensing proposal. Each license has specific terms and conditions. For example, a startup company can use its shares or product launch proceeds to pay the high upfront costs that the company normally would not be able to afford.

4.2.6 Monitoring progress

The signing of the license agreement marks the beginning of a long-term cooperative relationship, and the technology manager will monitor the technology's use within the licensing period. Most agreements require enterprises to provide regular financial or development reports.

4.2.7 Distribution of licensing revenue

The OTL collects all licensing royalties. After the end of Stanford University's fiscal year (August 1), the OTL takes 15% of the income from the technology licensing fee for administrative expenses, then deducts the patent fees that cannot be reimbursed by the company, and the remaining portion of the net royalties is distributed in the ratio of one-third for the inventor, one-third for the department, and one-third for the university. The licensing royalties of the department and university may only be used for research and educational purposes, however.

4.2.8 Sharing of equity

The OTL may sometimes accept shares in lieu of cash for part of the license issuance fee. After 15% is deducted for administrative expenses, inventors receive one-third of the equity, and the remaining portions are managed by Stanford's management company, and go toward the

OTL's graduate student scholarship fund.

4.2.9 Revision of licenses

When new circumstances arise, and it is necessary to reassess the licensing relationship, either party may request amendment of the agreement at any time during the licensing period.

4.3 Achievements and impact

Figure 21 The OTL's licensing revenue and main sources

(Units: USD million)

Rank	1970-1980	1980-1990	1990-2000	2000-2010
1	Fluorescence-activated cell sorting	DNA cloning	DNA cloning	Hypertext search technology
2	WYLBUR software	FM sound synthesis	Phycobiliproteins	Functional antibodies
3	Mediphor software	X-ray scanning	FM sound synthesis	Optical fiber amplifiers
4	Other	Other	Other	Other
Total income	**2.7**	**59**	**393**	**878**

Data source: 40 Years of Discovery (OTL 40th anniversary report)

In FY 2012, the OTL received 504 patent disclosure applications, generated licensing revenue from a total of 660 technologies, and completed 115 license approvals. The OTL received a total of U.S. $76.7 million in royalties from licenses, 36 of which generated more than U.S. $100,000 each in licensing revenue. Another U.S. $1.2 million in revenue was received from equity transfers.

Royalty revenue has grown significantly over the 40 years since the OTL was founded (Figure 21), from U.S. $2.7 million in the 1970s to U.S. $878 million in the first decade of the 21st century. From 1970 to 2011, the OTL generated U.S. $1.4 billion in patent licensing revenue.

Stanford emphasizes industry-oriented technology innovation, and the OTL has generated considerable patent licensing revenue by converting many technologies. The largest in scale to date was the hypertext search technology in 1996, with licensing revenue reaching U.S. $337 million, followed by functional antibody technology in 1984, with U.S. $3.189 million. In 1981, the OTL patented the "gene splicing" technology jointly invented by Professors Stanley Cohen and Hebert Boyer. The technology was granted to many companies under non-exclusive licenses, which launched the global biotechnology industry.

Figure 22 Representative OTL technological achievements

Year	Technology	Licensing fees
1971	FM sound synthesis	22.9
1974	Recombinant DNA technology	225
1981	Phycobiliproteins	46.4
1981	Optical fiber amplifiers	48.4
1981	MINOS	4.1
1984	Functional antibodies	318.9
1987	Selective amplification of polynucleotides	20.3
1990-1992	DSL discrete multi-tone technology	29.6
1993	Microarrays	2
1994	In vivo bio-optical imaging	7.2
1996	Hypertext search technology (licensed to Google)	337
2004	Refocusing photography technology	0.15

Data source: OTL

II. Germany

1. Basic information on Germany

Population: 81.73 million (ranked 16th)
GDP: U.S. $2.8144 trillion (ranked fifth)

In terms of the scale of IP in Germany, patents increased from 135,000 in 2000 to 176,000 in 2011; trademarks increased from 367,000 to 663,000; and industrial designs increased from 30,000 to 113,000, surpassing the United States. GDP also increased, from U.S. $2.4908 trillion in 2000 to U.S. $2.8144 trillion in 2011, ranking fifth in the world (Figure 23). Germany's R&D represented 2.84% of GDP in 2011.

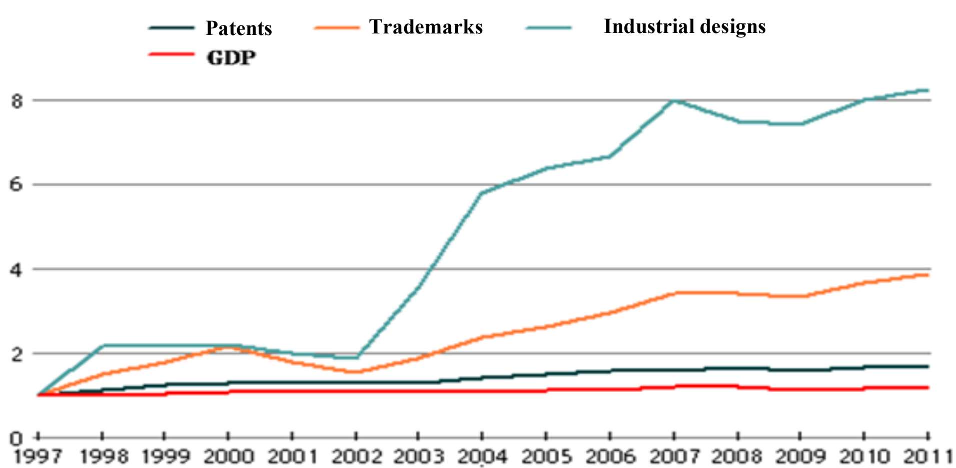
Figure 23 Intellectual property and GDP in Germany

Year	*Patents*	*Trademarks*	*Industrial designs*	*GDP (USD trillion)*
2000	135,003	366,545	30,235	2.4908
2001	137,722	307,345	27,409	2.5285
2002	132,706	264,888	25,724	2.5288
2003	134,821	316,298	48,244	2.5193
2004	146,475	404,603	79,546	2.5486
2005	153,973	448,577	87,331	2.5660
2006	161,282	505,555	91,033	2.6609
2007	164,076	577,558	109,401	2.7479
2008	172,104	583,421	102,656	2.7777
2009	162,522	570,292	101,712	2.6353
2010	173,532	625,258	109,576	2.7325
2011	175,550	663,269	112,884	2.8144

Data source: World Intellectual Property Organization

Growth of German IP applications of all kinds has outpaced economic growth since 1997, especially industrial designs, followed by trademarks. Patents grew by only slightly more than GDP (Figure 24).

Figure 24 Comparison of IP filings and economic growth in Germany

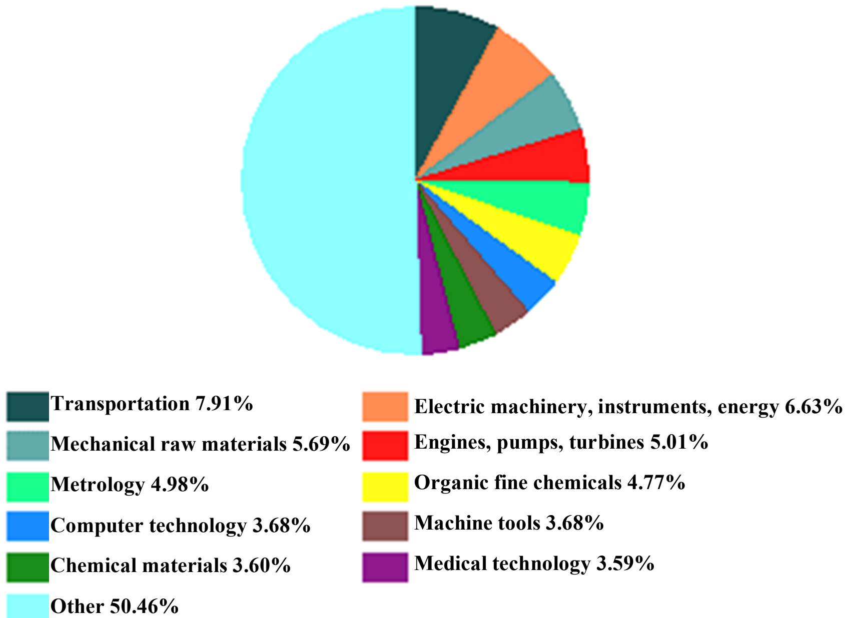


Note: Set equal to 1 in 1997

Data source: World Intellectual Property Organization

Transportation had the highest share of patent applications from 1997 to 2011, at 7.91%, followed by electric machinery, instruments and energy (6.63%), mechanical materials (5.69%), and engines, pumps and turbines (5.01%).

Figure 25 Technical fields of German patent applications



Data source: World Intellectual Property Organization

2. Steinbeis Foundation (SF) of Germany

- “Officially run with private support” (官办民助) technology transfer model

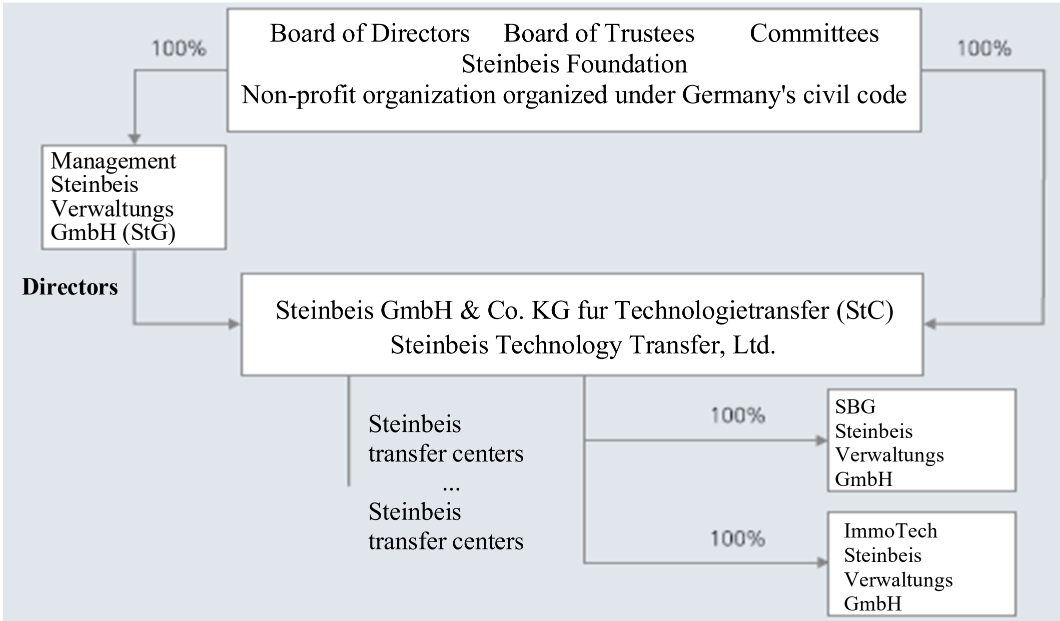
2.1 Overview

The Steinbeis Foundation (SF) was founded in 1868 by Ferdinand von Steinbeis. The SF was dissolved in 1923 during the inflationary crisis in Germany, but in 1971 it was reestablished as a non-profit organization under the German civil code, with its headquarters in Stuttgart, in southwest Germany. The SF promotes the development of SMEs through the "Technical Advisory Services" of state universities. In 1983, Johann Löhn became the first Government Commissioner for Technology Transfer, and assumed the chairmanship of the Board of Trustees of the SF at the same time. The SF has expanded rapidly since then, with the establishment of "transfer centers" at several universities and research institutes, including the Steinbeis University Berlin, which was founded by Johann Löhn in 1998. Over the past 40 years, the SF has grown from 16 transfer centers to more than 750, and has a network of more than 900 enterprises worldwide.

2.2 Organizational structure

In 1998, after a year of restructuring, the SF established a company dedicated to business transfer, Steinbeis Technology Transfer, Ltd., under the leadership of the nonprofit Steinbeis Foundation, effective January 1, 1998.

Figure 26 Organizational structure of the SF in 1998



Data source: Steinbeis 1983-2008

2.2.1 Steinbeis Foundation

As it continues to pursue non-profit operations, the Foundation's income is used primarily for non-physical technology transfer, such as lectures, presentations, and publications. In essence, its non-profit activities only include direct knowledge transmission. The SF's commercial activities are limited to projects that involve managing company equity or pre-market competition transfers. The SF is the sole shareholder of Steinbeis GmbH & Co. KG fur Technologietransfer (Steinbeis Technology Transfer, Ltd., or StC) and Steinbeis Verwaltungs GmbH (StG, the company that holds and manages StC's financial claims).

2.2.2 Board of Directors

Following a reorganization, the SF is governed by a board of directors consisting of a chair and up to three directors. The chair is responsible for managing day-to-day affairs. All directors represent the Foundation in judicial and nonjudicial matters. Each member of the Board of Directors has his or her own executive powers. The earliest Board of Directors consisted of three permanent officers: Johann Löhn, Josef Pfeffer, and Walter Weiss.

2.2.3 Board of Trustees

As before the reorganization, the Board of Trustees is composed of 23 ordinary members and 23 alternate members from the fields of politics, public administration, industry, science, academia, and research institutions. Its duties remain unchanged: determining the work of the Foundation and electing the members of the Board of Directors. Board of Trustees members include a chair and six members who can serve as replacements for the chair. The purpose of the Board of Trustees is to propose management activities to the Management Committee and supervise them.

2.2.4 Steinbeis Verwaltungs GmbH (StG)

StG manages equity held by the company, and carries out company-wide management tasks in support of the SF. Its principal officer is also Johann Löhn.

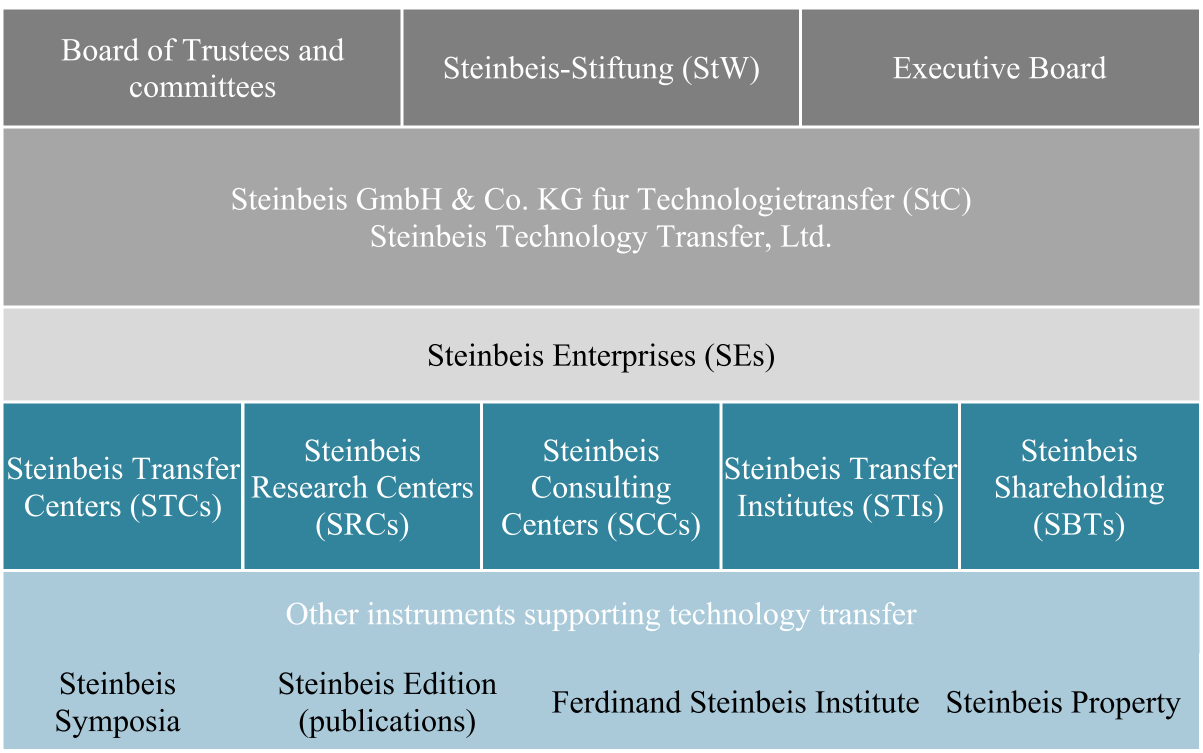
2.2.5 Steinbeis Technology Transfer, Ltd. (StC)

StC manages commercial technology transfer activities, which essentially take the form of projects. This sometimes involves the manufacture and sale of products if some projects are developed by a foundation or company in which the SF has a direct or indirect stake. StC is also involved in advising on and controlling the equity of the company, and it can also have equity participation in companies with similar objectives as StC, which is the sole shareholder of SBG Steinbeis GmbH. All but a minority of the SF's staff are employed by StC.

2.2.6 Steinbeis transfer centers and enterprises

Even though the business interests of the SF have been transferred to an independent corporation, the Steinbeis Transfer Centers (STCs) and Steinbeis Enterprises (SEs) are legally separate units as before. The STCs and SEs are arranged under StC's umbrella as in a corporation, but if an SE has retained a charitable nature, it is affiliated with the SF.

Figure 27 Organizational structure of the SF today



Data source: Steinbeis Foundation

The SF has further expanded its organizational structure in recent years for better development, forming a network structure with the Steinbeis Transfer Centers as pillars (Figure 27). The transfer institute at Steinbeis University Berlin also continues to grow. In addition to providing staff development training, it plays an important role in the consulting and R&D

operations of the entire SF organization. 2005 also saw the establishment of “Steinbeis Consulting Center, Ltd.” (Steinbeis Beratungszentren GmbH, SBZ) and "Steinbeis Research and Development Center, Ltd." (Steinbeis Forschungs- und Entwicklungszentren GmbH, SFZ). Both are wholly-owned commercial companies under StC, and they made huge contributions to the Steinbeis organization network in just one year. The technology transfer centers are also directly under StC’s umbrella. SBZ has established several Steinbeis Consulting Centers since 2005, which focus on SMEs and public institutions. Their main activities include business consulting, technology consulting, regional development, and economic development services. They enable SMEs to access knowledge and technology sources, and their services are free of charge. Steinbeis Research and Development Center, Ltd (SFZ) guides the Steinbeis Research Centers (SRCs) in market participation and technology transfer-focused R&D. Although the SRCs' main business is commercial projects, they also provide a small number of public services and carry out some R&D projects and grant projects. Steinbeis Innovations GmbH (SIG) was also established at the same time in 2005 under SFZ, and the Steinbeis Innovation Centers (SICs) under SIG are all charitable in nature.

In addition to 496 transfer centers, the Steinbeis organization also has a variety of new ventures supporting the efficient transfer of technology, including 42 research centers, 58 consulting centers, 102 Steinbeis Transfer Institutes, and 46 companies.

2.3 Business philosophy

The SF network has been molded step by step through expertise and technology transfers in a market-oriented entrepreneurial process. The SF promotes efficient collaboration between the global scientific and academic communities on one hand, and carries out trade and industrialization on the other. In addition, the SF focuses on providing a direct link to existing technical resources while adhering to market rules. By providing its own knowledge and skills to clients, the SF promotes the advancement of project partners' expertise, thereby driving their success.

2.3.1 Applying research achievements

The Steinbeis technology network has access to several research institutions, especially universities, and can directly or indirectly translate promising scientific knowledge into solutions for enterprise-related technological difficulties.

2.3.2 Providing expertise

The Steinbeis network makes new opportunities and solutions available to customers and project partners. The SF's services include technology transfer, technology development, and marketing. The SF's expertise is conveyed to Steinbeis Enterprises through Steinbeis publications and numerous activities. The SF's technology transfer capacity continues to increase through the establishment of new transfer enterprises.

2.3.3 Imparting skills

The services provided by the SF involve consulting, staff development training, research, assessment, and customized expert reports. By continuously imparting professional knowledge, the SF drives the commercialization of knowledge and technology, which expands the basic skills of SF's customers.

2.3.4 Operating as a technology network

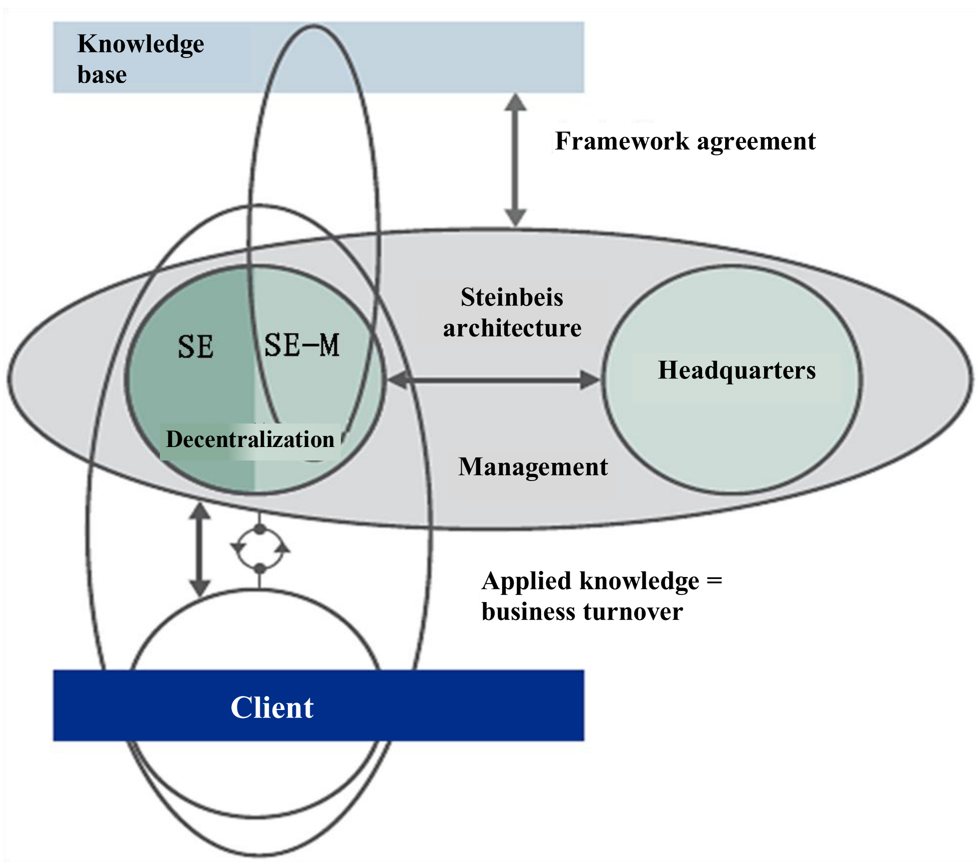
The SF network is a decentralized structure built on parallel hierarchies. Each Steinbeis Enterprise is managed as a "Steinbeis business within a business." Although they are all within the Steinbeis group, each enterprise director can exercise their rights independently, and can directly carry out confidential interaction with their clients.

2.3.5 Addressing the requirements of citizens and private enterprises

By providing solutions and services, the SF views itself as a partner to the public sector.

