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THE CHARACTERISTICS OF TECHNOLOGY TRANSFER INTO THE CHINESE STEEL INDUSTRY AND THE VALUATION PROBLEM

He Jinsheng, Tianjin University, China

Wang Xingming, Renmin University, China

David Bennett, Kirit Vaidya and Zhao Hongyu, Aston University, United Kingdom

Abstract

This paper describes some empirical studies that have been carried out to investigate the characteristics of the Chinese steel industry in terms of technological renovation and it's relationship with the more general question of technology transfer to China. Consideration is given to the question of technology valuation that is an issue when technology is being transferred between owners and acquirers. Comparisons are made between considerations of value in steel making and the results of earlier investigations in the machine tool sector.

1 INTRODUCTION TO THE TECHNOLOGY VALUATION MODEL

China is the world's largest steel producer and also the largest steel consumer. However, the quality of China's steel products is generally below world standards so the development of the industry relies heavily on introducing technology transferred from abroad. Empirical studies have been carried out to investigate the characteristics of the steel industry in terms of technological renovation and its relationship with the more general question of technology transfer to China.

These studies show that the valuation of technology is one of the most important considerations for ensuring successful intake of technology to the Chinese steel industry. In order to promote the healthy development of technology transfer into China from the rest of the world, ways of resolving the valuation problem must be found. Findings from a previous study involving the Chinese machine tool industry have proved very useful in addressing the technology valuation question for steel making technologies.

A previous study by the authors on technology transfer between the UK and China in the machine tool industry concluded that the issue of reaching mutual agreement on the value of technology was a major handicap to many transfer negotiations. The distribution of cost, risks and benefits varies substantially between types of arrangement as well as the specifics of the agreement. From previous research the following are the main factors making it difficult to determine a value for technology that is acceptable both to the supplier and acquirer [1].

i) Differences in the perceived strategic and commercial importance of the technology.

ii) Differences in the form of collaboration.

iii) Differences in perception concerning the technology gap.

iv) Differences in perception of product standards.

v) Differences in the amount of in-house and sub-contract production.

Because of these differences a disagreement often exists between the technology owner (supplier) and acquirer (buyer) involved in a technology transfer negotiation, so the views of these two sides are major determinants for deciding the value of technology. From the point of view of the owner, the value of the technology firstly involves the costs that have been incurred, which include expenditure on its development, production and supply. Apart from these costs the value of technology is also affected by the actual or potential threat from alternative competing technologies as well as barriers against entry into markets. For the potential acquirer the important considerations are the cost of the technology, its own absorptive capacity and the benefits to be gained from its use. Based on these considerations a conceptual model for technology valuation with four value components has been proposed. The four components are as follows:

1. 'Owner's value', which is the current worth of the technology to the owner based on the cost of its development, production and distribution, together with the cumulative costs of any other upstream activities (for example, those incorporated in the cost of components and other inputs) and opportunity cost considerations (for example, where the market value of the technology is lower than the cost of its development because of obsolescence).
2. 'Substitute value', which is the price that the acquirer could expect to pay for an equivalent technology from another source. This may be either the price of alternative technologies in the market, if such a market exists, or the cost of the acquirer developing its own technology.
3. 'Traded value', which is the income that could be derived if the technology was sold-on by the acquirer or its value if the acquirer was bought-out by a third party. If the acquirer is a listed shareholding company the traded value could be reflected in the change of its share price.
4. 'Transfer value', which is the potential worth of the technology to the acquirer, taking into account the proportion of added value generated further downstream in the value chain.

These four value components are highly interrelated. The value of technology to the current owner will be based on costs incurred upstream in the value chain. However both the potential acquirer and the owner can readily compare this with the price of an equivalent technology, if available in the market. Potential acquirers of technology will, in addition, be concerned with the traded value since it provides an indication of the gain if the technology is subsequently resold. Transfer value is of concern to the acquirer since it represents the worth of the technology taking into account any downstream value added. This would also be of interest to the supplier where a royalty is to be paid or a share of benefits can be gained in return for the use of the technology by the acquirer.