2.4 Operating model

Figure 28 The SF's operating model



Data source: Steinbeis 1983-2008

The key to the SF's success lies in the creation of a common structure within a decentralized organization of activities. Each SE has management and operational responsibilities, which are executed according to the "transfer specialist" model created by Ferdinand Steinbeis. In each SE, the manager makes his or her own decisions, but stays consistent with the central framework. Under normal circumstances, SEs belong to the SF from a legal point of view, but some enterprises are now independent, even if they still adhere to the "transfer center" principle. Managers are free to draft quotations, handle expenses, recruit staff, and maintain the business, and are also free to decide on quotations, fees, and terms based on their clients. They are also in charge of marketing the enterprise's services, converting expertise into turnover, and determining salary levels. Ultimately, the individual managers ensure that everything is sufficient to safeguard the enterprise's operations. When servicing customers, the managers and their SEs take on the role of suppliers, while the central department, namely, the head office, maintains the formal framework. Externally, both the headquarters and the SEs are accountable to the customer; internally, the managers are accountable to the headquarters (Figure 28).

2.5 Operations

In 2012, the SF's technology transfer business network consisted of 918 enterprises. These enterprises collaborate extensively with SEs, and 101 new enterprises joined the Steinbeis technology network in 2012 alone. In 2012, the SF achieved a total turnover of EUR 141 million, an increase of 13.7% compared to EUR 124 million in 2008.

The number of SEs has been growing steadily, with a slightly higher increase in the number of enterprises in 2005 due to an expansion of the organizational structure (Figure 29).

Figure 29 Number of Steinbeis Enterprises

Year	*Turnover (million Euros)*	*No. of Steinbeis enterprises*
2000	80.87	436
2001	82.24	470
2002	80.86	516
2003	8236	565
2004	83.01	621
2005	88.79	713
2006	109.58	722
2007	108.55	739
2008	123.56	765

Data source: Steinbeis 1983-2008

The SF's staff includes salaried employees, experts, and freelancers (Figure 30).

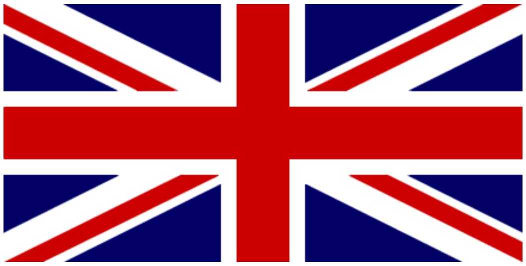
Figure 30 Number of SF employees

Year	*Regular staff*	*Experts*	*Freelancers*
2000	988	641	2300
2001	938	784	2389
2002	988	786	2440
2003	984	657	2373
2004	1071	713	2533
2005	1185	796	2680
2006	1219	869	3071
2007	1340	957	3348
2008	1383	991	3879

Data source: Steinbeis 1983-2008

III. The United Kingdom

1. Basic information on the United Kingdom



Population: 62.64 million (ranked 22nd)
GDP: U.S. $2.0342 trillion (ranked seventh)

In terms of the scale of IP in the UK, patents increased from 46,000 in 2000 to 51,000 in 2011; trademarks increased from 184,000 to 322,000; and industrial designs increased from 5,000 to 53,000. GDP also increased, from U.S. $1.7112 trillion in 2000 to U.S. $2.0342 trillion in 2011, ranking seventh in the world (Figure 31). The UK's R&D represented 1.77% of GDP in 2011.

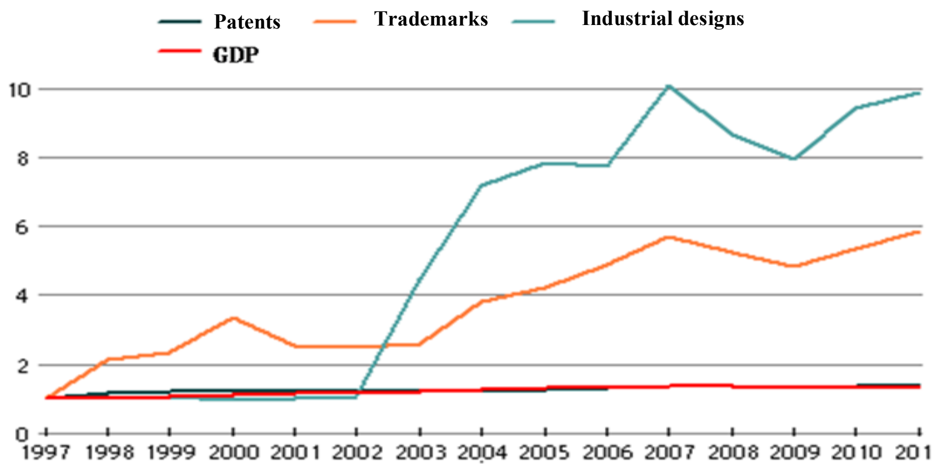
Figure 31 Intellectual property and GDP in the UK

Year	*Patents*	*Trademarks*	*Industrial designs*	*GDP (USD trillion)*
2000	46,310	183,523	5,228	1.7112
2001	46,864	139,785	5,321	1.7651
2002	45,275	136,326	5,771	1.8120
2003	45,141	140,753	23,991	1.8759
2004	46,179	209,446	38,451	1.9313
2005	47,068	230,495	42,046	1.9716
2006	48,030	267,592	41,555	2.0230
2007	50,197	312,544	53,988	2.0931
2008	51,433	286,901	46,518	2.0701
2009	48,767	265,517	42,595	1.9795
2010	50,865	293,618	50,504	2.0209
2011	50,749	322,374	52,912	2.0342

Data source: World Intellectual Property Organization

Growth in industrial design and trademark filings in the UK has outpaced economic growth since 2002, especially industrial designs, but patent growth has been comparable to that of GDP growth (Figure 32).

Figure 32 Comparison of IP filings and economic growth in the UK

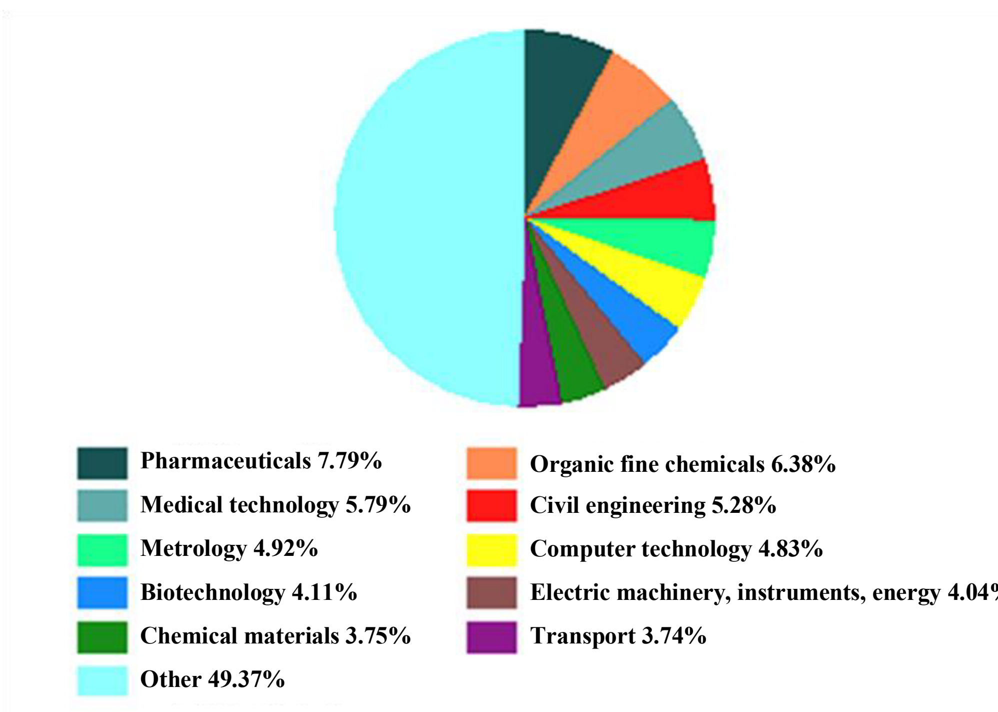


Note: Set equal to 1 in 1997

Data source: World Intellectual Property Organization

Among patent applications from 1997 to 2011, the highest share was in the pharmaceuticals field, with 7.79%, followed by organic fine chemicals (6.38%), medical technology (5.79%), and civil engineering (5.28%) (Figure 33).

Figure 33 Technical fields of UK patent applications



Data source: World Intellectual Property Organization

2. British Technology Group (BTG)[2]

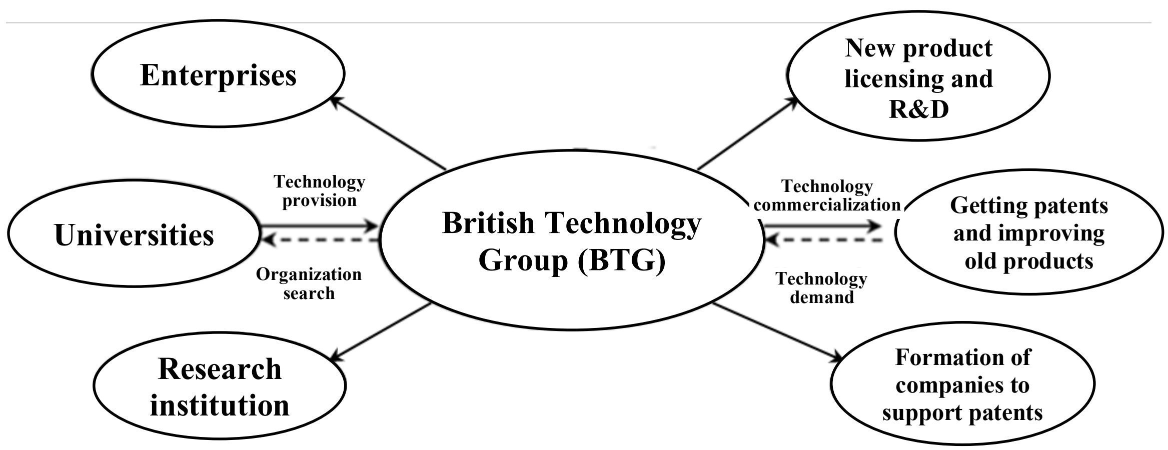
- Successful transition from technology transfer intermediary to healthcare company

2.1 Overview

The British government formed the National Research Development Corporation (NRDC) in 1948 to commercialize the achievements of government-funded research. In 1981, the NRDC was merged with the National Development Council and the National Enterprise Board to form the British Technology Group (BTG). BTG was privatized due to the British government's repeal of regulations governing state monopolies on government-funded technological achievements in 1984. Following an intense bidding process, the UK Department of Trade and Industry sold BTG to a consortium for GBP 27.75 million in March 1992. BTG was listed on the London Stock Exchange in 1995. In 2003, the inventor whose MRI technology BTG had licensed was awarded the Nobel Prize. BTG ultimately shifted the company's strategic orientation to focus on life sciences in May 2005, however, transforming it into a specialized healthcare company.

2.2 Before transformation

Figure 34 Technology transfer operating model of BTG before its transformation



BTG is a technology commercialization company that creates value by investing in IP and technology, earning profits through technology licensing, patent assessment, and sales of equity. BTG searches for, develops, and commercializes valuable life sciences IP, and applies this IP and commercial expertise in the health and high technology sectors using a multi-disciplinary approach.

BTG collaborates with universities, enterprises, and research organizations to identify complementary IP and technologies that are potentially valuable. At the same time, BTG commercializes technologies through three channels: first, by granting a license to a company in exchange for a royalties or a down payment, after which the company will refine the technology and market the end product; second, by getting a patent validated and used in products already on the market; and third, by choosing to establish a company to back a technology, and ultimately selling equity to other investors or enterprises.

[2] Translator's note: Boston Scientific acquired BTG in 2018-2019.

BTG focuses its investment portfolio on five areas of technology: 1. aging and neuroscience (medical drugs for pain, neurological disorders, and cardiovascular diseases); 2. Biotech and pharmaceuticals (used to accelerate pharmaceutical production chain therapeutic, diagnostic, and rescue technologies); 3. oncology (cancer treatment, adjuvant cancer therapy, and products to support cancer treatment); 4. semiconductors, optoelectronics, and nanotechnology (using low-power methods to improve system communication and storage functions, various optical components and devices including lasers and monitors, materials, manufacturing processes, etc.); and 5. development of strategic businesses to promote commercialization of IP and identify partnership opportunities, and to quickly identify opportunities outside the Group.

BTG generated revenues of GBP 52.88 million in 2004, the last year before its transformation (Figure 35). GBP 27.8 million of that was royalty income from existing products. Thirty-four technologies were acquired, 39 development projects were initiated, 17 licensing agreements were signed, and GBP 5.4 million was invested in nine enterprises.

Figure 35 Revenues of BTG before its transformation

Item	*2000*	*2001*	*2002*	*2003*	*2004*
Total revenue (GBP million)	36.40	37.81	33.15	31.53	52.88
Growth rate		3.87%	-12.32%	-4.89%	62.71%
Total					**191.77**

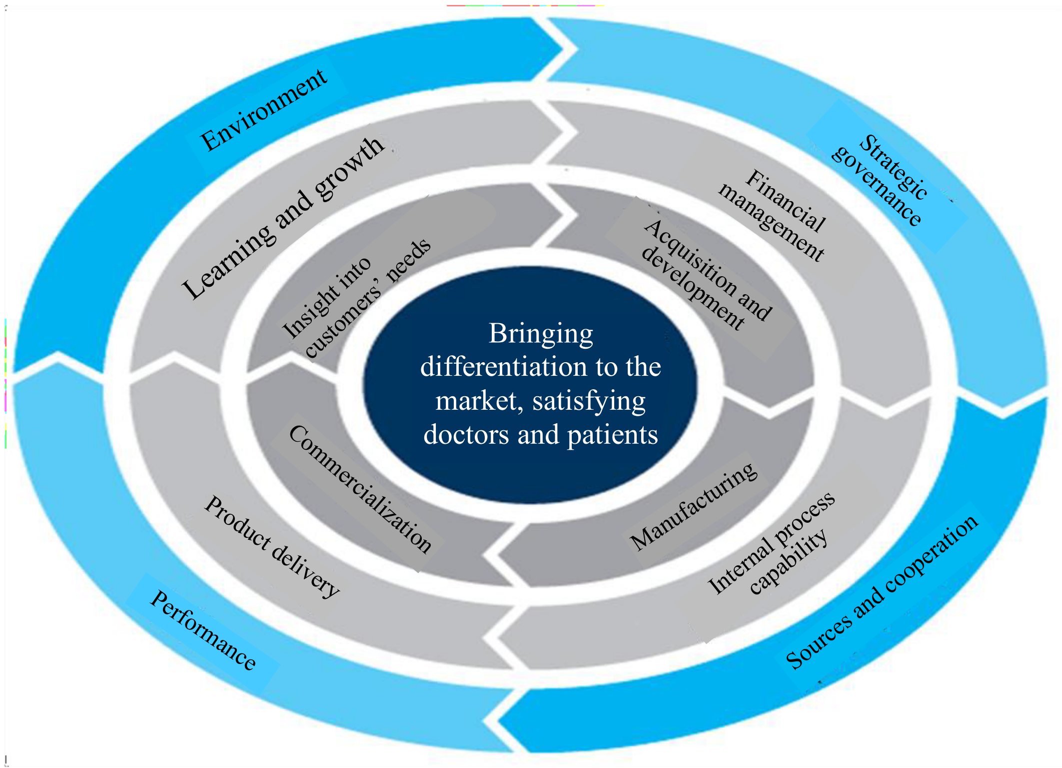
Data source: BTG Annual Report 2004

2.3 After transformation

BTG adjusted the company's strategic orientation in May 2005 to focus on life sciences, and transformed itself from a technology transfer intermediary into a specialized healthcare company. BTG's reorientation, which brought major changes in its strategy, operations, and personnel, was aimed at driving the Group's profitability and creating a business platform for sustainable growth in the future.

Since then, BTG has focused on developing new medical products, especially drugs in the oncology, aging, and neurology areas. BTG has access to research programs from around the world. It protects and develops products until they are validated, and then licenses them to enterprise partners that bring them to market. With its licensing fee income from sales of products increasing steadily, BTG has gradually expanded its drug distribution business, and increased value added through drug development.

Figure 36 BTG's post-transformation S&T healthcare model



Data source: BTG Annual Report 2013

BTG has positioned itself as a life sciences enterprise that develops and commercializes innovative medical products. Revenue has shown strong growth since the transformation (Figure 37), rising from GBP 85 million in 2008 to GBP 234 million in 2012, with annual growth averaging 35.12% over the past five years, and operating and administrative expenses have also been greatly reduced. BTG's three main business areas now are biotechnology licensing, specialty drugs, and interventional medical programs.

Figure 37 Revenues of BTG after its transformation

Item	***2008***	***2009***	***2010***	***2011***	***2012***
Total revenue (GBP million)	84.80	98.50	111.40	197.00	233.70
Growth rate		16.16%	13.10%	76.84%	18.63%
Total					**72540**

Data source: BTG Annual Report 2013

In 2012, biotechnology licensing, revenues from the specialty drugs, and interventional medical programs were GBP 100.4 million, GBP 97.2 million, and GBP 36.1 million, respectively, and their shares of total revenue were 42.96%, 41.59%, and 15.45% (Figure 38).

Figure 38 BTG's three main areas of business and sources of revenue

Rank	*Biotechnology licensing*	*Specialty drugs*	*Interventional medical programs*
1	Zytiga (prostate drug)	CroFab (rattlesnake immunity crystals)	LC Bead, DC Bead, and Bead Block
2	Two-Part Hip Cup (hip replacement prosthesis)	DigiFab (cardiac stimulant)	Brachytherapy (prostate cancer therapy)
3		Voraxaze (kidney detoxifier)	
Revenue (GBP million)	**100.40**	**97.20**	**36.10**
Share	**42.96%**	**41.59%**	**15.45%**

Data source: BTG Annual Report 2013

A clear corporate strategy has allowed BTG to enjoy good momentum and generate high profits for shareholders. BTG's main shareholders are banks and agencies, holding 312 million shares representing 94.9% of the total. They are followed by private shareholders, limited companies, BTG's employee share trust, insurance companies, and pension funds (Figure 39).

Figure 39 BTG shareholder structure and percentages

Type of shareholder	*Number of shareholders*	*Number of shares*	*Percentage of total shares*
Banks and agencies	956	311,588,514	94.9%
Private shareholders	8969	12,061,479	3.7%
Limited companies	65	788,206	0.2%
BTG's employee share trust	1	1,063,029	0.3%
Insurance companies and pension funds	125	2,775,643	0.9%

Data source: BTG Annual Report 2013

BTG now has a market value of GBP 1.356 billion. The share price of GBP 376.1 is up 6% compared to GBP 355 a year ago, and shows an overall upward trend (Figure 40).

Figure 40 BTG stock price movements

Data source: London Stock Exchange

IV. Insights from international technology transfer models

1. Having clear policies and regulatory guidance

The United States has nearly 30 laws on technology transfer, forming a complete legal system for the commercialization and smooth transfer of technological achievements.

Although a handful of U.S. universities began commercializing the achievements of their scientific laboratories as early as the 1920s, it was a report written by Vannevar Bush, "Science, the Endless Frontier," that really made "academic technology transfer" a formal concept. The report noted the value of university research as a vehicle for accelerating the flow of knowledge and strengthening the economy. It helped lead to the establishment of the National Institutes of Health (NIH), the National Science Foundation (NSF), and the Office of Maritime Research (OMR). Through the 1960s and 70s, however, due to the absence of a government policy defining property ownership of federally funded inventions, patents were owned by the federal government, limiting the flow of technology to industry. As a result of this legal deficiency, the U.S. federal government owned 28,000 patents in 1980, yet less than 5% were licensed to companies as commercialized products. It was in this context that the United States passed the *Patent and Trademark Law Amendment Act* in 1980.

Known as the *Bayh-Dole Act*, the law gave universities and enterprises the right to retain ownership of federally funded inventions, laying down the legal framework for technology transfer from U.S. universities. Since then, some organizations that were not active in technology transfer have also started to establish new offices for technology transfer, building teams covering legal, commercial, and scientific backgrounds. Membership in the Association of University Technology Managers (AUTM) has also grown rapidly, from 691 in 1989 to 2,178 in

1999. In fact, before the *Bayh-Dole Act* was passed, the association only had 113 members. Another significant effect of the *Bayh-Dole Act* is that it stimulated research collaboration between universities and industry. In the United States as a whole, industry support for university R&D costs accounts for under 7 percent of total university research funding, less than the 60 percent provided by federal agencies, but in terms of university innovation, private investment has driven the technology transfer that is increasingly important to industry, and has stimulated the creativity of university professors and staff. The *Bayh-Dole Act* has facilitated the transfer of technology from universities to industry, and ultimately to the public. The establishment of patent ownership for federally funded inventions has promoted the commercialization of technology, and it has protected the rights of scientists to continue to use and extend their research. For research-intensive institutions, it has also ensured that they can continue receiving research funding from partners interested in their research. The *Bayh-Dole Act* also requires universities to share patent license proceeds with inventors, but universities must invest the remaining revenues in scientific research and education after deducting expenses. The *Bayh-Dole Act* has spurred amazing progress in the United States in the medical, engineering, chemical, computer, and software industries, creating tens of thousands of jobs.

Figure 41   Technology transfer-related legislation in the United States

Time	*English*	*Chinese*
1862	The Morrill Land-Grant Act	莫里尔赠地法案
1958	National Aeronautics & Space Act	美国国家航空与空间法
1966	The Freedom of Information Act	信息自由法案
1980	Stevenson-Wydler Technology Innovation Act	史蒂文森-威德勒技术创新法
1980	Bayh-Dole Act	拜杜法案
1982	Small Business Innovation Development Act	小企业创新发展法
1984	Cooperative Research Act	合作研究法案
1984	Trademark Clarification Act	商标说明法
1986	Japanese Technical Literature Act	日本技术文献法案
1986	Federal Technology Transfer Act	联邦技术转移法
1987	Malcolm Baldrige National Quality Improvement Act	马尔科姆.鲍德里奇国家质量改进法案
1987	Facilitating Access to Science & Technology	促进科学与技术的获取
1988	Omnibus Trade and Competitiveness Act	综合贸易与竞争法
1988	Water Resources Development Act	水资源开发法
1989	National Institute of Standards & Technology Authorization Act	国家学院标准与技术授权法案
1989	National Competitiveness Technology Transfer Act	国家竞争力技术转移法
1991	National Defense Authorization Act	美国国防授权法案
1991	Persian Gulf Conflict Supplemental Authorization & Personnel Act	波斯湾冲突授权与人事补充法案
1991	Intermodal Surface Transportation Efficiency Act	联合运输表面效率法
1991	American Technology Preeminence Act	美国技术卓越法案
1991	Technology Transfer Improvements Act	技术转移改进法

1992	Small Business Technology Transfer Act	小企业技术转移法
1993	National Department of Defense Authorization Act	美国国防部门授权法案
1993	National Defense Authorization Act	国防授权法
1995	National Technology Transfer and Advancement Act	国家技术转移促进法
1998	Commercial Space Act	商业空间法
1998	Technology Administration Act	技术管理法
2000	Technology Transfer Commercialization Act	技术转让商业化法

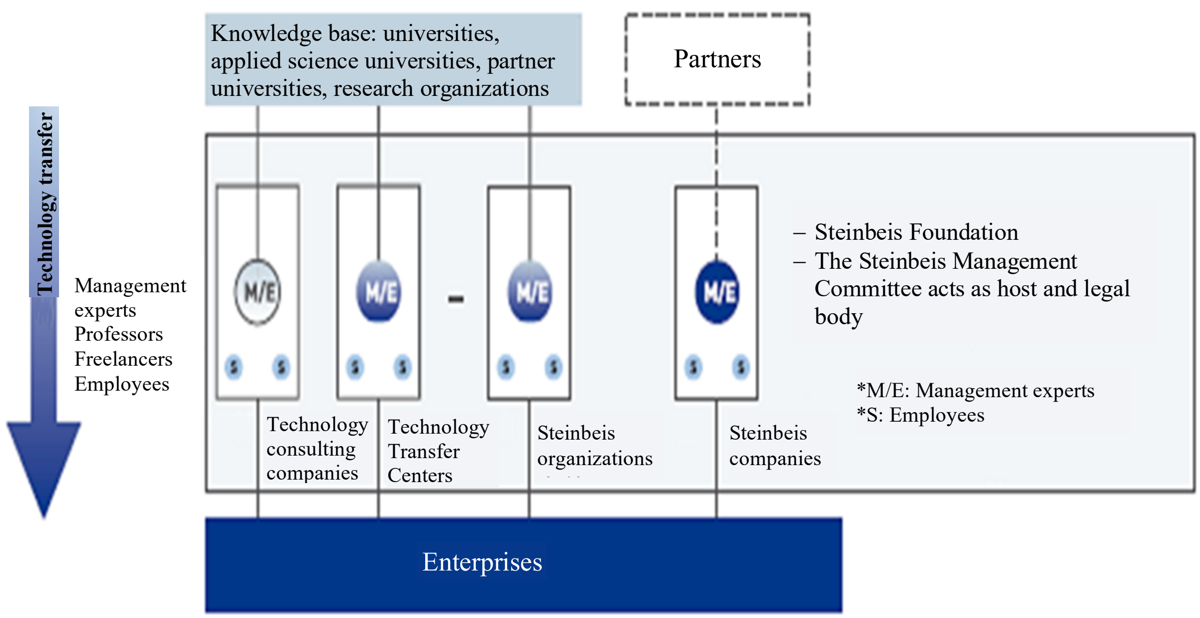
The *Bayh-Dole Act* laid the foundation for government, universities, and industry to cooperate in technology transfer and promote technology commercialization, and mobilized the enthusiasm of universities and research institutions for carrying out technology transfer. The *Stevenson-Wydler Technology Innovation Act*, *Federal Technology Transfer Act*, *National Competitiveness Technology Transfer Act*, and *National Technology Transfer and Advancement Act* constructed a system of technology transfer institutions at the national level. In 1980, the *Stevenson-Wydler Technology Innovation Act* provided that federal laboratories must establish specialized technology transfer institutions, legally clarifying the responsibilities of relevant government departments in technology transfer. It was supplemented in 1986 by the *Federal Technology Transfer Act*, which established a mechanism for federal laboratories to collaborate with enterprises in R&D, strengthening information communication channels for technology transfer. The *National Competitiveness Technology Transfer Act* of 1989 added guidance on joint collaborative R&D agreements, and strengthened the rights of federal laboratories to contract directly with private industry. The *National Technology Transfer and Advancement Act* of 1995 is an amendment to the *Stevenson-Wydler Technology Innovation Act* that granted companies full intellectual property rights and enhanced provisions on incentives for marketable technologies. The *Small Business Innovation Development Act* of 1982, on the other hand, established the Small Business Innovation Research (SBIR) program, requiring government agencies to provide funding for small business R&D related to their missions, and it played a huge promotional role in the development of the Silicon Valley in the 1980s. The *Cooperative Research Act* of 1984 encouraged two or more companies to work together on an R&D project, free from *Antitrust Act* restrictions. This spurred the formation of several university and industry alliances. The *Omnibus Trade and Competitiveness Act* of 1988 further encouraged cooperation between universities, government research institutions, and enterprises, and promoted the application of federally funded advanced technology projects to SMEs through the establishment of regional manufacturing technology transfer centers.

2. **An open, networked management system combining centralization and decentralization**

Following the Steinbeis Foundation's reorganization, many new opportunities have sprung up continuously. Its network-type management system has also given it more room to maneuver, and allowed it to continue growing and creating new Steinbeis Enterprises. Today, the Steinbeis Foundation remains a nonprofit organization, representing credibility and integrity. The Steinbeis Management Board, on the other hand, functions as a private, profit-driven service provider. It establishes branches under its banner, from technology transfer centers to in-house development and marketing organizations, or creates new technology companies. The reorganization of the Steinbeis Foundation not only generated payable dividends, but also provided the Steinbeis network with broad room for growth, opening up a win-win situation.

The various organizations within the Steinbeis network have a clear division of labor. Steinbeis-Stiftung is the central organization of the transfer network, while the non-profit Steinbeis Foundation and its Steinbeis Technology Transfer, Ltd. (StC) subsidiary are responsible for all commercial activities involving the transfer of knowledge and technology. Within StC's network, there are numerous Steinbeis Transfer Centers focusing on various key fields. Steinbeis Research and Innovation Centers specialize in project research: marketing, technology-focused research on development and transfer networks, and projects of a philanthropic nature. Steinbeis Consulting Centers, on the other hand, specialize in business-related consulting, assessment, and training. The Steinbeis Transfer Institute on the campus of Steinbeis University in Berlin conducts technology transfer-oriented research and provides competency-based training for staff development. Steinbeis Holding GmbH oversees majority equity interests and the shareholdings of several companies. Steinbeis Symposia feature discussions on trending topics in technology and management, showcasing the SF's technical expertise level. In addition, the Steinbeis Foundation publishes publications written by experts. The Ferdinand Steinbeis Institute promotes technology transfer by coordinating and implementing research projects. Steinbeis Property, on the other hand, is primarily used to provide a network of suitable infrastructure for enhancing the knowledge and technology transfer process.

Figure 42 The Steinbeis Foundation's networkized management system



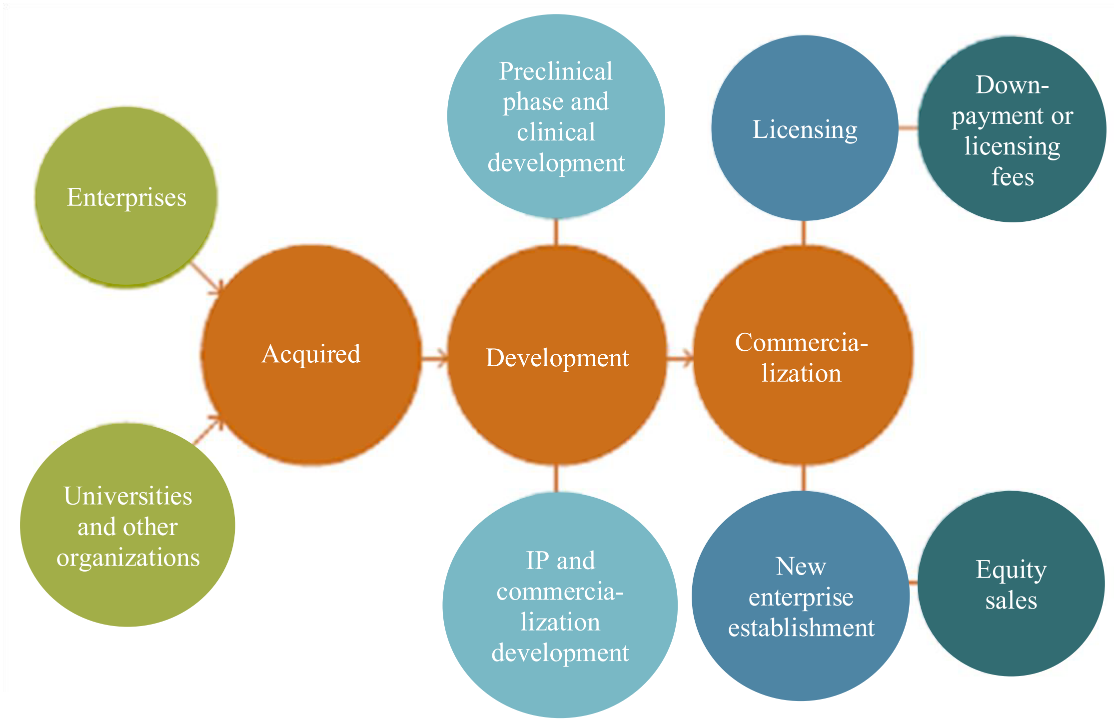
Data source: Steinbeis 1983-2008

The managers of Steinbeis Enterprises make their decisions within their respective technology transfer organizations. The umbrella organization merely serves as a public framework for the application of knowledge and provides services. It supports the technology transfer process of the individual companies, intervening only if necessary, and all Steinbeis enterprises are affiliated with Steinbeis-Stiftung (StW). The Steinbeis organization and its decentralized technology transfer institutions all work in an orderly manner under unified management, providing a solid foundation for the development of the entire Steinbeis network.

3. Key to successful technology transfer—focusing on promising high value-added technologies

BTG adjusted the company's strategic orientation in May 2005 to focus on life sciences, and transformed itself from a technology transfer intermediary into a specialized healthcare company. BTG's reorientation, which brought major changes in its strategy, operations, and personnel, was aimed at driving the Group's profitability and creating a business platform for sustainable growth in the future. BTG originally had four types of IP commercialization: 1. licensing life science and physical science technologies to companies that have completed the development phase and begun marketing their products; 2. providing patents on life science and physical science technologies; 3. creating companies to apply IP developed in-house; and 4. IP services, such as third-party rights audits. After the transformation, BTG shifted the focus of its work to the acquisition, development, and commercialization of pharmaceuticals and other medical technologies in oncology, aging, neurology, and pharmaceuticals (such as adjuvants for cancer and other supportive care products). Demonstrating the utility of a drug or medical technology increases its value. BTG subjects new chemical entities to Phase II clinical studies to demonstrate their utility for patients with the target disease. In the case of drug repositioning, it can be a new formulation of an existing product, a drug for a new indication, or a combination of two drugs that are not approved for individual use. Through a global network, BTG acquires early-stage drugs and other innovative medical technologies from enterprises, universities, and research institutions. BTG finances and manages these projects, maintains their IP, and implements commercialization plans. It then licenses the technologies to pharmaceutical companies or directly establishes companies to apply the drugs and technologies.

Figure 43 BTG's S&T healthcare strategy



Data source: BTG Annual Report 2005

In terms of market opportunities, societal factors such as population aging, health consciousness, and health insurance status are driving the rapid growth of the pharmaceutical and medical industries, increasing demand for innovative medical products, and creating immense opportunities for BTG. Enterprises, research institutes, and universities tend to conduct scientific research that pays off, but they find it difficult or impossible to invest in projects that prove the utility of their inventions. Such research institutions are thus willing to partner with BTG to commercialize their technologies. In addition, there has always been an "innovation gap" in the pharmaceutical industry, where large R&D investments fail to generate new products or revenues as predicted. As a result, MNCs and niche healthcare companies actively seek novel drugs or technologies that can enter late-stage development. BTG works with these companies to include them in its customer network and development strategy, obtaining royalties from the products through technology licensing.

BTG's transformation strategy was founded on a thorough analysis of the Group's overall past operating conditions, performance, strengths and weaknesses, potential portfolio, and markets. In order to achieve sustainable growth, BTG has taken decisive steps to cut GBP 5 million in annual operating costs and target ongoing investments in areas that can generate huge returns in the future. BTG used GBP 15 million in extra savings to implement and execute the new strategy, with the Group's fixed costs coming out of recurring patent revenue. In the short term, BTG's costs for the direct acquisition or development of pharmaceuticals and other medical technologies came out of non-recurring royalty income, down payments on new agreements, and income from the sale of royalty rights and shareholdings. In the long term, by focusing its business on promising, high value-added pharmaceuticals and medical technologies, BTG will generate revenues that will far exceed its costs and investment by significant and increasing margins. BTG's commercialized inventions include magnetic resonance imaging (MRI), the Oxford knee, hip replacement prostheses, factor IX clotting in leukemia, and [treatment of] chronic lymphocytic leukemia. Key to BTG's success has been access to potentially high value-added early-stage drugs and other medical technologies. Today, BTG has built a strong global network of pharmaceutical and biotech companies, research institutions, and universities.

Part Three: Current Supply and Demand Situation in Shenzhen for International Technology Transfer Services

Shenzhen's economic development model is at a critical stage of transition from being factor of production-driven to being innovation-driven. In recent years, Shenzhen has achieved outstanding results in terms of promoting technology transfer and successfully industrializing achievements. Shenzhen can derive great advantages and outward-radiating effects in the field of technology transfer, for the following reasons: First, Shenzhen is adjacent to Hong Kong, has a superior environment for innovation and entrepreneurship, and has a strong high-tech industry foundation. In particular, the rising overall scale and quality of Shenzhen's high-tech industry provides broad room for the development of technology transfer in Shenzhen. Secondly, Shenzhen has mature market-based absorption mechanisms. The decisive factor for technology transfer lies in the buyer's discernment and its digestion and implementation abilities. In China at its present stage, Shenzhen has a unique advantage in both the thirst for technology resources and the ability to discern and invest in technologies (Yang Jingru, 2003).

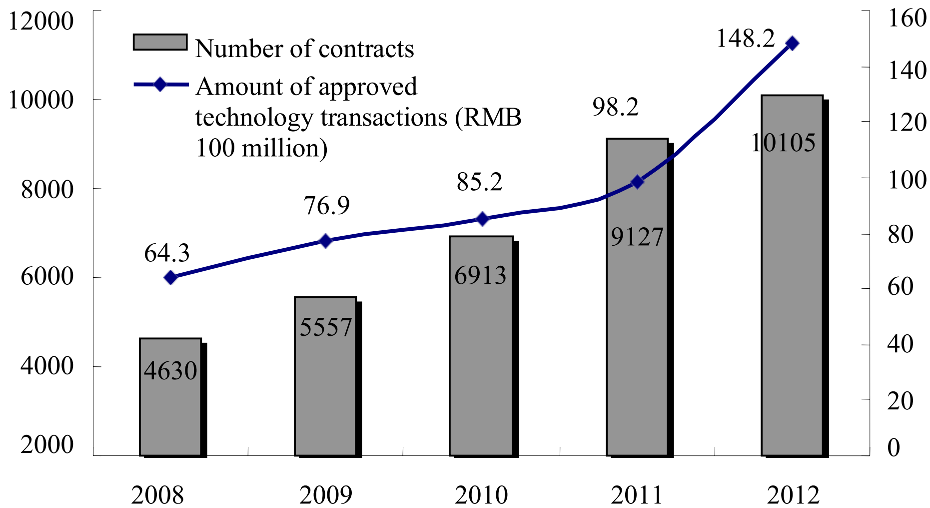
I. Technology transfer situation in Shenzhen

In the process of Shenzhen becoming an important city for technology transfer nationwide, government departments and a host of intermediary service organizations have acted as powerful "boosters," allowing Shenzhen to become a technology project "hub" and one of the most active cities for the industrialization of S&T achievements.

1. Stable development of Shenzhen's technology market

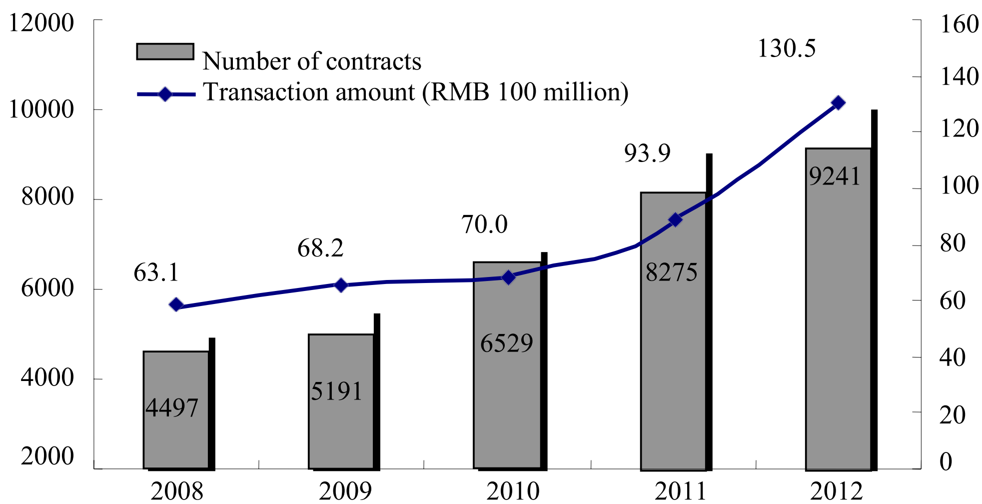
In recent years, Shenzhen's results in technology transfer have been significant (Figures 44 and 45). Rapid growth has been maintained in both directions—technology exporting and technology absorption—and the technology contract amount still tops the list of cities with independent planning status under the national economic and social development plan (计划单列市). The amount of technology export transactions is significantly higher than that of technology absorption transactions, and the dominant position of technology exporters has become more pronounced. In 2012, Shenzhen registered 10,105 technology export contracts, compared with 9,127 in the same period of 2011, for an increase of 10.7%. The contract transaction amount reached Chinese yuan Renminbi (RMB) 15.33 billion, an increase of 37.9% YoY. The approved technology transaction amount was RMB 14.82 billion, having risen 50.9% from RMB 9.82 billion the previous year. Shenzhen registered 9,241 technology absorption contracts in 2012, compared with 8,275 in 2011, an increase of 11.7%. Contract transactions amounted to RMB 13.05 billion, compared with RMB 9.39 billion in 2011, representing a YoY increase of about 39.0%. It is clear that the growth of Shenzhen technology transaction amounts was relatively flat from 2008 to 2010, but the growth momentum behind Shenzhen's technology transaction amounts intensified after 2010.

Figure 44 Shenzhen technology export contract transactions



Data source: Shenzhen Technology Transfer Promotion Center

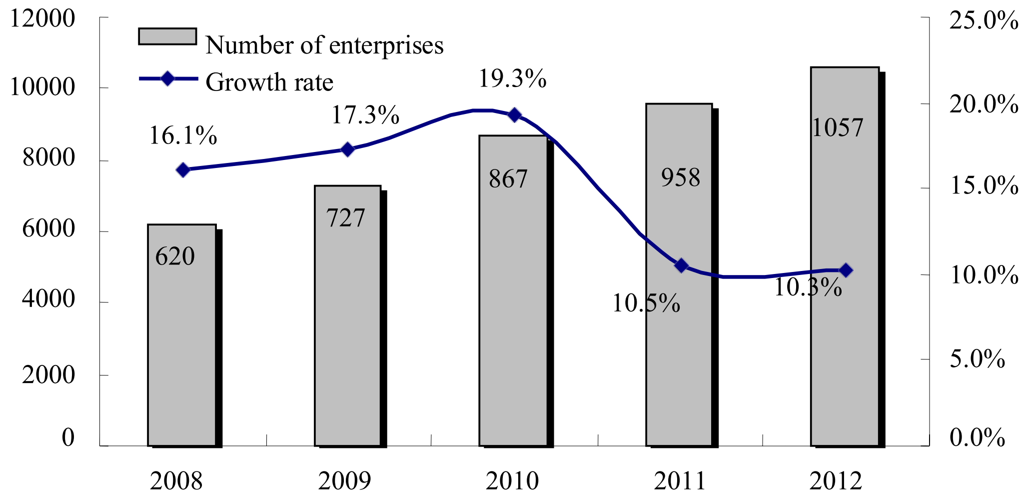
Figure 45 Shenzhen technology absorption contract transactions



Data source: Annual Report of National Technology Market Statistics, 2008-2014

As the volume of technology contract transactions has increased, so has the number of enterprises registering technology contracts, with Shenzhen now ranking fourth in the country and first among cities with independent planning status under the national economic and social development plan (Figure 46). Shenzhen registered 1,057 enterprises with technology contracts in 2012, an increase of 99 enterprises over 2011, with a growth rate of 10.3%. The highest number of registered contracts for a single enterprise reached 798 in 2012, compared with the 2011 record of 721 registered contracts for a single enterprise, an increase of 10.6%. The number of registered contracts exceeded 100 for 20 enterprises, an increase of six compared with 2011. The highest amount of approved technology transactions for a single enterprise reached RMB 3.66 billion, 8.5 times the highest amount (RMB 430 million) in 2011. There were 16 single enterprises with approved technology transaction amounts above RMB 100 million, compared with 18 in 2011, a decrease of 2 enterprises. Data from 2008 to 2012 show that about 100 micro, small, and medium-scale enterprises newly came forward each year to register technology contracts in Shenzhen, with an annual increase of more than 10%, indicating that the preferential policy of tax reductions for technology contracts is becoming more and more extensive in coverage, and the policy effectiveness in getting better.

Figure 46 Number of enterprises registering technology contracts in Shenzhen



Data source: Shenzhen Technology Transfer Promotion Center

As seen from the composition of contract categories (Figure 47), S&T innovation has become the core task for accelerating transformation of the economic development model (经济发展方式转变) based on innovation-driven, endogenous growth. S&T research and development and innovation capabilities continue to strengthen, supporting vigorous growth of technology transactions. Shenzhen registered 8,811 technology development contracts in 2012, compared with 7,680 in the same period of 2011, an increase of 1,131, for a growth rate of 14.7%. Technology development contracts accounted for 87.2% of the total number of 10,105 contracts in the year, compared with 84.1% of the total number of 9,127 technology development contracts in 2011, an increase of 3 percentage points, indicating the continued dominance of technology development contracts. The approved technology transaction amount of technology development contracts increased 22.8% to RMB 9.65 billion from RMB 7.86 billion in 2011. The ratio of the approved technology transaction amount of technology development contracts to the total approved technology transaction amount was 65.1%, compared with 80.0% in 2011, for a decrease of about 15 percentage points. In 2012, the number and amount of technology transfer contracts in Shenzhen increased significantly, with the number increasing to 555 contracts, compared with 452 contracts in 2011, an increase of 22.8%. The approved technology transaction amount nearly quadrupled to reach RMB 4.93 billion, compared with RMB 1.61 billion in 2011 on growth of 206.2%. The approved technology transaction amount for the category as a percentage of the total approved technology transaction amount also doubled to

33% from 16.4% in 2011. In 2012, the number and amount of technology service contracts in Shenzhen decreased to different degrees, but were still dominated by general technology service contracts. The number of registered contracts was 712, down 27.8% compared with 986 in 2011. The approved technology transaction amount was RMB 230 million, down RMB 120 million or 34.3% compared with RMB 350 million in 2011. The category's approved technology transaction amount also fell at the same time, from 3.6% in 2011 to about 2%. The number of technology consulting contracts in Shenzhen was only 27 in 2012, which nonetheless was a slight increase over 9 in 2011. Their approved technology transaction amount was RMB 40 million, an increase of RMB 30 million YoY. Their proportion of approved technology transactions was still very small, remaining at 0.05% or less. It is obvious that technology development and technology transfer account for the bulk of technology registration contracts in Shenzhen, with sum of the two categories of transactions having exceeded 96% of the total, and the main position of technology transfer is becoming more and more significant.