Evidence collected from case studies and surveys along the UK-China value chain shows that owner's value is firstly determined by the cost structure, which has previously been analysed by the authors [2]. However, for a supplier the reality of valuing technology is not simply a matter of determining its cost and adding a margin to earn an adequate return. Neither for the acquirer is it just a matter of judging its worth in the market. The relevant value components need to be identified, their relative importance determined, and an overall assessment needs to be made based on a balance between the potential gains and risks. As a consequence, in many cases the actual technology transfer process is not a straightforward market transaction but involves an arrangement for sharing the gains, costs and risks associated with the transfer.

Because the focus of the research is on the transaction between the owner and the acquirer, the development of the model has concentrated on the owner's and transfer values. The other two value components may also influence the price of the technology and the cost and form of transfer arrangement. This can be taken into account in the decision-making processes of the owner and acquirer.

Investigations have also been made in the machine tool industry regarding the development of the model for transfer value. They concluded that transfer value is a balance between the acquisition gains and costs as summarised in Figure 1.

More recently, research has been conducted into steel making industries both in the UK and China. This has been aimed at verifying the technology valuation model and assessment framework for technology transfer derived from the machine tool industry research. Case companies visited have included Avesta Sheffield Ltd. and British Rollmakers Corporation in UK and Shougang Steel Works (also Shougang Machinery and Electric Corporation), Tianjin Pipe Corporation, and Tianjin Steel Works in China. A general survey of China's steel industry has also been carried out. These investigations show that the industry is potentially another big market for foreign technology. Billions of US dollars of foreign technology have been purchased from developed countries since the implementation of the "open door policy" and much more is still needed along with the restructuring of the industry and the reform of state-owned enterprises. The features of this industry suggest that valuation of technology is also a vital issue and serves as one of the major barriers for successful technology transfer from developed countries to China.

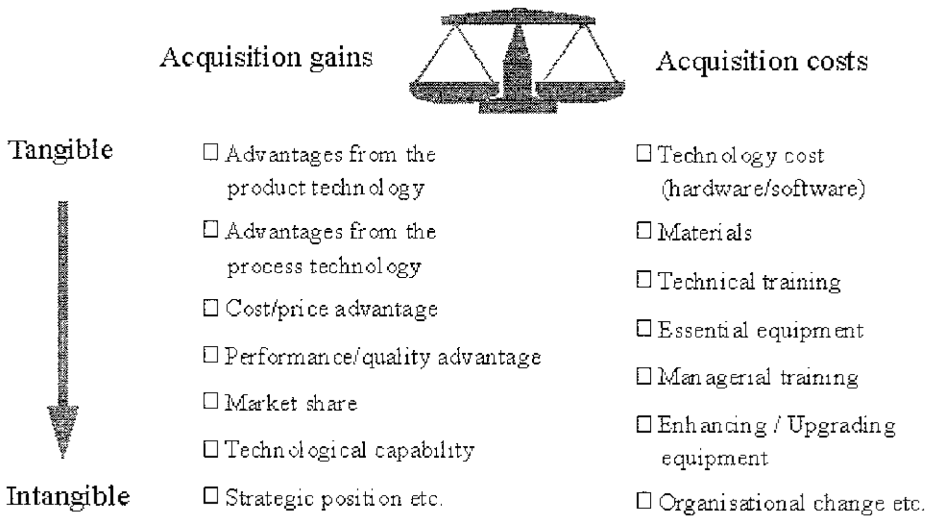

Figure 1 The Development of the model of transfer value

Unlike the machine tool industry, steel making is a process industry. This implies many special characteristics regarding the technology valuation problem and the applicability of the proposed model derived from the previous research. This paper focuses on the analysis of the characteristics of the steel industry and the technology valuation problem in this industry based on investigations to date.