Figure 47 Distribution of Shenzhen technology contracts by category

(Units: number, RMB 100 million)

Year	***Technology development***			***Technology transfer***		
	Number of contracts	***Amount***	***% of total***	***Number of contracts***	***Amount***	***% of total***
2011	7680	78.6	80.01%	452	16.1	16.39%
2012	8811	96.5	65%	555	49.3	33%
Year	***Technology services***			***Technology consulting***		
	Number of contracts	***Amount***	***% of total***	***Number of contracts***	***Amount***	***% of total***
2011	986	3.5	3.56%	9	0.04	0.04%
2012	712	2.3	2%	27	0.01	0%

Data source: Shenzhen Technology Transfer Promotion Center

With regard to the composition of technology fields (Figure 48), against the background of industrial restructuring, technology transactions in strategic emerging industries such as digital information, biotech and pharmaceuticals, new energy, new materials, and energy conservation and environmental protection have grown rapidly. In recent years, Shenzhen has registered technology contracts in 11 major technology fields, including digital information, aerospace, advanced manufacturing, biotech and pharmaceuticals, new materials and their applications, new energy and energy efficiency, environmental protection and comprehensive utilization of resources, nuclear applications, agriculture, modern transportation, and urban construction and social development. Data in Figure 48 show that the scale of technology transactions in Shenzhen is largest in digital information, followed by biotech and pharmaceuticals, nuclear applications, new energy and energy efficiency, and advanced manufacturing. In the digital information technology field, the amount and number of technology contract transactions in 2012 far exceeded other technology fields. The number of contract transactions for the year rose by 962 over 2011 to reach 9,013, an increase of about 12%. Approved technology transactions amounted to RMB 12.78 billion, an increase of 57%. Their share of total approved technology transactions increased by 3.3 percentage points relative to 2011, to 86.2%. The digital information technology contract category consists mainly of computer software, communications, digital audio and video, microelectronics and optoelectronics, computer hardware, and computer network technologies. Among these, computer software is dominant. The number of registered software contracts in 2012 was 7,792, accounting for 86.5% of digital information technology contracts. Approved technology contract transactions amounted to RMB 6.88 billion, accounting for 53.8% of the total amount of digital information technology contract transactions. In the field of biotech and pharmaceuticals, the number of technology contract transactions in 2012 was 390, 113 less than the previous year. The amount of approved technology transactions was RMB 750 million, up by RMB 150 million or 25%, and accounting for 5.1% of the total approved technology transactions, which represents a decline of 1 percentage points from 2011. In the field of nuclear applications, the number of technology contract transactions in 2012 was 55, 20 less than the previous year. The approved technology transactions amounted to RMB 410 million, down RMB 50 million or about 10% from the previous year, and accounting for 2.8% of the total approved technology transactions, a decline of 2% percentage points from 2011. In the new energy and energy efficiency field, the number of technology contract transactions in 2012 was 154, a decrease of 7. The amount of approved technology transactions was RMB 290 million, an increase of RMB 110 million or 61% over 2011, and accounting for 2% of the total approved technology transactions, which represents an increase of 0.12 percentage points relative to 2011. In the advanced manufacturing field, the number of technology contract transactions in 2012 rose by 77 over 2011 to reach 169, an increase of about 83.7%. Approved technology transactions amounted to RMB 230 million, an increase of 109.1% YoY. Their share of total approved technology transactions increased by 0.4 percentage points relative to 2011, to 1.5%. It can be seen that digital information technology remains in the lead in technology contract transactions, with the absolute increase in its total deal amount far exceeding that of other technology fields, although the growth of deal amounts in advanced manufacturing and in new energy and energy efficiency has been faster.

Figure 48 Main technology fields of Shenzhen technology contracts

(Units: RMB 100 million)

Year	***Digital information***		***Biotech and pharmaceuticals***		***Nuclear applications***		***New energy and energy efficiency***		***Advanced manufacturing***	
	Number	***Amount***	***Number***	***Amount***	***Number***	***Amount***	***Number***	***Amount***	***Number***	***Amount***
2010	6163	65.4	245	10.1	55	1.8	88	0.9	76	1.2
2011	8051	81.4	503	6.0	75	4.6	161	1.8	92	1.1
2012	9013	127.8	390	7.5	55	4.1	154	2.9	169	2.3

Data source: Shenzhen Technology Transfer Promotion Center

In terms of the breakdown of innovation entities by type (Figure 49), the position of enterprises among the different innovation entities is quite solid, and domestically funded enterprises are still the main force in technology exporting, taking first place among all kinds of enterprise legal entities. The approved technology transaction value of Shenzhen enterprises' export contracts reached RMB 14.46 billion in 2012, up 52.7% compared with RMB 9.47 billion in 2011 and representing 97.6% of the total approved technology transaction value, an increase of 1.1 percentage points relative to 2011. Domestically funded enterprises exported a total of 7,832 technologies in 2012, up 1,274 or 19.4% compared with 2011. Their approved technology transactions amounted to RMB 10.66 billion, up 76.2% YoY and representing 71.9% of the total approved technology transaction amount, an increase of 10 percentage points relative to 2011. As far as foreign-invested enterprises are concerned, the number and amount of their technology exports in 2012 increased to in differing degrees. They registered 739 technology contracts, 35 more than in 2011 and up 5% YoY; the amount of approved technology transactions was RMB 1.69 billion in 2012, up 14.2% YoY and representing 11.4% of the total, which was a 3.7 percentage point decrease relative to 2011. Hong Kong, Macau, and Taiwan-invested enterprises exported a total of 7,832 technologies in 2012, up 1,274 or 27.7% compared with 2011. Their approved technology transactions amounted to RMB 10.66 billion, up 4.2% YoY and representing 11.7% of the total approved technology transaction amount, an increase of 10 percentage points from 2011. In terms of scientific research institutions and higher education institutions, there remains a large gap in their total number of technology export contracts compared with enterprises. In 2012, their total number of registered technology contracts was 406, an increase of 29.7% over the same period last year, accounting for only about 4% of the total registered contracts; the amount of approved technology transactions was RMB 270 million, an increase of 22.7%, accounting for about 2% of the total approved technology transactions. It is very clear that, although the technology contracts of research institutes account for a relatively small portion, their annual growth rate is far higher than the overall growth rate, and their role as a source of innovation is gradually strengthening.

Figure 49 Shenzhen registered technology contracts of different innovation entities

(Units: RMB 100 million)

Year	Scientific research institutes		Enterprises		Domestically funded enterprises		Foreign-invested enterprises		Hong Kong, Macau, and Taiwan enterprises	
	Number	Amount	Number	Amount	Number	Amount	Number	Amount	Number	Amount
2010	217	0.9	6642	89.9	4974	52.0	645	14.4	993	14.8
2011	313	2.2	8697	94.7	6558	60.5	704	14.8	1390	16.7
2012	406	2.7	9552	139.2	7832	107	739	16.9	1005	17.4

Data source: Shenzhen Technology Transfer Promotion Center

Looking at the breakdown of technology flows (Figure 50), in 2012, intra-Shenzhen technology contract deals numbered 4,130, 40.8% of the total number of transactions. The scale of transactions with other domestic regions was largest for Beijing, followed by Guangzhou, Shanghai, and Jiangsu, the number of contract deals being 924, 518, 595, and 287, respectively, and accounting, 9.1%, 5.1%, 5.9%, and 2.8% of the total. Shenzhen's internal approved technology transactions amounted to RMB 7.4 billion, up 136.4% and accounting for 49.9% of the total, while transactions with Beijing, Guangzhou, Shanghai, and Jiangsu were RMB 1.21 billion, 580 million, 420 million, and 360 million, with growth rates of -18.8%, 26.1%, 75.0%, and 28.6%, accounting for 8.2%, 3.9%, 3.9%, and 2.4% of the total technology transactions, respectively.

Compared with 2011, whereas the numbers and amounts of technology contract transactions within Shenzhen and with Guangzhou, Shanghai, and Jiangsu increased to varying degrees, some fifty percent of the amount of technology transactions were within Shenzhen, while the amount of technology transactions with Beijing decreased.

Figure 50 Geographical distribution of Shenzhen technology exports

(Units: number, RMB 100 million)

Year	*Overseas*		*Shenzhen*		*Beijing*		*Guangzhou*		*Shanghai*		*Jiangsu*	
	Number	*Amount*	*Number*	*Amount*	*Number*	*Amount*	*Number*	*Amount*	*Number*	*Amount*	*Number*	*Amount*
2010	479	16.1	2796	24.7	562	8.9	305	7.7	354	2.3	187	1.7
2011	530	14.1	3995	31.3	864	14.9	410	4.6	397	2.4	235	2.8
2012	410	12.7	4130	74.0	924	12.1	518	5.8	595	4.2	287	3.6

Data source: Shenzhen Technology Transfer Promotion Center

2. Shenzhen's international technology transfer is oriented toward absorption

In recent years, the cross-border exports of Shenzhen's technology contracts have gone mainly to a group of more than twenty countries and regions. The largest in terms of the scale of exports was Hong Kong, followed by the United States, Japan, Singapore, and Taiwan. The vast majority of the exported technology has been in digital information technology fields, especially computer software, and in digital audio and video, communications, and microelectronics and optoelectronics technologies.

Data show that Shenzhen had 530 international technology export contracts in 2011, up 10.6% YoY. The approved technology transactions amounted to RMB 1.41 billion, down 12.4%. There were 69 technology export contracts to the United States, with the transactions amounting to RMB 330 million, the number and amount of transactions having declined to different degrees. Technology export contracts to Japan, meanwhile, have surged. The number of contracts registered for the year was 56, and the amount of technology transactions was RMB 800 million, up by 330.8% and 100% YoY, respectively. In 2012, Shenzhen had 410 international technology export contracts, down 22.6% YoY, and the approved technology transactions amounted to RMB 1.27 billion, down 10.1%. Among them, 44 technology export contracts were to the United States, with a transaction amount of RMB 180 million. The amount and number of transactions maintained declining trends. Contracts exporting technology to Singapore, meanwhile, showed substantial growth: a total of 12 registered contracts and a transaction amount of RMB 400 million, up 140% and 102.1%, respectively. One can see that Shenzhen's technology output grew year by year, being mainly increased "exports" of technology within the city and to other parts of the country, while technology exports to foreign countries decreased significantly. Shenzhen's international technology transfer has gradually tilted toward technology absorbers.

Shenzhen South International Technology Exchange Market (深圳市南方国际技术交易市场), one of China's permanent technology (property rights) exchange institutions, is the only international technology exchange market in China oriented toward the world's technological and economic resources, and is also the main institution facilitating international technology transfer in Shenzhen. The data in Figure 51 also show that the amount of technology contracts facilitated by the Shenzhen South International Technology Trading Market increased from RMB 188.59 million in 2008 to RMB 294.08 million in 2011, with a YoY decline of -23.7% followed by increases of 38.4% and 47.7%. Although the number of technology contracts facilitated by the Shenzhen South International Technology Trading Market in 2011 was only half of the number in 2008, the total transaction amount rose by 55.9%.

Figure 51 Property rights transactions in Shenzhen South International Technology Trading Market

Year	Number of technology contracts	Total amount of transactions
2011	22347	29408
2010	17702	19912
2009	23550	14383
2008	44417	18859

Data source: Annual Report of National Technology Market Statistics, 2008-2014

3. Technology transfer promotes Shenzhen's economic growth

GDP is an added value concept, and to measure the contribution of technology transactions to GDP, we must find data in the technology market database that can correspond to the "added value" of technology transferors. The value of a technology transaction is the amount after deducting from the contract amount such non-technology costs as the cost of hardware and equipment provided by the technology transferor. This is not exactly the same as the value added by the technology transferor in transferring the achievements, but it is roughly the same. Therefore, this paper uses the value of technology transactions to calculate their direct contribution to GDP. Generally speaking, the main effect of a technology market is reflected in the effects of the transfer and diffusion of technology on the productivity growth of whole industries, which generates a great pulling effect on GDP. Moreover, technology application increases the economic benefits of the technology transferees, and that value-added of the technology transferees is included in GDP each year. On the whole, the economic benefits received by the technology transferees are much larger than those received by the technology transferors. Accordingly, the focus of measurement should be on technology transferees. However, domestic and international studies have shown that it is difficult to measure quantitatively the economic benefits brought by technology transactions to the transferee and their impact on regional economic growth. This is due to the lack of appropriate measurement methods and the lack of corresponding raw data.

In studying the impact of new technology transfer and diffusion on an economy, it is actually difficult to separate technological innovation and technology transfer. Technological innovation is an important source of economic growth, but when it comes to the contribution of technological innovation to economic growth, its potential power can only be fully realized through a gradual process of transfer and diffusion. Hence, it is difficult to measure the contribution to the economy of technological innovation or technology transfer alone. But if the combined benefits of technological innovation and technology transfer on industrial productivity improvement are to be measured, this kind of measurement is much clearer (Shenzhen Technology Transfer Development Research Report, 2011).

Since 2000, the fundamental role of Shenzhen's technology market in allocating S&T resources has strengthened significantly. It has promoted the transformation and upgrading of traditional industries and the large-scale application of high technology, and accelerated the process of conversion and industrialization of S&T achievements into practical applications (科技成果转化和产业化). As can be seen from Figure 52, between 2007 and 2012, Shenzhen's GDP grew from RMB 680.157 billion to RMB 1.29508 trillion, an increase of 90.4% in five years, and although the annual growth rate gradually declined, it still maintained a growth rate of over 10%. The amount of technology contracts grew from RMB 4.25 billion to RMB 14.82 billion, an increase of nearly 350%. The annual compound growth rate was 28.4%, much higher than the growth rate of GDP. The ratio of the technology contract amount to GDP also increased from 0.63% to 1.14%, up by 0.51 percentage points. In 2012, while GDP maintained steady growth of 10%, the value of technology contract transactions jumped by 50.9%, and the ratio of technology transaction value to GDP increased from 0.85% to 1.14% in 2011, up by 0.29 percentage points. We also found from the data that the growth rate of technology contract transactions was significantly higher than the growth rate of GDP in 2008, 2009, and 2012, and the ratio of the amount of technology transactions to GDP increased. In 2010, on the other hand, the growth rate of the technology contract transaction amount was lower than the growth rate of GDP, and the ratio of the technology transaction amount to GDP decreased. In 2012, the growth rate of GDP was the same as that of 2011, but the growth rate of the technology contract transaction amount in 2012 was three times that of 2011, and the ratio of the technology transaction amount to GDP increased greatly. Evidently, growth in the amount of technology contract transactions and regional economic growth have the notable feature of being linked in stages: Technology transactions can accelerate the flow of advanced S&T knowledge and human capital in the world and produce many spillover effects, thus benefiting the whole city's economy and exerting a certain pulling effect on regional economic growth.

Figure 52 Comparison of Shenzhen GDP and technology contract transaction growth

(Units: RMB 100 million, %)

Year	GDP	GDP growth rate (%)	Amount of technology contract transactions	Growth of transaction amount (%)	Ratio of the technology transaction amount to GDP (%)
2007	6801.57	14.8	42.5	0.71	0.625
2008	7786.79	12.1	64.3	**51.29**	0.826
2009	8201.32	10.7	76.9	**19.60**	0.938
2010	9581.51	12.2	85.2	10.79	0.889

2011	11502.06	10.0	98.2	15.26	0.854
2012	12950.08	10.0	148.2	**50.9**	1.144

Data source: Shenzhen Technology Transfer Promotion Center

4. Technology transfer fosters an innovation environment for Shenzhen

Since the early 1990s, Shenzhen has boldly developed innovative policies and reformed institutional administration. By 1998, it had led the country by introducing 22 new regulations for the development of high-tech industries. By 2001, it had built a "high-tech industry belt" with unified planning and phased development. And in 2004, "Document No. 1" promoted the expansion of high-tech industries in regional directions. Having transformed from "taking orders" to "independent innovation," Shenzhen has frequently taken the lead in the four pillar industries—high technology, finance, logistics, and culture—and shifted its focus toward high technology. By 2005, the output value of high-tech products in Shenzhen accounted for more than 50% of total industrial output value, and Shenzhen ranked first among major cities in China in the value added of high-tech industries as a percentage of citywide industrial value added and as a proportion of total economic output (GDP). In June 2008, Shenzhen obtained approval to create the first national innovation city.

In 2012, Shenzhen's GDP grew by about 10%, and Shenzhen's total societal investment in R&D increased to 3.81% of GDP, the leading level in China. Its Patent Cooperation Treaty (PCT) international patent applications numbered 8,024, accounting for 40.3% of the country's total, and ranked first in China for the ninth consecutive year. The output value of high-tech products was RMB 1.29 trillion, with 61% of such products having independent IP (Shenzhen Science and Technology Innovation Development Report, 2012). At present, relying on its advantages in information, channels, and geography, Shenzhen is integrating the technology demand of developed manufacturing regions with the technology supply of mainstream international channels (such as foreign S&T parks and technology transfer centers), which will be more conducive to achieving the goal of "innovation city" construction. The key to Shenzhen's innovation vitality does not lie in how strong its research base is, but in the cultivation of an innovation ecosystem through the construction of the technology transfer system.

4.1 Comprehensively building the environment for innovation and entrepreneurship

To foster an innovation culture, Shenzhen set up various special S&T funds to finance and support innovative activities of SMEs, established an array of innovation awards, and screened and cultivated innovative projects.

4.2 Promoting the integration of technology and finance

Shenzhen has perfected credit guarantees, financial leasing, and S&T insurance. It established venture capital guidance funds, optimized the environment for private equity investment, and promoted the agglomeration of angel investment and innovation enterprises. In 2011, it newly registered 951 equity investment and venture capital funds of various kinds, including national venture capital funds for metamaterials and new energy. This exceeded the total number of registrations during the 11th Five-Year Plan, and the number of venture capital institutions and the scale of capital management exceeded one-third of the nationwide totals.

4.3 Establishing effective mechanisms for the conversion of S&T achievements into practical applications (科技成果转化)

Shenzhen supported the development of S&T intermediary service institutions, and focused on building a service system for the conversion of S&T achievements, promoting the conversion of S&T achievements into practical applications. The International Hi-Tech Fair became an important global platform for the display of S&T achievements. Shenzhen also innovated in technology property rights trading models and actively explored the creation of a "technology property rights bank," formed various types of industry-academia-research institute-capital (产学研资) alliances, and refined the support service system covering the entire innovation chain, thereby promoting the linking of innovation chains with production chains and value chains. It is this vibrant innovation ecosystem that has awakened the innovation vitality of each "market cell." Enterprises that have become core leaders of niche industries include E-5continents and 3Nod Electronics in digital information fields, Hepalink and Landwind Group in biological fields, Xunlei and A8 Music in internet fields, Beauty Star and Changyuan New Material in new materials, and Huaqiang Culture Technology in the cultural and creative fields. Between 2008 and 2011, 107 Shenzhen SMEs went public. Of that number, 83 (77.6%) were in high technology. Shenzhen has maintained a leading position among large- and medium-sized cities in China for five consecutive years in the number of SMEs going public (Shenzhen Technology Transfer Development Research Report, 2011).

5. Shenzhen's legislative assurance for technology transfer

Because of the externalities, public good attributes, information asymmetries, etc., that characterize technology transfer, market failures arise from time to time in the technology transfer process. These characteristics of technology transfer mean that the government must assume a crucial role, and needs to effectively solve the problems caused by market failures in technology transfer through measures such as laws, taxes, and financial subsidies, as well as by promoting the development and improvement of the market and providing public service platforms.

Improving technology transfer legislation is an indispensable part of building a new technology transfer system and promoting technology transfer work. Many laws and regulations related to technology transfer, patents, and technology market management have been introduced in China since the 1990s, such as the *Law on Scientific and Technological Progress* and the *Law on Promoting the Conversion of S&T Achievements into Practical Applications*. These have played a positive role in promoting the development of technology transfer in China, yet there has never been a law with nationwide scope specifically for technology transfer. This lack of technology transfer legislation is not conducive to the further development of China's technology transfer efforts. It was not until April 1, 2011, with the official implementation of the *Regulation on Promoting Technology Transfer of Nanjing City*, that the vacancy for the first local regulation on the promotion of technology transfer in China was filled. Shenzhen became only the 2nd city in China to introduce local technology transfer regulations, after Nanjing.

In 2012, after three years of research, study, and pilots for the *Technology Transfer Regulations of Shenzhen Special Economic Zone*, its measures and provisions were basically mature. They were deliberated and passed by the Standing Committee of the [Shenzhen City] People's Congress in February 2013, and came into effect on June 1, 2013. The Regulations mainly give prominence to promotion measures in six areas (Guo Tao, 2013):

(1) Focusing on innovation in management models, clarifying the relationship between the responsibilities of technology transfer-related departments and specialized institutions, not imposing any new administrative approval items, and emphasizing the public service function of the government for technology transfer entities;

(2) Enhancing government support, stipulating that the Shenzhen City government should arrange for a certain percentage of the Shenzhen S&T research and development funds each year to be earmarked for technology transfer, particularly for encouraging the introduction and cultivation of new financial institutions, so as to provide assurance for technology transfer;

(3) Strengthening incentives for technology transfer, clarifying the transfer methods for S&T achievements formed with government funding, and providing legal support for the transfer of S&T achievements, thereby enhancing operability;

(4) Supporting the construction of technology transfer institutions (TTIs), encouraging universities, research institutions, and enterprises to establish technology transfer departments and raise professional service capabilities;

(5) Actively carrying out technology transfer exchanges and cooperation internationally and with overseas regions, encouraging the introduction of international TTIs, jointly building TTIs and technology transfer bases, recruiting international technology transfer talents, and carrying out international technology transfer cooperation, while also supporting and rewarding the industrialization of international technology achievements in Shenzhen;

(6) Attracting flows of projects and high-end technology transfer talents to Shenzhen, supporting the conversion of key technology transfer achievements into products, and providing accommodating conditions for technology transfer talents in terms of entry and exit, finding housing, school enrollment for children, and job placement for spouses.

II. Channels for provision of technology transfer services in Shenzhen

Against the background of economic globalization, international technology trade continues to grow, and technology transfer is becoming more and more frequent. In addition, following the economic crisis, pure international trade has become less stable due to economic factors such as exchange rate volatility, so enterprises of various countries prefer the mature development of technology transfer. The international technology transfer transaction system involves a series of functional components, such as technology evaluation, property rights transactions, foreign-related laws, foreign-related patents, etc. Fast and efficient transfer transactions would be impossible to achieve without the support of a professional service system. Shenzhen urgently needs to establish an efficient technology transfer system with Shenzhen characteristics to promote the flow of knowledge and transfer of technology among Shenzhen's innovation-based enterprises, and between enterprises and universities and research institutes, thereby improving the innovation ability and competitiveness of enterprises.

1. Technology transfer institutions

Technology intermediary service institutions are a bridge for the flow, diffusion, and transfer of knowledge and technology. They are an indispensable service link between S&T and its application, production, and consumption, an indispensable and important support for S&T innovation, and a sure sign that high-tech achievements are being transformed into real productivity and reflected in the level of technological innovation. Shenzhen has also proposed in its Overall Plan for Shenzhen as a National Innovation-Oriented City (2008-2015) that intermediaries should fully play their role as a bridge and link in the allocation and use of innovation resources. From this, there can be no doubt as to the importance of TTIs.

As of 2012, the number of registered TTIs in Shenzhen had grown to 34, eight of which have been selected as national technology transfer demonstration institutions (TTDIs): Shenzhen Advanced Technology Research Institute Engineering Center, Shenzhen South International Technology Trading Market, Ltd., China International Hi-Tech & Property Exchange Co. Ltd. (first batch); Shenzhen-Hong Kong Industry-Academia-Research Base Industrial Development Center, Shenzhen Tsinghua International Technology Transfer Center (second batch); Shenzhen Technology Transfer Promotion Center (third batch); Shenzhen Nanshan Science and Technology Institute, and Chinese Academy of Sciences Intellectual Property Investment Co., Ltd. (fourth batch). Other representative municipal TTIs include: Shenzhen Zhonghengxin Asset Evaluation Co., Ltd. (深圳市中衡信资产评估有限公司), Shenzhen Weishi Technology Transfer Center Co., Ltd. (深圳市伟仕技术转移中心有限公司), Shenzhen Haizhili Technology Industrial Co., Ltd., Shenzhen Ruode Technology Brokerage Firm, Shenzhen Scinfo Venture Capital Management Co., Ltd., Shenzhen Technology Enterprise Incubator Association, Shenzhen Software Industry Association, Shenzhen Intellectual Property Society, Shenzhen Broker Association, Shenzhen Polytechnic, and Shenzhen Academy of Aerospace Technology. These organizations have made outstanding contributions to Shenzhen in the research of international technology transfer policies, the construction of institutional mechanisms for the conversion of S&T achievements into practical applications, the recruitment and cultivation of high-end talent, the enhancement of S&T innovation capacity, and the development of strategic emerging industries.

In terms of institutional classification (Figure 53), Shenzhen's Type II institutions—government-established institutional legal persons or association legal persons—are largest in number, with a total of 8 institutions, accounting for 42% of the total number of TTIs; next are Type III TTIs—internally established institutions of various legal persons such as universities and research institutes or enterprise legal persons, with a total of 6 institutions, or 32% of the total; then there is Type I, i.e., independently operated enterprise legal persons or their internal institutions, with a total of 4, or 21% of the total; finally, there is Type IV, i.e., various technology markets, with only 1, or 5% of the total. There are a large number of technology transfer demonstration institutions that are government-established legal entities or internal institutions of various legal entities such as universities and research institutes or enterprise legal entities, so their S&T resource advantages can be fully utilized to achieve technology transfer.

In terms of the acquisition of IP, there are large differences in the acquisition of IP among the various types of TTIs due to their different service items, and only Type II and III institutions have acquired IP. As shown in Figure 54, in 2011, Shenzhen TTIs have obtained 286 IP items, of which 253 were obtained by Type III institutions and 33 by Type II institutions. Specifically, the largest number of IP items has been obtained by Shenzhen Polytechnic in Type III, with 155 items, including 35 invention patents, 67 utility model patents, 52 copyrights, and 1 design patent; it was followed by Shenzhen Advanced Technology Research Institute Engineering Center, with 90 items (47 invention patents, 27 utility model patents, 11 design patents, and 5 copyrights); next was Shenzhen Academy of Aerospace Technology, which has obtained 8 patents (4 invention patents, 3 utility model patents, and 1 copyright). Within Type II, the largest number of intellectual property rights has been obtained by Shenzhen Broker Association, with 30 items (29 trademarks and 1 copyright); it is followed by the Shenzhen-Hong Kong Industry-Academia-Research Base Industrial Development Center, with 3 items (2 invention patents and 1 copyright).

Figure 53 Names and types of some Shenzhen TTIs

Name of Institution	***Type of Institution***
Shenzhen Zhonghengxin Asset Evaluation Co., Ltd.	I
Shenzhen Weishi Technology Transfer Center Co., Ltd.	I
Shenzhen Haizhili Technology Industrial Co., Ltd.	I
Shenzhen Ruode Technology Brokerage Firm	I
Shenzhen Technology Transfer Promotion Center	II
Shenzhen Scinfo Venture Capital Management Co., Ltd.	II
Shenzhen-Hong Kong Industry-Academia-Research Base Industrial Development Center	II
Shenzhen Technology Enterprise Incubator Association	II
Shenzhen Software Industry Association	II
Shenzhen Intellectual Property Society	II
Shenzhen Broker Association	II
Shenzhen United Property and Share Rights Exchange	II
Shenzhen Nanshan Science and Technology Institute	III
Shenzhen Tsinghua International Technology Transfer Center	III
Shenzhen Institutes of Advanced Technology Engineering Center	III
Shenzhen Polytechnic	III
Shenzhen Academy of Aerospace Technology	III
Chinese Academy of Sciences Intellectual Property Investment Co., Ltd.	III
Shenzhen South International Technology Trading Market	IV
……	……

Data source: Shenzhen Technology Transfer Promotion Center

Note: The *Appraisal Index System for National Technology Transfer Demonstration Institutions (for Trial Implementation)* divides technology transfer demonstration institutions into four categories according to their functions: Type I, independently operating enterprise legal persons or their internal institutions; Type II, government-established institutional legal persons or association legal persons; Type III, internally established institutions or enterprise legal persons of various legal persons such as universities and research institutes; and Type IV, various technology markets.

Figure 54 IP acquisition by Shenzhen TTIs

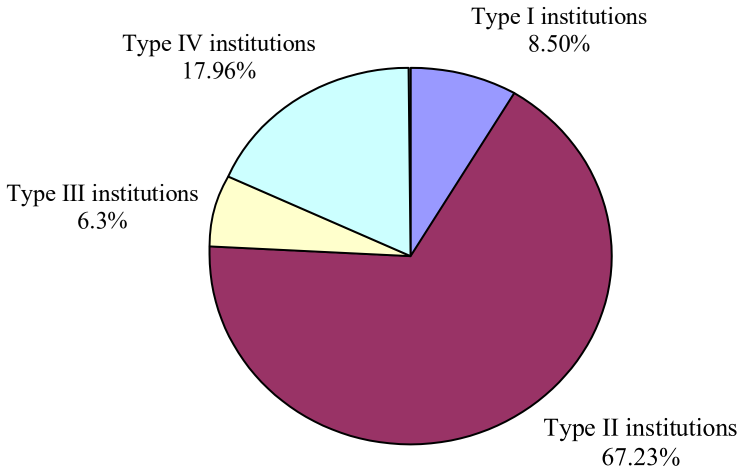
(Unit: items)

Name of Institution	***Type of Institution***	***Total***	***Invention patents***	***Utility patents***	***Design patents***	***Trademarks***	***Copyrights***
Shenzhen Polytechnic	III	155	35	67	1	0	52
Shenzhen Institutes of Advanced Technology Engineering Center	III	90	47	27	11	0	5
Shenzhen Academy of Aerospace Technology	III	8	4	3	0	0	1
Shenzhen Broker Association	II	30	0	0	0	29	1
Shenzhen-Hong Kong Industry-Academia-Research Base Industrial Development Center	II	3	2	0	0	0	1

Data source: Shenzhen Technology Transfer Promotion Center

In terms of technology deals, Shenzhen TTIs facilitated a total of 4,108 technology transfer deals in 2011, accounting for 45% of the annual number of technology contracts (9,127), and the transaction amount reached RMB 2.127 billion, accounting for 21.66% of the annual technology transaction amount (RMB 9.82 billion). The largest number of technology transfer deals was facilitated by Type II institutions (Figure 55), which facilitated 2,762 deals, accounting for 67.23% of the total number of deals, followed by Type IV, Type I, and Type III institutions, with 738, 349, and 259 deals, respectively, accounting for 17.96%, 8.50%, and 6.30% of the total (4,108).

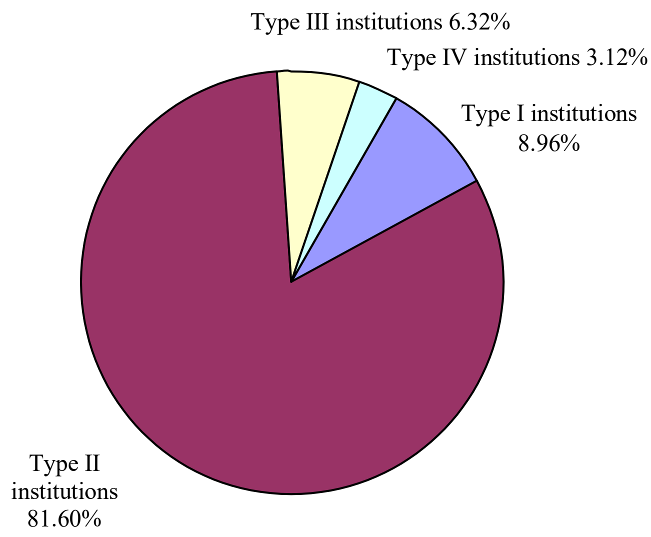
Figure 55 Numbers of Shenzhen technology transfer deals facilitated by different types of TTIs



Data source: Shenzhen Technology Transfer Promotion Center

The largest amount of technology transfer transactions was also facilitated by Type II institutions (Figure 56), followed by Type I, Type III, and Type IV institutions. They contributed RMB 1.736 billion, RMB 191 million, RMB 134 million, and RMB 66 million respectively, accounting for 81.60%, 8.96%, 6.32%, and 3.12% of the total amount (RMB 2.127 billion). It is clear that Type II institutions dominate the technology transfer facilitation process.

Figure 56 Amounts of Shenzhen technology transfer deals facilitated by different types of TTIs



Data source: Shenzhen Technology Transfer Promotion Center

In terms of national technology transfer demonstration institutions (Figure 57), the number of project transactions of the six such institutions in Shenzhen in 2011 changed significantly, with a dramatic decrease of 1,310 projects. The transaction amount of RMB 1.827 billion represented a significant YoY decrease of 59.9%. Some 28 international technology transfer projects were concluded in 2011, a decrease of 1 project compared with the previous year. The transaction amount was RMB 35 million, an increase of RMB 23 million or 192% compared with the previous year.

Figure 57 Project transactions of Shenzhen technology transfer demonstration institutions

(Units: items, RMB 100 million)

Year	*Number of project transactions*	*Amount of project transactions*	*Number of international technology transfer project transactions*	*Amount of international technology transfer project transactions*
2010	65913	45.60	29	0.12
2011	1310	18.27	28	0.35

Data source: Shenzhen Technology Transfer Promotion Center

With regard to technology transfer services (Figure 58), Shenzhen TTIs organized 144 technology trading activities and 112 technology transfer trainings in 2011, serving 18,735 enterprises and addressing 27,198 enterprise needs. Of those services, Type I institutions organized the most technology trading activities (59) and technology transfer trainings (40), but they served the smallest number of enterprises (437), addressing 169 enterprise needs; Type III institutions organized 29 trading activities and 32 trainings, though also serving relatively few enterprises (458) and addressing 491 enterprise needs; Type II and Type IV institutions served enterprises on a larger scale, organizing 26 and 30 technology trading activities, and 28 and 12 trainings, respectively, but serving 11,680 and 6,160 enterprises, and addressing 25,472 and 1,066 enterprise needs, respectively.

Figure 58 Service circumstances of different types of TTIs in Shenzhen

Type of Institution	**Technology trading activities organized**	**Technology transfer trainings organized**	**Number of enterprises served**	**Number of enterprise needs addressed**
Type I institutions	59	40	437	169
Type II institutions	26	28	11680	25472
Type III institutions	29	32	458	491
Type IV institutions	30	12	6160	1066
Total	**144**	**112**	**18735**	**27198**

Data source: Shenzhen Technology Transfer Promotion Center

In terms of national technology transfer demonstration institutions (TTDIs) (Figure 59), the scale of services in 2011 was smaller than in 2010, with 63 technology trading activities organized, 75 less than the previous year; 60 technology transfer trainings were organized, 569 less than the previous year; the number of enterprises served was 16,940, a decline of 47.87%; 24,342 enterprise needs were addressed, 59.71% less than in 2010.

Figure 59 Service circumstances of TDDIs in Shenzhen

Year	Technology trading activities organized	Technology transfer trainings organized	Number of enterprises served	Number of enterprise needs addressed
2010	138	629	32496	60424
2011	63	60	16940	24342

Data source: Shenzhen Technology Transfer Promotion Center

With regard to revenue and expenditures (Figure 60), in 2011, Shenzhen TTIs realized total revenue of RMB 535 million and total expenditures of RMB 464 million. The revenue of Type III institutions was RMB 362 million, accounting for the highest share of total revenue across institutions, at 67.73%, and their expenditures of RMB 376 million also accounted for the highest share of the total expenditures, at 81.05% They were followed by Type II institutions, with revenue and expenditures of RMB 150 million and RMB 65 million, respectively, accounting for 28.06% and 14.02% of the totals. Next were Type IV institutions, with revenue and expenditures of RMB 19 million and RMB 18 million, respectively, accounting for 3.47% and 3.94% of the totals. Type I institutions had the least revenue and expenditures, RMB 4 million and RMB 5 million, respectively, accounting for 0.74% and 0.99% of the totals.

Figure 60 Revenue and expenditure circumstances of different types of TTIs in Shenzhen

Type of Institution	*Revenue*		*Expenditures*	
	Total (RMB 100 million)	*% of total*	*Total (RMB 100 million)*	*% of total*
Type I	0.04	0.74	0.05	0.99
Type II	1.50	28.06	0.65	14.02
Type III	3.62	67.73	3.76	81.05
Type IV	0.19	3.47	0.18	3.94
Total	**5.35**	**100**	**4.64**	**100**

Data source: Shenzhen Technology Transfer Promotion Center

Looking at the revenue composition of different types of TTIs (Figure 61), the total revenue of Shenzhen's Type III institutions in 2011 was RMB 362 million, of which RMB 111 million was from business expense allocations and accounted for 30.62% of their revenue. RMB 110 million (30.36%) was from program project allocations, RMB 102 million (28.15%) was technical revenue, and RMB 39 million (10.87%) was other revenue. The revenue of Type II institutions mainly came from technical revenue and other revenue, which accounted for 42.28% and 54.81%, respectively. For Type I institutions, the proportion of technical revenue was greater, accounting for 59.53% of the total, and they received basically no allocations for program projects or business expenses, while other revenue accounted for 40.47%. Type IV institutions mainly relied on program and project allocations and other revenue, accounting for 15.27% and 78.08% respectively, and their technical revenue was a very low proportion, only 6.65%.

Figure 61 Revenue composition of different types of TTIs in Shenzhen

Type of Institution	*Revenue source*			
	Technical revenue	*Program project allocations%*	*Business expense allocations%*	*Other revenue%*
Type I	59.53	0	0	40.47
Type II	42.28	1.24	1.66	54.81
Type III	28.15	30.36	30.62	10.87
Type IV	6.65	15.27	0	78.08

Data source: Shenzhen Technology Transfer Promotion Center

In terms of national TTDIs (Figure 62), the total revenue of the six institutions in 2011 was RMB 407 million, of which technical revenue was RMB 95 million, a decrease of 23.9% compared with the previous year, accounting for 23.34% of the total revenue. Ranked by amount of revenue, Shenzhen Advanced Research Institute Engineering Center had the largest total, followed by Shenzhen United Property and Share Rights Exchange, Shenzhen South International Technology Trading Market, Ltd., Shenzhen Tsinghua International Technology Transfer Center, Shenzhen-Hong Kong Industry-Academia-Research Base Industrial Development Center, and Shenzhen Technology Transfer Promotion Center, realizing RMB 248 million, RMB 129 million, RMB 18 million, RMB 5 million, RMB 4 million, and RMB 3 million in annual revenue, respectively. The technical revenue of Shenzhen Advanced Technology Research Institute Engineering Center was RMB 38.2107 million, an increase of 374.41% over the previous year, accounting for 15.43% of its total revenue; the technical revenue of Shenzhen United Property and Share Rights Exchange was RMB 52.1652 million, a decrease of 45.88% YoY, accounting for 40.49% of its total revenue; Shenzhen South International Technology Trading Market Co., Ltd., Shenzhen Tsinghua International Technology Transfer Center, and Shenzhen Technology Transfer Promotion Center had less technical revenue; the technical revenue of Shenzhen-Hong Kong Industry-Academia-Research Base Industrial Development Center was RMB2.73 million, accounting for 64.85% of its total revenue.

Figure 62 Revenue and expenditure circumstances of different types of TTDIs in Shenzhen

(Units: RMB 100 million, %)

Name of institution	*Total revenue*	*Technical revenue*	*Technical revenue percentage*
Shenzhen Institutes of Advanced Technology Engineering Center	2.48	0.38	15.43
Shenzhen United Property and Share Rights Exchange	1.29	0.52	40.49
Shenzhen South International Technology Trading Market, Ltd.	0.18	0.01	6.65
Shenzhen Tsinghua International Technology Transfer Center	0.05	0.00	0.00
Shenzhen-Hong Kong Industry-Academia-Research Base Industrial Development Center	0.04	0.03	64.85
Shenzhen Technology Transfer Promotion Center	0.03	0.01	19.83

Total	4.07	0.95	23.34

Data source: Shenzhen Technology Transfer Promotion Center

2. The Innovation Relay Station (创新驿站) and Technology Transfer Alliance

The ultimate goal of S&T services is to promote technology transfer, and constructing the Innovation Relay Station is an important part of the construction of the S&T service system. The Shenzhen regional site cooperates closely with two grassroots sites, the Shenzhen Institute of Advanced Technology of the Chinese Academy of Sciences and the Shenzhen South International Technology Trading Market. Using a one-stop platform, together with Shenzhen's technology contract registration efforts, it conducts extensive research on the technology needs of enterprises and, using the technical advantages of the Institute of Advanced Technology and other Alliance members, collaborates in addressing the technology needs of enterprises. In 2011, the Shenzhen regional site accepted 50 applications from technology brokers and held three training courses for technology brokers. A total of 47 technology brokers completed qualification essays and participated in technology brokerage business practice. In 2011, the number of technology brokers in Shenzhen increased from 321 the previous year to 368, an increase of 14.64% YoY, providing talent support for the development of technology transfer service institutions. Based on this talent resource, as of 2012, the Shenzhen regional site had signed agreements with more than 20 technology brokers, completed more than 2,000 enterprise studies, uncovered more than 300 enterprise technology demands and 712 technology supplies.

The extent to which the Relay Station can help address the technical needs of enterprises depends on how many technical supply resources and service resources can be mobilized. In order to gather more resources in the region for enhancing the service capacity of the Relay Station, Shenzhen has established the Shenzhen-Hong Kong-Macau Technology Transfer Alliance. Using technology transfer resources from Hong Kong, Macau, and Taiwan, it aims to promote knowledge flows and technology transfers among research institutes and enterprises, truly strengthen the cohesiveness of the alliance, and enhance the symbiosis of alliance members. At the same time, in response to the networkization (网络化) trend in international technology transfer services, Shenzhen built the Alliance's One-Stop platform as a way for enterprises, universities, research institutions, and technology transfer service providers to obtain resources, and to serve as a means of information support for collaborative work. The Relay Station, alliance, and platform are organically combined, forming a work model of "Relay Station + alliance + platform" with the Relay Station as the core. In other words, taking as the starting point the Technology Transfer Alliance's assistance to the China Innovation Relay Station (中国创新驿站) in finding out the technological needs of enterprises, and taking the "public service network platform" as their work tool, Alliance members work together to address technological needs in a market-oriented way, so as to achieve technology transfer and conversion as the end point (Shenzhen Technology Transfer Development Research Report, 2011).

In addition, the Relay Station and the Alliance hold activities such as "Technology Transfer Lecture Hall," project promotion meetings, and investment briefings every year to promote the interregional flow of technology, redress regional disparities in S&T resources, and help those in need of technology understand the technology acquisition channels and obtain the needed technology as soon as possible, thereby satisfying the needs of enterprises for independent innovation. In order to promote international technology cooperation and exchange, an Alliance member (Shenzhen Tsinghua International Technology Transfer Center) and Isis, a technology commercialization company wholly owned by the University of Oxford, have reached a cooperation agreement to mutually establish offices and jointly launch the "Sino-European Technology Exploitation Programme" (SETEP) project. The project builds a high-speed technology transfer channel between European universities and research institutions, high-tech parks, and high-tech venture capital organizations on the one hand, and Chinese enterprises and markets on the other, and transfers relatively advanced and mature high-tech projects and companies from Europe to Shenzhen. The SETEP project was first launched in Spain, where nearly 20 high-tech companies were screened and linked with requirements through the Shenzhen Tsinghua International Technology Transfer Center. In the past year since its establishment, the Center has screened more than 180 high-tech projects in different fields from many European countries, and more than 50 European high-tech companies have been linked. By the end of October 2012, the Center has completed conversions of 174 technical achievements and patents, including 64 in the energy and environment fields, 52 in life science, 39 in advanced manufacturing, and 19 in the field of information engineering.

Members of the alliance have established close cooperation with nearly 150 universities and institutions around the world with rich international S&T talent resources, unique advanced technology channels, and collaboration networks. They have established a North American center in Silicon Valley, and are preparing to build a Russian center in Moscow. Grassroots site Shenzhen South International Technology Trading Market has reached cooperation intention agreements with the Isis in the UK, the Commonwealth Scientific and Industrial Research Organisation (CSIRO) in Australia, Honeywell in the United States, etc. In cooperation with Taiwan's Industrial Technology Research Institute, the bulk trading of Chinese Academy of Sciences patents in the Taiwan market has been achieved. Using these resources, and recruiting some of the renowned international universities that have shown interest in coming to Shenzhen, an international technology transfer alliance has been formed, and is gradually developing and growing there, exploring innovative models of international technology transfer led by China.

3. Technology transfer network service platforms

Technology transfer network service platforms are intelligent, convenient, and professional tool-based public technology service platforms for all participants in technology transfer. By uncovering the technology supply and demand of enterprises and achieving cross-agency and cross-regional cooperation in technology transfer, such platforms can effectively solve the problem of inadequate technology sources for industrial upgrading and transformation, inadequate technology flow methods, and difficulties in obtaining solutions to meet technology needs, promoting project achievements, and effectively linking various innovation strengths and resources to needs, as well as other market demand problems related to insufficient regional innovation resources. On these network service platforms, technology suppliers and demanders can trade like on Taobao, thus accelerating the industrialization of S&T achievements and effectively improving the technological innovation capability of regional enterprises and the core competitiveness of regional industries.

The public network service platforms used by enterprises in Shenzhen mainly include Shenzhen Stock Exchange Technology Transfer Platform, South China Technology Exchange Network (www.scten.com), Technology Transfer One-Stop Site (http://www.ttdak.com/), Shenzhen-Hong Kong-Macau-Taiwan Technology Transfer Union, Huoxing 863 (www.hx863.com), China Technology Broadcast (www.chinatbc.com), China Private Technology Network (www.chinamk.com), etc. Take the Technology Transfer One Stop Site as an example. This platform is the first technology transfer user demand support system in China that has been analyzed and researched according to market science (市场学). At its core are three market elements: users, behavior, and products. Demand for its construction came from actual research on technology transfer activities, analyzed in accordance with market science, and consistent with market economy principles and various user practices. The platform provides various users a service model similar to Alibaba's, and is a platform for interacting and for publishing various technology transfer activities and products. It can serve different technology transfer market players, such as government, enterprises, universities and research institutes, intermediaries, industry associations, and investment and financing institutions.

The platform facilitates linking of technology projects to funds and talent, improves public social awareness and participation in technology transfer, expands the technology transfer service talent team, and improves the service level. It also promotes the gearing of university and research institute R&D to the market, and it effectively increases the technology transfer abilities of enterprises themselves, and improves the technological content and international competitiveness of their products, thereby promoting S&T progress and economic development.

III. Problems in Shenzhen's technology transfer services

Shenzhen is vigorously promoting independent innovation, and technology transfer is one of the core issues. It is also the weakest link in the innovation system. The technical complexity of high-tech products has increased significantly in recent years. Technological breakthroughs for products require the integration of technologies from different disciplines and different directions—a difficult task for an enterprise to accomplish on its own. The intensification of global competition and changes in technology have forced enterprises to shift from internal vertical integration to horizontal integration. On one hand, they must enhance their core advantages in particular areas, and must strengthen the use of external resources on the other.

The results of a survey conducted by the Shenzhen Science and Technology Innovation Commission (2011) show that technology transfer in Shenzhen is less than ideal, and one important reason is the lack of an efficient and scientific interaction mechanism between technology absorbers and exporters. Enterprises view technology to be of considerable importance for maintaining their competitiveness, and their demand for technology is great, but the supply of technology appears to be insufficient, and most of them think that it is not easy to obtain the technologies desired.