2 THE TECHNOLOGY STATUS OF CHINA'S STEEL INDUSTRY

Along with most of China's key industries, iron and steel making has received massive investment in recent years and many of the enterprises have been considerably modernised and upgraded. Some of the new technologies and processes introduced include molten iron pre-treatment, converter blowing, refining outside the furnace, and continuous casting. Much of the equipment has been transferred from abroad and in recent years there have been several hundred foreign technology transfer projects. In 1986 the Chinese government made the conscious decision to increase its steel production capacity by 10 million tonnes by way of foreign investment. Some of the important investments include:

Anshan Iron & Steel Co. Here the steelworks has recently been equipped with US $700 million of equipment including a Japanese continuous casting machine, a US equipped wire making plant and German control systems.

Baoshan Iron & Steel Co. With construction starting in 1978 this is China's most modern integrated steel complex and uses high quality iron ore from Australia. The first phase, with an investment of US$ 3 billion, was comple!ted in 1985 and comprises 88% Japanese equipment. The second phase, costing a further US$ 4.6 billion was completed 1989 and contains 56% German equipment. In both phases the balance of equipment was supplied from within China.

Capital (Shougang) Iron & Steel Co. Here a 500,000 tonne capacity plate mill and a high speed wire rolling machine with a capacity of 80 metres per second (for US$ 17 million) was purchased from the USA. A steel smelter with an annual capacity of 3 million tonnes was purchased from Belgium for US$ 12.5 million. Much of this was used equipment so the plant was re-equipped for only one third the cost of building a similar type of plant with equivalent capacity.

Panzhihua Iron & Steel Co. This was the first large-scale steel plant to be built with Chinese designed and manufactured equipment. Construction began in 1965, operations started in 1970 and overall design capacity was reached in 1980. It has since become the largest vanadium extracting and steel-smelting centre in the world. A second phase was begun in 1986 and has now been completed, for which US$ 210 million was borrowed from foreign countries. Although the general policy of self-reliance has been upheld, some advanced equipment has been imported from abroad for this phase. Output of steel has reached more than 2.5 million tonnes per year and some products compete in international markets. New techniques are being developed to smelt steel and extract vanadium and titanium with the aim of creating one of the world's most important iron, steel, vanadium and titanium centres. Equipment installed in this phase included a new sintering machine and computer control for its blast furnaces. Top-blown furnaces replaced all the open-hearth furnaces.

In addition to these large-scale steelworks many new or smaller steel enterprises have also imported foreign technology. Among many others these include:

Tianjin Pipe Corporation. This is a new Chinese enterprise for which construction began in 1989. There are three main parts: steel making, rolling and tubes making, including processing of tube ends with auxiliary facilities and sub-mills. The plant was started from scratch and has been almost completely equipped with foreign machinery and equipment. The annual capacity of the plant is; molten steels: 600,000 tonnes, steel billets: 560,000 tonnes and steel pipes: 500,000 tonnes.

The plant was originally commissioned in 1994 and the first full year of production was 1996. Most of the steel making and casting facilities are from Germany. The pipe making facilities are from Italy. The pipe finishing machines are mainly from USA. The initial investment was more than US$ 1 billion, of which the greatest part was for buying foreign equipment.

Tianjin Steel Works. This was established in 1958 and based on a previous factory. It has three blast furnaces for steel making with a total capacity of 150,000 tonnes per annum. It imported continuous casting technology from Germany in 1982. 50% of the equipment was supplied by the Demag Company and the rest was made locally based on drawings supplied by Demag. It was the first continuous casting technology to be introduced into China. One of the continuous casting machines for plates was also purchased from Demag. In 1993, a high-speed wire mill was introduced with full production beginning in 1995. The technology was purchased from

Morgan in the USA. 30% was imported directly and the other 70% made locally to designs supplied by Morgan. Electrical equipment was supplied by ABB.

3 TECHNOLOGY VALUATION IN THE STEEL INDUSTRY

In order to value technology in the steel making industry, we first need to use the technology valuation model and framework derived in the previous study for the machine tool industry to test its appropriateness in this different context. Then we may possibly need to establish new thinking into this area to develop a more generalised technology valuation model.

3.1 Owner's value in the steel industry

From the point of view of the seller of technologies, five factors were identified from the machine tool industry research that influenced the way in which the owner perceives the value of technology. Almost all of these are meaningful in the steel industry. They are:

i) The distinctive features of the technology being considered.

ii) The cost of development, production and distribution.

iii) The availability and cost of bought-in components and software incorporated into the owner's processes and products.

iv) The actual or potential threat from competing technologies.

v) Barriers against entry into target markets.