The survey results indicated:

(1) 59% of enterprises believed it was due to failure to find the right technology;

(2) 46% of enterprises suspected that the introduced technology was immature;

(3) 39% of enterprises thought the price of the introduced technology was too high;

(4) 38% of enterprises had difficulties in communicating with technology providers;

(5) 24% enterprises had financial difficulties

(6) 21% offered other reasons.

Response (1) reflects a lack of innovation sources or supply and demand information channels; (2), (3) and (4) all reflect to some extent a lack of technology transfer professionals or technology brokers, and a failure to provide professional supply and demand matching services; (2) suggests that an enterprise fears the risks involved and has insufficient support before it can begin mass production. (In fact, technologies that have never been industrialized are always high-risk, but huge market returns can be earned once they succeed, making it easy for enterprises to form core technology capabilities. To seize the high end of the production chain, industrialization of this technology should be supported more.) (4) reflects that an enterprise's own technical capacity falls short; (3) and (5) can reflect an enterprise's financing difficulties, insufficient venture capital, etc.; and (6) suggests there are many difficulties that had not been thought of.

There may be several important reasons for this kind of technology supply and demand imbalance:

(1) Shenzhen's own innovation sources are inadequate; it is difficult for technical achievements to meet the requirements of market demand-oriented enterprises; technology transfer services are scattered, shallow, and have short chains, making it difficult to meet the huge market demand;

(2) and Shenzhen's technology transfer channels are still not smooth enough. Intermediaries lack an effective division of labor and collaboration. They stick to a certain local domain or region, providing low-level sporadic services in the absence of sound information and collaboration systems, and are unable to meet the technology transfer requirements of industry as a whole for leap-forward development (跃进式发展). In the process of technology transfer activities, on one hand, the service capacity of individual institutions is limited. When they can only complete part of the work of a certain technology transfer activity, it is difficult for them to split up and subcontract work due to the lack of communication and collaboration experience among institutions. This hinders the normal development of technology transfer activities. On the other hand, because different institutions are working separately, information does not flow smoothly and resources are not effectively shared. This leads to a large amount of duplicated work and causes extreme waste of resources.

(3) The number of TTIs in Shenzhen is relatively large, but their scale is generally small. Their service capacity is not strong, and they lack broad social recognition. Their grasp of the needs of enterprises is shaky as well, and they have not yet found a stable profit model for technology transfer. It is still difficult for them to achieve self-development relying entirely on market-based operation.

(4) The government does not pay enough attention to technology transfer work, and there is a lack of targeted policy support. The initial investment in technology transfer generally comes from venture capital, but for venture capital companies, the vast majority of technologies produced by Shenzhen's research program are not yet in view. Therefore, it is necessary for the [Shenzhen City] government, under the guidance and support of the State, to take greater risks than venture capitalists, increase investment in technology transfer, and cultivate a greater number of optional "projects" for venture capital. This indeed gets at the crux of technology transfer.

Part Four: Feasibility Plan for the Building of Shenzhen into an International Technology Transfer Center

I. Regional environment and need

1. Basic information on China

Population: 1.34 billion (ranked first)
GDP: U.S. $9.9524 trillion (ranked second)

China's intellectual property rights have developed rapidly in recent years. In addition to patents being second only to the United States, the trademark and industrial design forms of IP are far higher than those of the United States. The number of patents increased from 26,000 in 2000 to 436,000 in 2011, 4,400 short of the United States. The number of trademarks increased from 188,000 to 1,371,000, 1.7 times that of the United States, and the number of industrial designs increased from 47,000 to 523,000, 6.3 times that of the United States. GDP also increased, from U.S. $3.368 trillion in 2000 to U.S. $9.9524 trillion in 2011, a difference of $3.2859 from the United States, and ranking second in the world (Figure 63). China's R&D represented 1.84% of GDP in 2011.

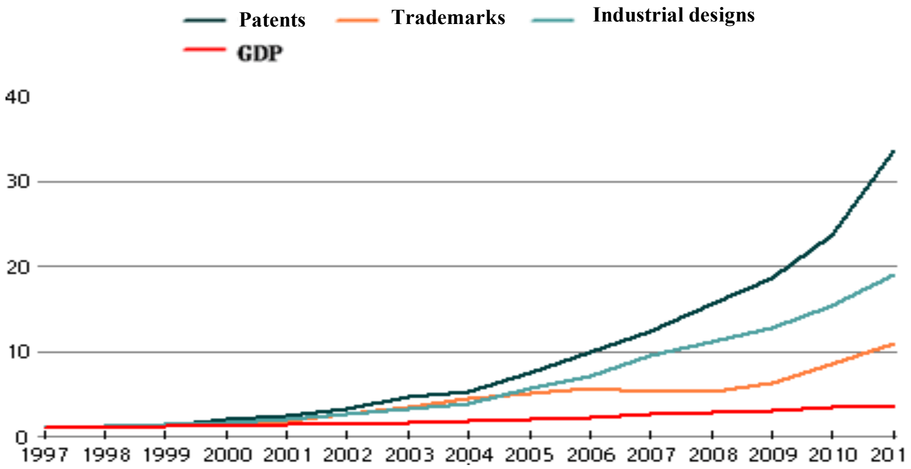
Figure 63 Intellectual property and GDP in China

Year	*Patents*	*Trademarks*	*Industrial designs*	*GDP (USD trillion)*
2000	26,475	188,367	46,743	3.3681
2001	31,339	238,002	56,748	3.6476
2002	41,436	327,649	73,825	3.9796
2003	58,801	417,922	87,740	4.3775
2004	69,051	548,971	104,556	4.8196
2005	97,998	630,014	155,236	5.3643
2006	129,333	713,878	193,379	6.0455
2007	161,390	656,986	262,386	6.9040
2008	204,354	647,332	309,388	7.5668
2009	241,547	796,122	350,114	8.2629
2010	308,318	1,051,326	421,380	9.1222
2011	436,144	1,370,935	523,310	9.9524

Data source: World Intellectual Property Organization

China's IP filings have increased at a faster rate than economic growth since 2000, with patents, trademarks, and industrial designs all showing a uniform growth trend. Patents have grown the fastest, followed by industrial designs and trademarks (Figure 64). A slight difference from the developed countries of the United States, Germany, and the UK is that the fastest growth in those countries has been in industrial designs, while in China it has been in patents.

Figure 64 Comparison of IP filings and economic growth in China

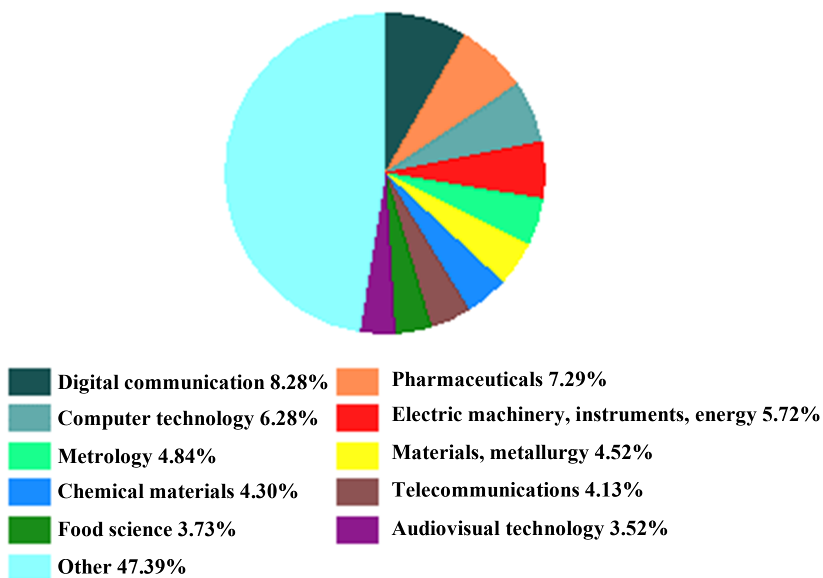


Note: Set equal to 1 in 1997

Data source: World Intellectual Property Organization

Among patent applications from 1997 to 2011, the highest share was in the digital communications field, with 8.28%, followed by pharmaceuticals (7.29%), computer technology (6.28%), and electric machinery, instruments, and energy (5.72%) (Figure 65).

Figure 65 Technical fields of Chinese patent applications



Data source: World Intellectual Property Organization

2. The Guangdong regional environment

Guangdong [Province] has developed rapidly in the last several decades through traditional industries led by processing and manufacturing, but the characteristically rough and labor-intensive processing and manufacturing of the past also brought with them low S&T innovation growth rates, a lack of economic diversification, and the low value-added of those industries, and their limitations were increasingly apparent. Considerable gaps exist between Guangdong and developed Western countries in terms of the scientific research system and investment in scientific research.

2.1 Innovation investment has grown steadily, but the proportion of government funds is low

Guangdong's research and experimental development expenditure grew steadily from 2007 to 2012. R&D investment rose from RMB 40.55 billion in 2007 to RMB 120.2 billion in 2012, with a cumulative R&D investment of 461.93 billion RMB. The average annual growth rate was 32.74%. In 2012, its proportion of GDP reached 2.11% (Figure 66), close to the 2015 target (2.2%) of the *National 12th Five-Year Plan for Science and Technology Development*. However, most of the R&D expenditures have come from enterprises, and the proportion of government funding—less than 10%—is low, far lower than that of Beijing and Shanghai.

Figure 66 Guangdong R&D expenditures.

	2007	*2008*	*2009*	*2010*	*2011*	*2012*
Total R&D expenditures (RMB 100 million)	405.50	504.57	652.98	808.75	1045.50	1202
Percentage of GDP	1.3%	1.41%	1.65%	1.76%	1.96%	2.11%

Data sources: Ministry of Science and Technology, National Bureau of Statistics, Guangdong Department of Science and Technology, Guangdong Bureau of Statistics

2.2 Innovation investment leads the nation, but investment intensity is low

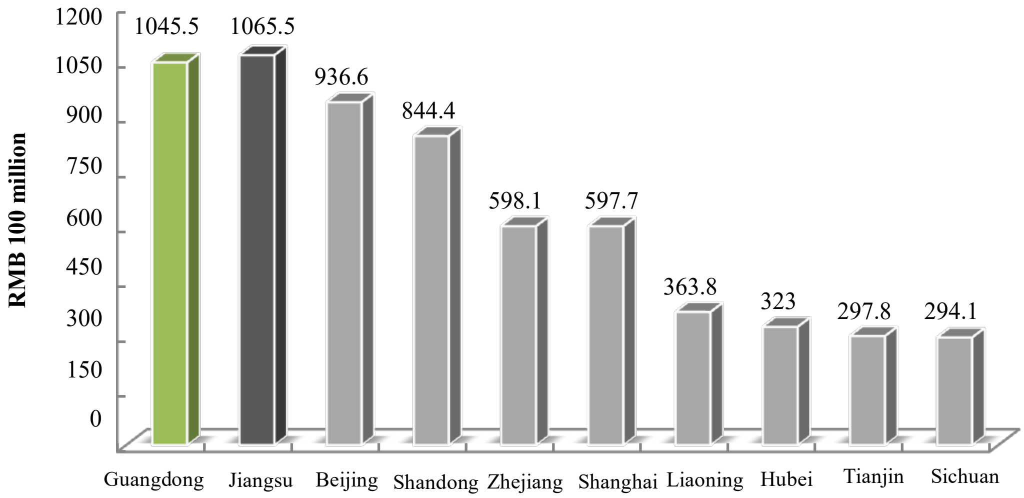
Figure 67 Comparison of China's top six locations in R&D expenditures

Item	*Guangdong*	*Jiangsu*	*Beijing*	*Shandong*	*Zhejiang*	*Shanghai*
R&D funding (RMB 100 million)	**1045.5**	1065.5	936.6	844.4	598.1	597.7
Ratio of R&D to GDP (%)	**1.96**	2.17	5.76	1.86	1.85	3.11

Data sources: National Bureau of Statistics, Ministry of Science and Technology, Ministry of Finance

In 2011, Guangdong's R&D expenditure investment ranked number two in the nation, second only to Jiangsu's RMB 106.55 billion. The top five provinces and municipalities were Jiangsu, Guangdong, Beijing, Shandong, and Zhejiang, with a total of RMB 449.01 billion, representing 51.69% of the nationwide total. Although Guangdong is near the top of the national rankings, the intensity of investment is low, with R&D expenditure of only 1.96% of GDP, slightly higher than the national average of 1.84%, and behind Beijing, Shanghai, and Jiangsu among developed provinces and cities (Figure 67), while in developed countries it is generally greater than 2%.

Figure 68 China's top ten locations by R&D expenditures



Data sources: National Bureau of Statistics, Ministry of Science and Technology, Ministry of Finance

2.3 The S&T talent team has recovered to the pre-financial crisis level

The province-wide number of R&D personnel increased from 368,800 in 2006 to 515,600 in 2011 (Figure 69). The number of R&D personnel dropped after the financial crisis in 2008, but has gradually increased and returned to the previous level. As of 2011, there were 99 CAS academicians in the whole province.

Figure 69 Guangdong R&D activity personnel

Indicator (10,000 people)	***2006***	***2007***	***2008***	***2009***	***2010***	***2011***
Scientific research and technology development institutions	1.23	1.41	1.58	0.89	0.95	1.19
Regular full-time higher education schools	2.77	3.19	3.43	2.99	3.39	3.64
Industrial enterprises	20.85	28.51	34.14	29.89	35.95	41.60
Other	12.03	12.05	14.04	4.56	4.38	5.13
Total	**36.88**	**45.16**	**53.19**	**38.35**	**44.66**	**51.56**

Data sources: Guangdong Department of Science and Technology, Guangdong Bureau of Statistics

The province-wide number of professional technical personnel in SOEs and public institutions[3] increased from 1,375,500 in 2006 to 1,448,000 in 2011. Among them, there were 879,600 teaching personnel, 254,000 health technicians, 151,700 engineering technicians, 13,500 agricultural technicians, and 5,300 scientific researchers, accounting for 17.54%, 10.48%, 0.93%, and 0.36% of the total number of personnel, respectively (Figure 70).

Figure 70 Professional technical personnel of SOEs and public institutions in Guangdong

Indicator (10,000 people)	***2006***	***2007***	***2008***	***2009***	***2010***	***2011***
Teaching staff	80.54	82.45	83.71	85.67	87.85	87.96
Health technicians	24.67	24.65	26.09	26.88	25.73	25.40
Engineering technicians	13.78	14.08	14.49	15.36	15.43	15.17
Agricultural technicians	1.70	1.73	1.67	1.58	1.41	1.35
Scientific research staff	0.52	0.57	0.57	0.60	0.45	0.53
Other personnel	16.34	15.71	15.45	16.20	14.93	14.40
Total	**137.55**	**139.19**	**141.98**	**146.29**	**145.80**	**144.80**

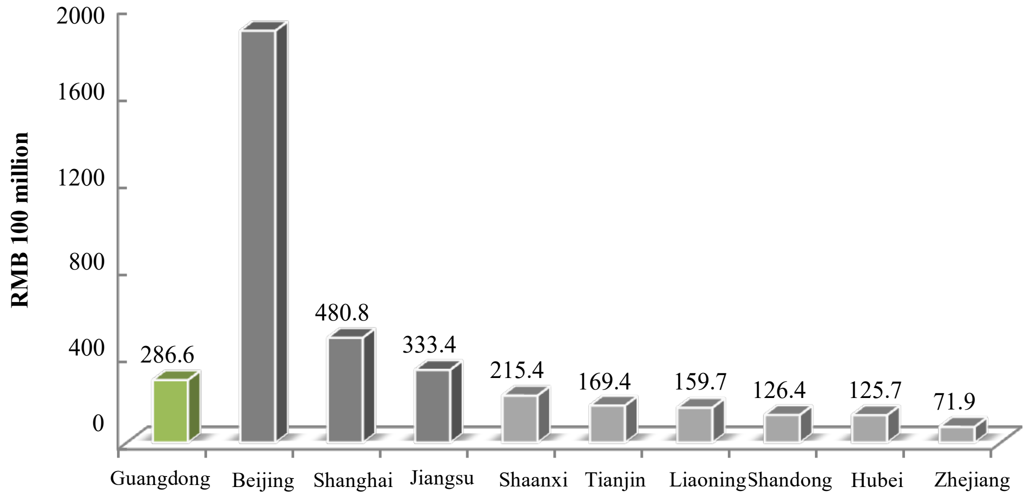
Data sources: Guangdong Department of Science and Technology, Guangdong Bureau of Statistics

2.4 In terms of transaction benefits, Guangdong's technology market falls far short of that of Beijing, Shanghai, and Jiangsu

In 2011, a total of 19,700 contracts were concluded in Guangdong, with a contract value of RMB 28.662 billion. Although it is ranked fourth in economic benefits, the gap with Beijing and Shanghai is large. The deal amount of the Beijing technology market was RMB 189.03 billion, 6.6 times that of Guangdong. The deal amounts of Shanghai and Jiangsu were RMB 48.08 billion and 33.34 billion (Figure 71).

Figure 71 Top ten locations in China by technology market deal amount

[3] Translator's note: "Public institutions" (事业单位) are organizations created and led by PRC government departments that provide social services. Unlike state-owned enterprises (SOEs), public institutions do not create material products and do not generate income. Public institutions are not considered government agencies, and their employees are not civil servants. Most public institutions are fully or partially government-funded, but some fully privately funded (but still government-led) public institutions exist. Public institutions typically provide services in areas such as education, science and technology, culture, health, and sanitation.



Data sources: National Bureau of Statistics, Guangdong Bureau of Statistics

2.5 The number of technology transfer contract projects has increased gradually, but the deal amount is still not very large scale

Among the number of technology contract projects in the province, the number of technology transfer contracts increased from 297 in 2000 to 1,216 in 2011, but the amount of technology transfer contract deals was only RMB 360 million in 2011, far behind previous levels (Figure 72).

Figure 72 Number and deal amount of technology contract projects in Guangdong

Indicator	*2000*	*2005*	*2010*	*2011*
Number of technology contract projects	5464	14432	17558	19721
Technology development contracts	921	5983	11629	14202
Technology consulting contracts	572	1279	1649	769
Technology transfer contracts	**297**	**639**	**868**	**1216**
Technical services contracts	3674	6531	3412	3534
Amount of technology contracts (RMB 100 million)	48.21	112.47	242.50	286.62
Technology development contracts	14.21	57.15	196.18	231.94
Technology consulting contracts	1.25	3.17	4.85	34.60
Technology transfer contracts	**11.03**	**28.89**	**34.43**	**3.60**
Technical services contracts	21.72	23.27	7.05	16.48

Data source: Guangdong Bureau of Statistics

3. Regional requirements

Against a background of economic globalization, a polarization of the division of labor in the world production chain has appeared. Developed countries continuously use core key technologies to occupy and control the upstream of the production chain, that is, the of product and technology development stages, while the majority of developing countries are crowded into the middle and downstream stages of the production chain, mainly in the order-based processing and manufacturing industries, and find themselves in a state of low value-added industrial production. Economic globalization has also promoted the international and interregional flow and integration of innovation factors. Technology is the main factor of economic growth and the basis of the information society and the knowledge-based economy. Today's emerging demand markets are dominated by technological advantages and innovation capabilities, and consumers pay more attention to the innovative features of new products and the overall experience they bring. Innovation has become an urgent need for society to achieve new development, and the manufacturing industry needs a transformation, from "made in Guangdong" to "created in Guangdong."

Given the structural adjustment and upgrading facing the development of Guangdong's industrial economy, there is a greater need to promote the transfer, adaptation, development, and application of technology to drive and promote growth at the high end of the production and value chains. It is necessary to put the factors for scientific innovation first, implement industrial restructuring and a forward-looking strategic layout, and achieve a paradigm shift for new types of industries. Seen in terms of experience in international S&T cooperation, integration of S&T resources is the direction in which S&T cooperation is heading. Technology transfer in particular can guide and promote the combining of innovation achievements with industrial capital, accelerate the pace of industrialization, and promote the commercialization of innovation achievements, thereby promoting the improvement and accelerated development of the overall innovation capacity of industry and achieving the rapid rise of S&T strength.

Guangdong needs an international technology transfer center that will promote the acquisition and application of modern technologies, with the goal of achieving sustainable development at the national and regional levels. The activities of such an international technology transfer center would cooperate fully with regional universities, R&D institutions, and the production and service sectors in order to form the needed synergies and streamlined interactions. The development of S&T service providers in Guangdong Province lags behind the development of S&T. S&T intermediaries are mainly divided into: 1. S&T research and technology development institutions, including research institutes, private research institutions, social science research institutions, key laboratories, engineering and technology research centers, enterprise technology centers, and university R&D institutions; and 2. S&T exchange and technology promotion service institutions, including S&T parks and bases, productivity promotion institutions, and S&T promotion institutions. The Guangdong-Commonwealth of Independent States (CIS) Center for Transnational Technology Transfer, established in 2010, is mainly responsible for promoting S&T industry cooperation and exchange with CIS countries, mainly Russia, Belarus, and Ukraine, and it is difficult for it to balance satisfactorily supply and demand, as well as cooperation needs. There are a wide variety of S&T service institutions in the province, but international S&T cooperation in the Pearl River Delta region has not yet entered the joint win-win era, and there are still certain gaps with developed countries. The United States has a well-developed system of S&T intermediaries with a high degree of specialization. Most such institutions provide information, consulting, technical, talent, and capital services for technology conversion and industrialization, and these S&T conversion institutions have contributed greatly to the rapid development of S&T in the United States. Acquisition of modern technology will affect the competitiveness of Guangdong Province in the knowledge-based global economy.

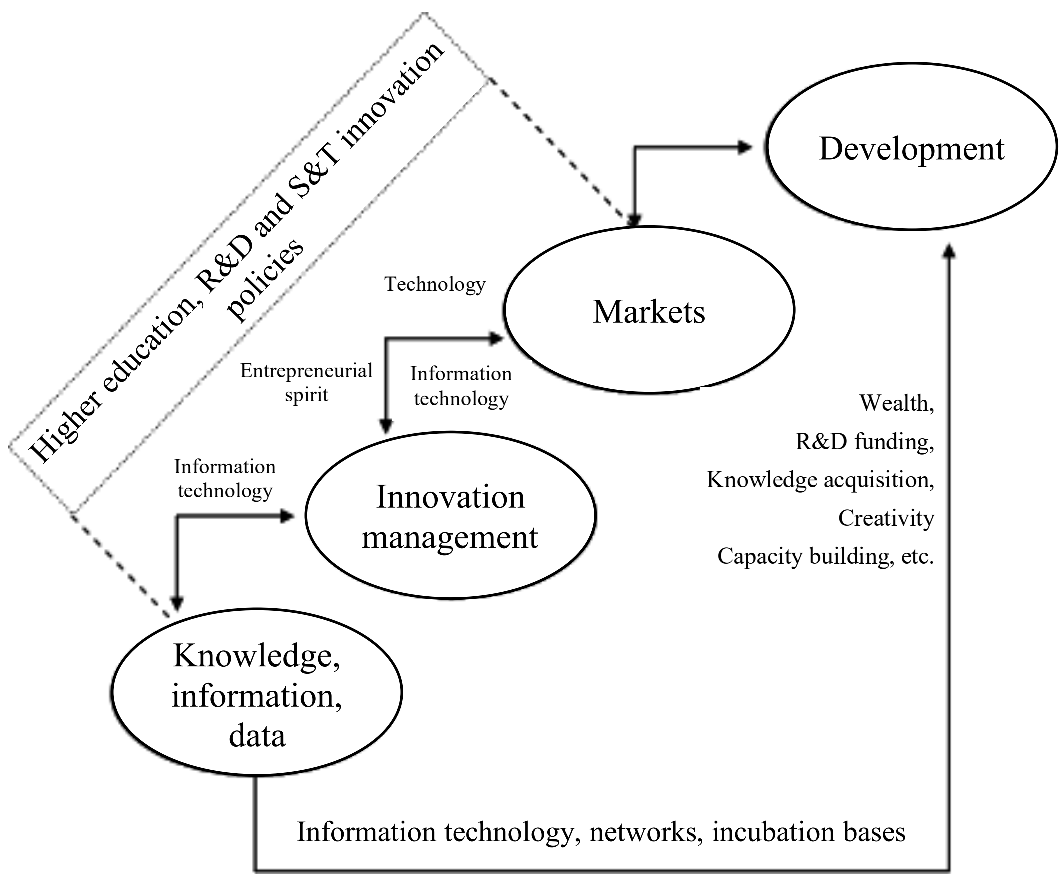
II. Shenzhen's strengths

1. Knowledge-based economy

A knowledge-based city a combination of S&T and economics, in which S&T is the strong driver behind economic diversification. According to the *2013 China City Competitiveness Blue Paper* jointly published by the Chinese Academy of Social Sciences and other departments in May 2013, Shenzhen is second only to Hong Kong in overall economic competitiveness. In addition, Shenzhen is also among the top ranks in China in a number of other categories, including third in both sustainable competitiveness and China knowledge-based city competitiveness.

In recent years, Shenzhen has grasped the principles of S&T achievement conversion and industrialization, combined scientific research and market development closely together, promoted the combination of technology, capital, and other factors, and guided the capital markets and social investment to pay more attention to investment in the conversion and industrialization of S&T achievements. It has optimized the layout of S&T intermediary service organizations, and perfected the S&T intermediary service system, strengthened the construction and demonstration of high-level S&T intermediary service institutions, and improved the service functions and service levels of productivity promotion centers, university S&T parks, technology business incubators, technology markets, TTIs, and other S&T intermediary organizations. It has also established and developed technology transfer service alliances, promoted resource sharing among S&T intermediary service organizations, and increased the cultivation of S&T associations such as societies, all of which have formed a knowledge-based economic system with Shenzhen characteristics (Figure 73).

Figure 73 Shenzhen's knowledge-based economy



Shenzhen is strong in S&T. It also neighbors Hong Kong and Macau, which have high levels of S&T marketization, and it can draw on the mature experience of these two places in transforming S&T into productivity and using S&T to promote economic development. By establishing an international technology transfer center in Shenzhen and laying out a regional S&T innovation system, it could fully bring into play the center's S&T outward-radiation role, and Hong Kong's strengths as an international information and financial center could be used to advantage, as it offers the best channel for exporting technology from Guangdong and for importing international technology. It could actively participate in the international division of labor and international markets, drive the upgrading and development of regional industrial innovation capacity, and effectively guide international industrial capital. In addition, while strengthening its own regional S&T strengths, Shenzhen could also transfer to other cities some S&T theoretical innovation knowledge with lower requirements as to economic environment, continuously stimulate regional innovation vitality, and speed up the construction of modern service industries with S&T innovation services at their core.

2. Shenzhen's S&T environment

2.1 Shenzhen leads the province in R&D expenditures, accounting for nearly half the total

Within the province as a whole, the Pearl River Delta region[4] has always maintained advantages in enterprise S&T activity investment levels and the quality of S&T activities. In 2011, the Pearl River Delta's R&D expenditures were RMB 84.474 billion, representing 93.92% of province-wide expenditures, while the eastern region, western region, and mountainous region[5] together accounted for 6.08%. Shenzhen has become a gathering place for S&T innovation entities, constantly radiating out to surrounding regions, industries, and enterprises. Shenzhen's R&D expenditures rank first in the province. At RMB 38.889 billion, they account for 43.24% of the provincial total (Figure 74). In 2012, Shenzhen's R&D investment represented 3.81% of GDP, the leading level nationwide.

Figure 74 Top five regions of Guangdong in R&D expenditures

Smart cities	*R&D funding (RMB 100 million)*	*Share of total provincial R&D investment (%)*	*Annual growth rate (%)*	*R&D activity personnel*
Shenzhen	388.89	43.24	23.94	155912
Guangzhou	140.67	15.64	18.43	58905
Foshan	116.35	12.94	26.17	57212
Dongguan	61.25	6.81	23.72	39400
Zhongshan	46.04	5.12	31.32	24815

Data source: Guangdong Bureau of Statistics

2.2 High-tech industries have made great strides, and innovation capacity has increased significantly

[4] [Translation of footnote in Chinese source text] The Pearl River Delta includes Guangzhou, Shenzhen, Zhuhai, Foshan, Huizhou, Dongguan, Zhongshan, Jiangmen, and Zhaoqing

[5] [Translation of footnote in Chinese source text] Eastern region: Shantou, Shanwei, Chaozhou, and Jieyang; western region: Yangjiang, Zhanjiang, and Maoming; mountainous region: Shaoguan, Heyuan, Meizhou, Qingyuan, and Yunfu

Figure 75 Top five regions in Guangdong by high-tech product output value

City	*Product output value (RMB 100 million)*	*Product sales revenue (RMB 100 million)*	*Export sales revenue (RMB 100 million)*	*Total profits and taxes (RMB 100 million)*
Shenzhen	11875.60	11436.43	5608.26	936.23
Guangzhou	6461.67	6033.82	266.9	836.53
Foshan	5379.89	4733.42	702.17	320.05
Dongguan	2800.01	2725.76	1695.18	151.48
Huizhou	2308.87	2282.91	894.59	183.05

Data source: Guangdong Department of Science and Technology

High-tech industries are Guangdong's number-one growth pole. In 2011, the top five regions in Guangdong in terms of high-tech product output value were Shenzhen, Guangzhou, Foshan, Dongguan, and Huizhou (Figure 75). Shenzhen's product output value was RMB 1.18756 trillion, nearly twice that of Guangzhou. Guangzhou's industrial economy has long relied on traditional manufacturing and traditional service industries, and it has lagged behind Shenzhen in the development of S&T innovation industries. In 2012, Shenzhen's high-tech product output value was 1.29 trillion RMB, an increase of 9% compared to 2011.

2.3 A good policy environment

Figure 76 Shenzhen's main S&T innovation policy regulations

	Important documents and plans
Documents of the Shenzhen City Party Committee and City Government	Decision on Striving to Construct a National Independent Innovation Demonstration Zone to Realize Innovation-Driven Development ([2012] No. 14) Decision on Accelerating Transformation of the Economic Development Model ([2010] No. 12) Several Opinions on Accelerating the Construction of a National Innovative City ([2008] No. 8) Decision on Implementing the Independent Innovation Strategy for Constructing a National Innovative City ([2006] No. 1) Opinions on Implementing the *Decision of the Guangdong Provincial Party Committee and Guangdong Provincial People's Government on Accelerating the Construction of a Strong Science and Technology Province* ([2004] No. 7) Decision on Refining the Regional Innovation System to Promote the Continuous Rapid Development of High-Tech Industries ([2004] No. 1)
Shenzhen Local Regulations	Technology Transfer Regulations of Shenzhen Special Economic Zone (2013.3) Regulations of Shenzhen Special Economic Zone on Promoting Accelerated Transformation of the Economic Development Model (2010.12) Regulations of the Shenzhen Special Economic Zone on the Promotion of Scientific and Technological Innovations (2008.8) Regulations of Shenzhen Special Economic Zone on High-Tech Industrial Parks (2006.10)
	Shenzhen Science and Technology Incentive Measures (Shenzhen Government [2012] No. 126) Several Measures on Promoting the Integration of S&T and Finance (Shenzhen

	Government [2012] No. 125)
Shenzhen City Regulatory Documents	Several Measures on Promoting the Development of High-Technology Service Industries (Shenzhen Government [2012] No. 124) Several Measures on Deepening the Reform of the S&T System to Increase S&T Innovation Capacity (Shenzhen Government [2012] No. 123) Several Measures on Promoting the Integration of S&T and Finance (Shenzhen Government [2012] No. 125) Several Measures on Accelerating the Development of S&T for the People's Livelihoods (Shenzhen Government Measures [2012] No. 53) Several Measures on Promoting the Integration of Culture and S&T (Shenzhen Government Measures [2012] No. 52) Development Policies for the New Generation Information Technology Industry in Shenzhen (Shenzhen Government [2011] No. 210) Guiding Opinions on Accelerating Industrial Transformation and Upgrading (Shenzhen Government [2011] No. 165) Several Policy Measures on Strengthening Independent Innovation to Promote Development of High-Tech Industries (Shenzhen Government [2008] No. 300) Four Supporting Policy Documents of the *Decision of the Shenzhen City Party Committee and Shenzhen City People's Government on the Implementation of the Independent Innovation Strategy to Construct a National Innovative City* ([2006] No. 8)
Shenzhen City Science and Technology Innovation Commission Regulatory Documents	Implementation Rules of the Shenzhen Science and Technology Award Measures (Shenzhen Science and Technology Innovation [2013] No. 13) Administrative Measures for Shenzhen Science and Technology Plan Projects (Shenzhen Science and Technology Innovation [2012] No. 9) Shenzhen Action Plan for Promoting the Development of Scientific Research Institutions (2013-2015) (Shenzhen Science and Technology Innovation Regulations [2012] No. 8) Several Measures for Promoting the Development of Science and Technology Enterprise Incubators (Shenzhen Science and Technology Innovation Regulations [2012] No. 7) Implementation Measures for the Validation Services of Scientific Research Institutions in Shenzhen (Shenzhen Science and Technology Innovation Regulations [2012] No. 6) Implementation Measures for the Identification of High-Tech Projects in Shenzhen (Shenzhen Science and Technology Innovation Regulations [2012] No. 2) Administrative Measures for the Identification of High-Tech Enterprises in Shenzhen (Shenzhen Science and Technology Innovation Regulations [2009] No. 1)

Data source: Shenzhen Municipal Science and Technology Innovation Commission

With policies designed to serve innovation, Shenzhen has rationally planned the promotion of S&T achievement industrialization, and for many years has continued to develop and improve technology innovation policies (Figure 76), thereby promoting the development of public innovation platforms and the industrialization of S&T achievements. Shenzhen took the lead in building a regional innovation system in 2004, launched the first *National Innovative City Master Plan* in 2008, and went on to launch the second local regulation on technology transfer in China after Nanjing, the *Technology Transfer Regulation*, in March 2013. The series of regulations promulgated by Shenzhen not only facilitates implementation of the national strategic plan, but is also conducive to Shenzhen's own innovation development, boosting independent innovation efforts, and creating a good rule of law environment for the conversion of IP. For example, the *Regulations on Technology Transfer of Shenzhen Special Economic Zone* encourage various investment methods and the recruitment and cultivation of new financial institutions. They clearly establish a multi-level risk assurance mechanism using S&T

achievements as collateral for financing, and encourage financial guarantee institutions to provide guarantee services for S&T achievement-based financing of SMEs, which solved a shortcoming of the knowledge innovation system. S&T innovation has become the leading force in determining the development of the world economy. Creating and optimizing the innovation system thus means enhancing the competitiveness of the region. Shenzhen's innovation policies and strategies have impelled innovative activities and technologies, improved the productivity of government public S&T inputs, and created a relaxed environment for the implementation of market-oriented innovation paths.

III. Operating model

1. Positioning and goals

Technology transfer usually consists of many complex and interconnected stages and is carried out at several levels. It is ultimately manifested in an enterprise's acquisition and use of technology that it had not possessed. Although it often involves existing firms, it is also applicable to the development of new industries. The stages involved include exploration of technologies useful to the enterprise or region; detailed evaluation or assessment of the potential uses of the technology; obtaining of patents; training of personnel to use the new technology; and the purchasing, developing, or manufacturing of new designs and equipment. Providing effective support for technology transfer implies having purposeful awareness of a certain aspect or form of the technology.

Issues related to constructing technology centers

1. Positioning: A platform providing multi-directional technology information services, it is the organizer of technology transfer projects, as well as the promoter and supervisor.
2. Priority focus: Research on commercial development and a comprehensive service platform integrating technology transfer and training
3. Added value: A technology center can better add value to existing conditions
    1) Exchange among relevant institutions, as well as cross-fertilization of knowledge
    2) Promote mobility and attract talent of the highest quality
    3) Raise scientific awareness, especially awareness of research and development
    4) Promote innovation and knowledge transfer
    5) Develop the demand side, and combine supply and demand
    6) Help develop business opportunities
    7) Promote entrepreneurial development and activities
    8) Support SMEs and regional social and economic development
    9) Engage in the effective configuration and structuring of the innovation process

Models that could be followed include large technology development centers such as the National Technology Transfer Center which, with six Regional Technology Transfer Centers (RTTCs), links U.S. companies to technology resources such as NASA, national laboratories, and universities through national channels in several ways (including web-based programs). However, many regional technology transfer centers operate on a much smaller model, and they all involve:

(1) Identification of new technologies and their commercial potential;

(2) The management of IP protection and the identification of business partners;

(3) Information search service operations;

(4) Commercial development of technologies developed from public funds by the private sector (私营部门);

(5) Effective development of databases and information technologies;

Usually, the technology transfers involve common technologies that have already been transferred to existing enterprises for use, including: different processes and new manufacturing technologies; application of computer-aided design; testing of new construction technologies; use of heating or photovoltaic technologies; and introduction of new cash crops or related varieties, etc. A better model for a technology transfer center is one centered around a well-established university, with a technology or science park established in its vicinity and containing incubation and business development facilities. University resources are abundant, and the relevant technology facilities are largely local. MIT's Industrial Liaison Program is a good example.

The main goal of a Shenzhen International Technology Transfer Center would be to achieve sustainable development and improve productivity and quality by supporting international and regional S&T innovation capacity building through the application of appropriate modern technologies, thereby ensuring its competitiveness in a knowledge-based global economy. Therefore, the Shenzhen International Technology Transfer Center will deal with three main interacting elements, namely, competition, transactions, and network contacts.

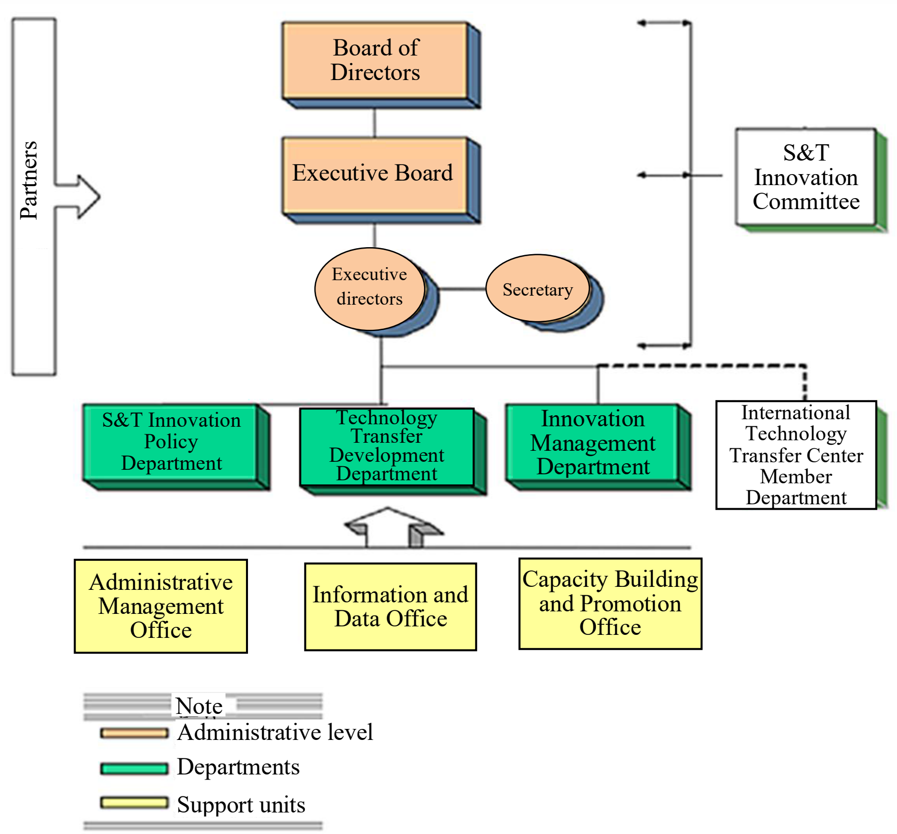
Objectives of the Shenzhen International Technology Transfer Center

1. Spur demand and raise awareness of the role of S&T in promoting regional R&D capabilities;
2. Strengthen the linkages between the technology supply and demand sides, apply modern technology, and promote social and economic development;
3. Promote coordination and complementarity at the regional level, and the interregional transfer and exchange of information and knowledge;
4. Address region-specific issues in technology transfer, and promote cooperation with global S&T innovation programs;
5. Strengthen regional liaison with other technology transfer intermediaries, promote partnerships, and promote modern tools and mechanisms, such as information technology, networks, clusters, and incubation bases.
6. Encourage an entrepreneurial spirit and commercial financing, and carry out effective interaction with international enterprises to obtain financing support;
7. Promote the restructuring of technology markets and strengthen the ability of Chinese companies to participate in international negotiations.

2. Proposed structure

The operating model is that of S&T intermediary investment with the joint participation of government, high-tech enterprises, research institutes, financial and insurance institutions, private capital (民间资本), and foreign capital (Figure 77).

Figure 77 Structure of the Shenzhen International Technology Transfer Center



Main roles and functions:

The Executive Director is in charge of overall operations. He will implement the instructions of the Executive Board directives and Board of Directors, and help set the agenda, as well as the constantly changing activities and priority. The three main levels are the administrative level, main departments, and support units.

2.1 Administrative level

As a S&T innovation clearinghouse and facilitator, the International Technology Transfer Center must have partners and establish alliances, especially with international organizations and public and private institutions involved in S&T innovation. Potential partners include: Asia-Pacific technology transfer centers; technology-related associations (industry associations, agribusiness associations, business development agencies, etc.); technology transfer intermediaries (economic cooperation agencies, national technology agencies, technology institutes and centers, technology consulting firms, specialized NGOs); technology-oriented academic institutions and universities; and technology information providers (technology publishers, technology information centers, industrial information networks).

2.2 Main departments

2.2.1 S&T Innovation Policy Department

Conducts research and assessment of the current S&T innovation situation in the Pearl River Delta region and the forward-looking nature of the national innovation system's S&T objectives, and introduces innovative and creative approaches to the areas of scientific research, technology and innovation policy, expanding the new horizons of the Pearl River Delta region. Taking into account environmental considerations, promotes and formulates S&T transfer guidelines, plans, and best practices applicable to the regional uniqueness of Guangdong. Functions:

- Formulates technology transfer guidelines, norms, and practices;
- Conducts forward-looking technology planning for the Pearl River Delta region.

2.2.2 Technology Transfer Development Department

Based on demand, provides technology acquisition and related consulting and advisory services to help enterprises define their technology needs; matches supply and demand sides with prospective partners, and assists in contract and technology transfer negotiations. Promotes financing tools sought by enterprises, such as venture capital, loan subsidies, and incentives, and helps enterprises position themselves in international markets. In addition, performs tracking services for projects already implemented, follows up on the information and data needed during cooperation, fully expands the levels of cooperation, and provides one-stop services. Functions:

- Primarily uses the following mechanisms to carry out technology transfer:

  a. Collaboration with intermediaries (including consultants, technology brokers, chambers of commerce, industry associations, and business information centers) to provide complementary technology transfer services;

  b. International liaison with technology brokers;

  c. Technology databases updated daily;

  d. Technology transfer periodicals, including technical publications, catalogs, and value-added technology information services;

  e. Business meetings, symposia, and training programs.

- Technology development through linkages between R&D institutions, universities, and production and service sectors;
- Technology upgrading and transfer to SMEs, and providing SMEs and intermediaries the following technology transfer services:

  a. Information related to technology and business investment opportunities;

  b. Matching and pre-selection of future business partners;

  c. Support services such as market feasibility studies, technology assessment, and contract negotiation;

  d. Financing syndication, including loans, venture capital, subsidies, and incentives;

  e. Product marketing

- Technology promotion and propaganda

2.2.3 Innovation Management Department

Provides SMEs with innovative and creative ways to add value to research achievements, promote competitiveness and open up international markets for their products, so that SMEs compete and grow in the ever-changing technology market environment. Promotes and supports R&D projects by providing suitable project models, and establishes technology parks, incubation sites, networks, and clusters. Functions:

- Strengthens the assistance of relevant policies and mechanisms, improves technology management capacity, and achieves the following objectives:
  a. Technology selection;
  b. Technology upgrading and modernization on the part of SMEs;
  c. Management, promotion, transfer, and use of environmental protection technology;
  d. Adoption and absorption of new technology.
- Constantly improves technology management programs to strengthen regional capacity and promote international cooperation in special areas, such as:
  a. Technology acquisition;
  b. Technology monitoring and assessment;
  c. Technology evaluation;
  d. Promotion of IP and its management in relation to SMEs;
  e. Proposals on technology transfer laws and regulations;
  f. Promotion of national and regional approaches to the negotiation of technology transfer contracts.
- Industrial R&D;
- Knowledge management

2.3 Support units

2.3.1 Administrative Management Office

Mainly responsible for human resources, administration and operations, financial affairs, maintenance, and procurement.

2.3.2 Information and Data Office

Regularly updates technology transfer databases, business and technology periodicals, and information transfer networks, and promotes the creation of regional databases by advertising them on a specially designed Shenzhen International Technology Transfer Center website. Information technology has become an important tool for innovation: Through information technology, knowledge has become compilable and transferable. This unit will provide necessary IT support to all the departments. The portal website will be designed and implemented so as to enhance the activities of the Center and promote the management of information and knowledge on these activities, and will provide different technical data from various regions in standardized formats. The databases will include aspects such as patents and other IP, technology standards, and overseas investment environments, and will be dynamically updated, emphasizing timeliness and authoritativeness. The website will not only provide information retrieval and topic setting services, but will also allow opening of interactive recommendation and consultation windows on the homepage. It will help promote the Center's activities, promote financing activities, and strengthen the breadth and depth of information.

2.3.3 Capacity Building/Promotion Office

Conducts seminars, workshops, and other training on priority issues in the Pearl River Delta region to promote S&T innovation capacity building, thereby raising awareness of S&T innovation as a driver of economic development to the public awareness decision-making level. Provides enterprises additional assistance on new market creation, as well as private sector activities related to technology products and services. It also fosters a culture of product development and design innovation among S&T innovation institutions and enterprises, planning and collaborating with relevant regional and international institutions whenever possible.

3. Proposal model

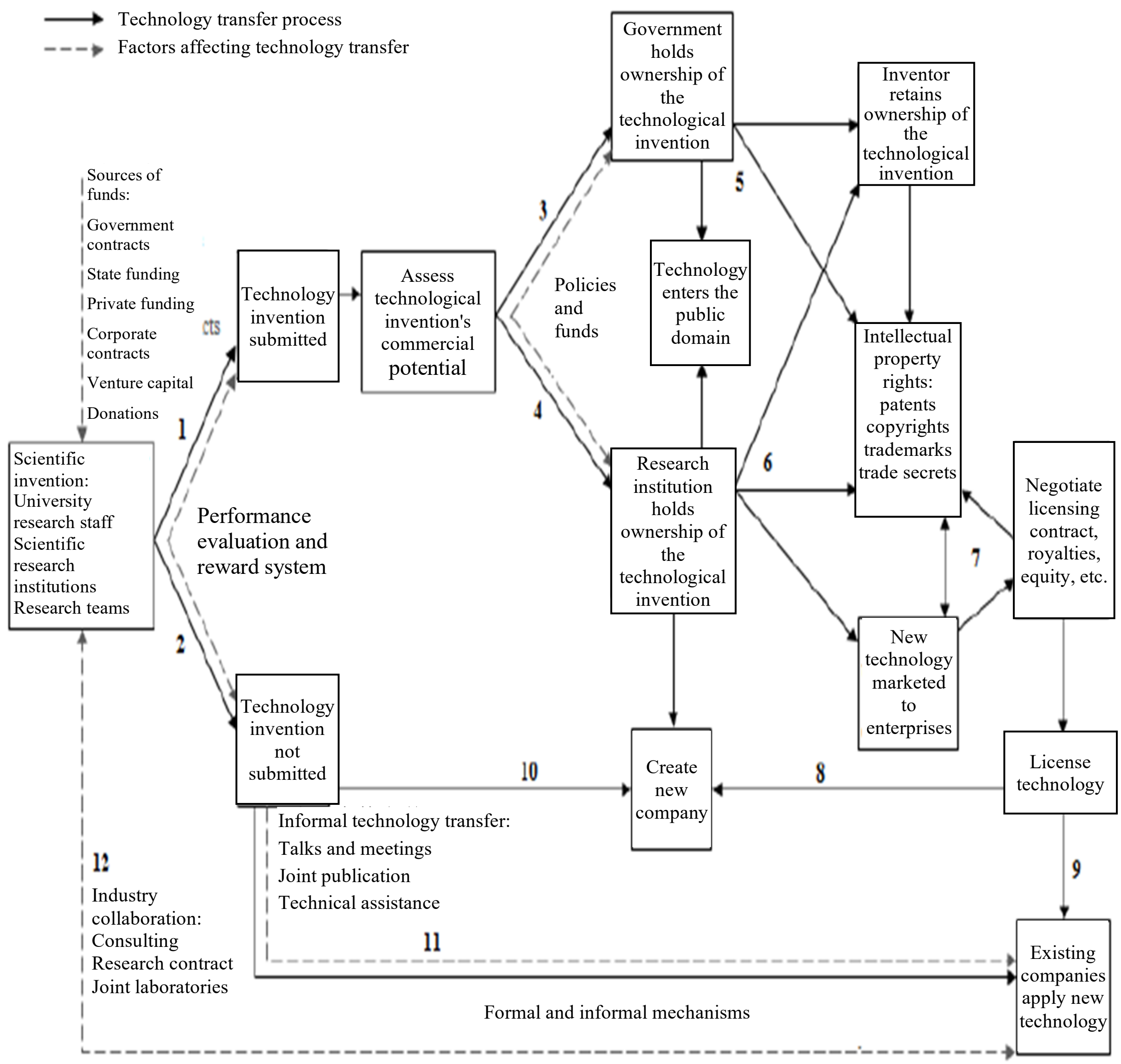
It starts with scientific discoveries, but differentiates the different creators in the actual research—university researchers, scientific research institutions, and research teams. Possible sources of funds at the beginning of the exploration process include: government contracts, state subsidies, private subsidies, corporate contracts, venture capital funds, and donations.

Once a new invention is made, the technology transfer process will take one of two routes: The inventor discloses his or her invention to the technology transfer center or the inventor chooses not to disclose the invention. As indicated by the dashed gray arrows [in Figure 78], an inventor's decision to disclose an invention is influenced by the performance evaluation and reward system. If the Transfer Center has a reward system that provides incentives for researchers to engage in commercial activities, inventors are likely to disclose their inventions and participate in formal technology transfer mechanisms. However, if there are too many obstacles and disadvantages to participating in technology transfer and official channels, inventors may avoid disclosure and use informal technology transfer mechanisms.

When an inventor decides to disclose an invention to the Technology Transfer Center, the Center will evaluate the commercial potential of the invention, including the time to bring it to market and the market potential, i.e., profitability, of the technology. If the Technology Transfer Center decides to adopt the technology, it will consider the relevant issues of the entity that owns the invention.

If the discovery was obtained from a government-funded research project, the government may require that the property rights to the invention be obtained, bringing it into the public domain and effectively ending the technology transfer process. Provided the government agrees, the inventor may retain ownership of the invention and submit an application for IP protection. Or, the Technology Transfer Center may choose to hold ownership of the invention, as well as decide how to proceed with commercialization, market the technology to companies or entrepreneurs, and promote technology development. The Technology Transfer Center may also begin the process of obtaining IP protection in the form of patents, copyrights, trademarks, trade secrets, etc. Inventors are allowed to retain ownership of their inventions with the consent of the funding institution.

Figure 78 Operating model of the Shenzhen International Technology Transfer Center



The processes of technology marketing, IP protection, licensing agreement negotiation, and monetary returns do not need to be in a linear path, as these processes can overlap and occur simultaneously. If the Technology Transfer Center wants to assess market interest in an invention before investing significant time and resources, it can market the technological invention before obtaining IP protection. Or, if the technological invention looks particularly promising, it can opt to file for a patent and copyright, etc., before marketing to potential investors. Before the IP protection process is complete, the Technology Transfer Center can successfully complete the marketing, find interested companies or entrepreneurs, and begin licensing negotiations. Once the technology is protected and successfully marketed, a licensing agreement should be signed to formally license the technology to a company, organization, or entrepreneur. If the technology is licensed to an entrepreneur, the entrepreneur may develop additional products or form a company around the technological invention. If the technology is licensed to a company and the technology is not yet mature, then further development or technological refinement must be done before it can be put on the market.

If the inventor chooses to act through informal mechanisms, then informal technology transfer mechanisms available include consultation, co-publication, demonstrations, conferences, and other communication processes between research institutions or personnel and industry contacts. The ideas and knowledge conveyed through informal technology transfer mechanisms may lead to the adoption and use of the scientist's discoveries, ideas, or knowledge by established companies, or to other forms of knowledge absorption, including free disclosure of the invention to the public.

IV. Analysis of operational issues in the technology transfer process

1. Technology pricing issues

Appraising the asset value of a technological invention is an important part of technology transfer. There are three asset valuation methods in relatively general use internationally: the cost approach, the market approach, and the income approach. In the cost approach, the appraised value is inferred by subtracting the accumulated depreciation from the cost required to replace the appraised asset. In the market approach, it is determined by comparing the similarities and differences between a market reference and the appraised asset, and adjusting the market price of the reference asset. In the income approach, the appraisal method is to estimate the future value of the asset and measure its present value according to a certain discount rate.

Since the value of a technological invention is mainly determined by the cash flow earnings it can bring, the income (present value) approach is generally used for appraisal. Adopting this method requires determining the economic life of the asset and the applicable discount rate, and the effects of inflation and various risk factors need to be considered. However, for technologies in the early stages of development, using risk assessments of off-the-shelf projects as substitutes poses difficulties. In addition, overlooking certain potential investment opportunities and their returns can easily lead to inaccurate risk assessments. In order to overcome this shortcoming, the "real options approach" (“实物期权法”) is gradually gaining currency in the international arena. Similar to financial options, investors pay a certain cost to own options on technological inventions. The evolutionary cycle of technological inventions is lengthy, and investors can decide whether to invest in the next stage of a technology based on its development circumstances and market information. This is a continuous investment process. If the investor gives up, there will be no opportunity to invest in the next stage and enjoy the profits, even if the project looks likely to make considerable profits.

The "real options approach" was introduced in China only very recently, and in the current legal system of appraisal, except for the *Measures for the Administration of State-Owned Assets Appraisal* and *Rules for the Implementation of Measures for the Administration of State-Owned Assets Appraisal* promulgated by the State Council in 1991, other regulations are scattered in many laws such as the "Company Law" and "Partnership Enterprise Law," and some of the provisions are no longer adapted to actual needs. Moreover, the regulations imposed by different departments lack coordination and communication, and need to be rationalized to ensure they are systematic and effective. In Europe and the United States, research on the appraisal of IP such as technological inventions is relatively mature and widely used in practice. In China, however, technology appraisal is still a new appraisal field, and a complete cultural appraisal theory and institutional system has yet to form. Consequently, we should draw on the successful experiences of foreign countries and construct and perfect a stable and relatively standardized technology appraisal system, starting from the objective requirements of technological inventions in China, taking the appraisal index as the main content and guidance in practice as the fundamental purpose, and adhering to the principle of being objective, scientific and systematic, so as to achieve relatively fair appraisal results, thus creating the conditions for technology transfer implementation.

2. **IP issues**

The transfer of IP and the distribution of benefits are an essential part of technology transfer. There are two main types of technology pre-development, namely, commissioned R&D and cooperative R&D. The principle for handling the attribution and sharing of technology development achievements follows the principle of priority of agreement and the principle of legal ownership. If there is a contractual agreement, the ownership issue will be decided according to the agreement; if there is no contractual agreement, execution will be according to legal provisions.

However, unlike technology development, technology transfer is the transfer of existing technical achievements and technical achievements with technology rights and interests, including the transfer of patent rights, the transfer of patent application rights, the transfer of patent implementation licenses, and the transfer of the right to use technology secrets, i.e., the transfer of technology ownership and the licensing of technology use rights. Its scope mainly involves existing and relatively complete technologies with technology rights and interests, including product technologies, process technologies, formulas, software programs, etc. Therefore, the focus of the ownership issue is on protecting subsequently improved technical achievements in the process of technology transfer. According to Article 354 of the *Contract Law*: "The parties may, based on mutual benefit, provide in the technology transfer contract the method for sharing any subsequent improvements resulting from the exploitation of the patent or use of the technical secrets. Where no such method has been agreed upon or the agreement is not clear, and it cannot be determined in accordance with Article 61 of this *Contract Law*, neither party shall be entitled to share any subsequent improvement made by the other party." If the subsequent improvement of the technical achievements by others is shared, it is a paid act.

In the case of technical consulting services, IP issues are also involved in the recommendations, opinions, and solutions to technical problems, including specific feasibility certifications, technical forecasts, and analysis and evaluation reports made for the client engaging the services, and regarding its scientific research, technology development, technical improvement, engineering construction, S&T management, and other projects. According to Article 363 of the *Contract Law*, "during the performance of a technical consulting contract or technical service contract, any new technology developed by the consultant or service provider using the technical materials and working conditions provided by the client belongs to the consultant or service provider. New technology developed by the client using the work results provided by the consultant or service provider belongs to the client. If the parties provide otherwise by contract, such provision shall prevail." In fact, technical consulting does not involve technical rights and interests, except where provided by contractual agreement. However, it is worth noting that if the recommendations and solutions contain technological achievements that need to be protected, the parties should expressly agree on the nature and attribution of such technological achievements.

3. **Legal issues**

China's IP legislation and enforcement have been continuously strengthened and improved in recent years. Thus far, however, China does not have a coherent *National Technology Transfer Law*. The United States, in contrast, has nearly 30 laws on technology transfer. Perfecting the legal system is key for the commercialization and smooth transfer of technological achievements. For promoting technological innovation, China has the *Patent Law* of 1987, the *Technology Contract Law* of 1989, the *Law on Scientific and Technological Progress* of 1992, and the *Law on Promoting the Conversion of S&T Achievements into Practical Applications* of 1996. However, these laws do not have content on the attribution, disclosure, and supervision of S&T achievements generated by state funding. The only regulation specifically for national technology transfer is *Several Provisions on the Management of Intellectual Property Rights of Research Results of National Research Program Projects* issued by the Ministry of Science and Technology and the Ministry of Finance in 2002. In addition, the only laws involving international technology transfer are the *Foreign Trade Law of the People's Republic of China*, implemented since July 1, 1994, and the *Regulations of the People's Republic of China on Administration of Import and Export of Technology*, implemented since January 1, 2002. China's *Anti-Monopoly Law*, in effect since August 1, 2008, does not have explicit provisions on technology monopolies. The scope of prohibited and restricted technologies is only stipulated in the *Catalog of Technologies Prohibited or Restricted by China from Import*, which was revised on October 23, 2007, and the *Catalog of Technologies Prohibited or Restricted by China from Export*, which was revised on September 16, 2008. China's regulatory system at its current stage mainly focuses on the import and export of technologies and technology products, tariffs, and technology market administration. It seldom touches upon technology transfer, which only appears in some local laws and regulations, such as the *Regulation on Promoting Technology Transfer of Nanjing Municipality* adopted by Nanjing in January 2011, the *Guidance on Further Promoting the Conversion and Industrialization of S&T Achievements* issued by Beijing in March 2011; and the *Regulations on Technology Transfer of Shenzhen Special Economic Zone* adopted by Shenzhen in February 2013. The importance of technology transfer has not attracted enough attention at the national legislation level.

V. Recommendations on the establishment of the Shenzhen International Technology Transfer Center

1. **Formulate and implement effective long-term industrial strategies**

China is a world trade power (世界贸易大国), but the share of its exported merchandise that has independent brands and IP is not large, and labor productivity is a mere one-tenth that of the United States. It ranks first in the world in production of color TVs, cell phones, desktop computers, and DVD players, but is still dependent on imports for key chips. The overall S&T contribution rate in agriculture is only 54.2%, more than twenty percentage points lower than in developed countries. Contracts involving foreign technology are increasing year by year, and high technology is a hot spot in technology transactions, but in the globalized economy, just developing high technology is not enough to have a competitive advantage in the market. Unique competitive advantages in the market can only be formed in the end with effective industrial strategies.

International industrial transfer is an inevitable trend for industrial upgrading. The economic system and investment environment directly affect the international transfer of industries and the flow of factors of production. In order to win competitive advantage in the global economy, countries have been ramping up international industrial transfer, and the speed, scale, and scope of international industrial transfer have expanded continuously. Large-scale structural reorganization and upgrading have also elevated the technological level of industrial transfer. The increasingly high-end nature of international industrial transfer has made high technology-intensive, high-value-added, and processing-intensive industries the key areas of industrial transfer. Shenzhen is a society in the middle and late stages of industrialization. The internal structure of industry has shifted from being dominated by capital-intensive industries to being dominated by technology-intensive industries. It needs to participate in international industrial transfer more effectively, create a unique environment and technological advantages, provide differentiated guidance for different industries, combine industrial transfer with technology transfer, integrate informatization with industrialization, and implement two-way circular transfer. It must promote transformation of the economic growth model from extensive to intensive growth, develop industries that are high value-added, high-tech, and environmentally friendly, and that have high investment density and low energy consumption. To improve Shenzhen's position in the international industrial division of labor, it must promote industrial upgrading and encourage the transfer of domestic low value-added industries to countries low on the industrial gradient.

In carrying out international technology transfer, we should consider the following points:

(1) The introduction of technology from abroad should be firmly rooted in structural optimization. Industrial transfer is driven by economic rationality and mutual interests. The international flow of technology factors directly affects the regional industrial structure. If the industrial system is not laid out strategically, it will be squeezed at the bottom rungs of the international division of labor for a long time. Shenzhen must carry out technology transfer in a targeted manner and focus on upgrading industry levels. And, in accordance with the circular economy concept, it must develop eco-production chains, and take a new sustainable development path of industrialization.

(2) It must occupy the high value-added links of the production chain. In the era of the knowledge-based economy, international industrial transfer has entered a new stage. Industrial transfer is no longer limited to transfer between developed and developing countries, or marginal industries, but is focused more on integrating advantages across entire production chains around the world. International industrial transfer has expanded from production fields to independent processes such as R&D. In the process of technology transfer, Shenzhen can develop core technologies for supporting industries based on the vertical relationships between upstream and downstream industries, forming extensions of the production chains, and evolving into multi-faceted, composite economies of scale covering creative design, research and development, value-added services, and so on.

(3) Shenzhen must increase the development of local cutting-edge technologies for overseas emerging markets, cultivate brands, control patented technologies and core skills, and prevent technology spillovers. Internally, it must build a "high-tech ecosystem" to compensate for the lack of industrial space in the special economic zone and the lack of talents outside the zone; externally, it must increase investment in the development of biotechnology and new materials technology. And it must focus on

creating an environment for independent innovation, accelerate the flow of knowledge and technology transfer, and realize the commercialization, industrialization, and internationalization of S&T achievements by improving the combination of the three elements of technology, talent, and capital.

2. Further refine the legal framework for international technology transfer

Drawing on the experiences of relevant countries, technology transfer must be carried out under legal norms. Innovation-oriented countries such as the United States, Germany, and the United Kingdom have made technology transfer an important part of their national innovation strategies and established relatively sound legal systems to institutionalize international technology transfer, and under such legal assurance their innovation capabilities have developed rapidly. The long-standing lack of technology transfer legislation in China has seriously hampered the advancement of technology transfer. China should establish a legal framework system with a *National Technology Transfer Law* as the core, supplemented by trade laws and regulations such as the *Regulations on Customs Protection of Intellectual Property Rights*, and supported by legislation on market order such as the *Anti-Unfair Competition Law*. At the same time, the economic legal system necessary for the implementation of the new law should be introduced, thereby providing a good legal environment for the virtuous circle of China's technology transfer. The main point in formulating the *National Technology Transfer Law* is to establish a multi-party collaboration and supervision mechanism among government, universities, research institutes, and enterprises. Coordination and cooperation among government, universities, and enterprises is the basis for the establishment of a national innovation mechanism, and formation of the innovation mechanism requires government support and regulation. The government should take on the obligation of funding innovation activities, as well as managing and supervising the funded projects. The establishment of a technological innovation service system requires the effective integration of resources in institutions of higher education, research institutes, S&T service organizations and key enterprises, which are both vehicles for disseminating knowledge to society and seedbeds of innovative activities. These universities and institutions have obligations to actively carry out innovative activities, including multi-channel and multi-level technology transfer work such as technology R&D services, technology achievement commercialization and promotion services, and industrial technology talent training and exchange services, so that inventions can be applied in practice. Enterprises are the receptors that make specific conversions of inventions. We should continuously improve the efficiency and quality of technology transfer, and refine effective mechanisms for enterprises to acquire national patented technologies.

In addition, in the process of formulating the legal framework for international technology transfer, the following aspects will need to be handled properly:

(1) IP involving national security, national interests, and significant social and public interests should be implemented in accordance with Article 22 of Chapter 4 of the *Interim Provisions on Intellectual Property Management for Key National Science and Technology Projects* issued on July 1, 2010: "The rights belong to the State, and the units in charge of the project (research topic) shall have the right to use them free of charge," and contracts for project (research topic) tasks shall make explicit agreements on the ownership of the resulting intellectual property rights according to the above principle, and a corresponding specific transfer mechanism shall be formulated for the

intellectual property rights to which the State retains ownership.

(2) The technology transfer legislation should coincide with the public interest, bring S&T output to the market and create wealth, promote real improvement of people's living standards, comprehensively enhance the internationalization of the economy, and refine the open economic system of internal and external linkages and win-win outcomes.

(3) Technology transfer management relationships should be adjusted, stipulating the establishment, subordination, jurisdiction, and legal powers and responsibilities of the state agencies in charge of technology transfer activities in China. The domestic administrative departments related to technology transfer should also be adjusted and unified based on the principles of streamlining agencies, reducing staff, and increasing efficiency in the reorganization of agencies. The departments in charge of technology transfer should exercise the powers to formulate and revise technical and economic norms, approve technology transfer projects, support technology importation, track technology transfer, keep custody of technology import reserves, perform acceptance checks on technology import projects, and reward and punish technology transfer according to corresponding regulations, so as to ensure an orderly and efficient virtuous circle of technology transfer, thus promoting the smooth development of an outward-oriented economy.

3. Strengthen the coordinated handling of international IP disputes

China has relatively numerous import, export, and foreign-related IP disputes, and there is a lack of corresponding legal norms and administrative departments to coordinate and resolve them. To prevent contract risks, clear and specific provisions must be made in technology transfer contracts regarding rights, responsibilities, and benefits, avoiding, as much as possible, unnecessary disputes later due to a lack of prior agreement or different interpretations by the parties of specific terms in the text. Attention should also be paid to distinguishing between the expected project achievements and the scientific research achievements already made, as well as to strengthening the management of intangible assets. In terms of preventing contract risks, we recommend that the professional staff of the International Technology Transfer Center jointly review and manage the technology contracts of researchers, clarify and complete the relevant legal provisions of contracts, agree on the IP ownership of S&T achievements, and scientifically assess the intangible assets involved in contracts. For the transfer of technical secrets, both parties to a contract should clarify the scope of classification, its content, the personnel involved in classification, etc., to avoid leaking of technical secrets due to human factors. The International Technology Transfer Center can also draw on international experience and establish corresponding institutions responsible for international IP disputes, help enterprises identify projects with high returns and market potential, achieve effective avoidance of potential risks, and ensure the successful linkage of parties for technology transfers. In addition, it should further strengthen coordination and cooperation with domestic IP authorities, customs, and judicial departments, and actively study overall strategies for the protection of IP in foreign trade.

4. Technology transfer should be combined with SMEs' right of first refusal

There are flaws in China's investment and financing mechanisms for supporting innovation.

SMEs in particular face multiple obstacles in all aspects of innovation activities, such as investment in the early stages of innovation activities, financing in the growth period, and credit investment in the expansion period, exposing serious disconnects in the overall S&T system combining the innovation, capital, and commercial chains. In order to encourage SMEs to convert their scientific research results into commercially valuable technologies, SME start-up guidance funds can be established to support the entrepreneurial development of SMEs. The *Small Business Innovation Development Act* enacted in 1982 in the United States has made small enterprises one of the main forces for promoting the conversion of federal research achievements. It did so by encouraging them to engage in technical innovation and participate in the research programs of federal laboratories. One such program, The Small Business Innovation Fund (SBIR), which provides government agencies with funding for small business R&D related to their mission, played a huge promotional role in the development of Silicon Valley in the 1980s. As we engage in the technology transfer process, we can also encourage R&D institutions to give priority to domestic manufacturing industries and SMEs as technology transfer targets, promoting the rapid growth of SMEs. We can carry out pilot incubation of technology-based SMEs before they go public, provide various investment and financing services for SME technology transfer, simplify the use of financial instruments such as venture capital, matching capital, and angel capital, and adopt government fiscal and financial incentives to promote the combination and linkage of supply and demand, the creation of collaborative R&D centers, and the consolidation of S&T partnerships.

5. **Accelerate cultivation of technology transfer professionals**

Talent is an important guarantee for the successful conversion of technological achievements into actual productive forces (生产力). Most of the personnel engaged in technology transfer work in China's technology transfer institutions have been converted from scientific research managers, or are scientific research managers doing technology transfer work on a part-time basis. The lack of high-end interdisciplinary talents engaged in technology transfer has become a bottleneck hindering the high-speed development of international technology transfer activities. Shenzhen should accelerate the training and qualification management of technology transfer professionals. Through multiple channels and pathways, it should cultivate various types of technology transfer talent echelons specializing in the service, review, management, and judicial aspects. Furthermore, taking into account the new situations and new characteristics emerging in current technology transfer work, it should conduct targeted education for staff and management personnel on IP law, contract law, and other relevant regulations, and periodically host trainings on a full range of business knowledge and skills, as well as training on IP management and protection. And it should also invite experts to give courses and lectures on patent application, IP protection, and patent infringement case analysis. The focus should be on improving the overall quality of technology market management personnel, establishing a qualification certification system for technology transfer-related occupations and positions, and encouraging the qualification management of technology brokers, so that all links in the international technology transfer process will have practitioners with corresponding technical, legal, and business expertise backgrounds. This will raise the efficiency and competitiveness levels of professional technology service organizations, and lay a solid foundation for the smooth implementation of international technology transfer.