Our interviews and visits to UK steel companies all identified technologies that were suitable for China's market. These steel companies and equipment suppliers see a demand for their technology from Chinese steel plants, but find that their prices (or owner's value) are often not acceptable to Chinese purchasers, so very few of them had actually reached an arrangement for sale or transfer. The most frequently mentioned reason was the different perceptions about the price of the technology. It seems that a new way of thinking about owner's value is needed.

The above five factors by which technology owners perceive the value of their technology can be analysed further. The first factor is an intangible one. The second factor includes a sinking fund for the cost of development together with fixed and variable costs for production and distribution. The third is a tangible and variable factor. The fourth is either an intangible factor, like the first, or is one that may impose effects on the value of technology through its impact on the other four factors. The fifth factor is an opportunity cost.

If we take technology as an ordinary commodity and regard its value as dependent on market competition the value is actually related to its marginal costs, while only the fixed, variable and opportunity costs add to its marginal cost. In this way the seller of technology ought to make a specially detailed assessment only of these cost factors. On the other hand, the intangible costs and sinking costs payable to owners can be traded-off. In this way, the interval of negotiable prices of the technology will be greatly expanded and the opportunity for technology transfer and technology co-operation will be greatly increased. This will consequentially benefit global economic and technological development.

There are two ways to acquire technology in steel making industries. One is from steel making firms; the other is from companies producing steel making machinery. For the former channel, the technology sold tends to be less standardised. Therefore there is more technology content and tacit knowledge involved. With the latter, the technology is more standardised and can be sold to anybody who has sufficient capital and has the ability of manipulating production as well as the market.

In the steel industry, technology transfer is mainly in the form of equipment sales. In terms of intellectual property protection, owners can retain their 'key' technologies by only supplying complete machines, provided there isn't any leakage of information about how the machine is produced. To some extent, these kinds of technology introductions are more like the trade in commodities and they possess many of the features of ordinary trade. For some other parts of the technology, which they regarded as having lower technology contents and lower value added, they may provide drawings to allow them to be produced locally. This kind of technology transfer has more intangible elements involved and therefore contains more tacit and descriptive knowledge. In the steel industry these transfers often involve a third party that undertakes supply of the auxiliary equipment.

For facilities provided by the supplier, again it can be further separated into two kinds of technologies; one is the proprietary 'core' technology, the other comprises market cost elements, which are the purchased items of various types. In the steel industry, the buyer of technology may not be able to separate these two categories, while drawings provided by technology suppliers can be regarded as pure technology transfer. In this case, the owner can decrease the cost of bought-in products as point iii) mentioned earlier indicates.

3.2 Transfer value in the steel industry

Transfer value is what mainly concerns acquirers. Case studies of steel companies that have experienced technology transfer show that the financial results of technology introduction vary substantially with different companies and different projects. Some of them have generated very good financial results, while others are making heavy losses. Therefore the acquirer is very much concerned with transfer value when considering new projects.

As transferred technology in the machine tool industry is mainly product technology, the value of the technology for the acquirer is realised by the number of end produ!cts sold and the higher price customers will pay for the advantage offered by that product.

The advantages of using transferred technology identified from the machine tool industry include the following:

i) Better quality.
ii) Greater reliability.
iii) Greater accuracy.
iv) Ease of operation and control.
v) Faster and/or more efficient operation.
vi) Less time for preparations and repairs and cheaper maintenance.
vii) Aesthetic factors (e.g. more compacts and attractively styled machines).

In addition to the merits of the product generated by the transferred technology that the end-customers are looking for, the acquirer also expects the supplier of technology to provide managerial and market knowledge and skills, or to offer training in these areas. The managerial gain from technology transfer is one of the most important elements when determining transfer value [3]. The cost to the acquirer therefore includes the actual price paid for the technology, together with any equipment and training costs and the cost implications of any organisational changes that are required.

As in the machine tool industry, transfer value in the steel industry is a balance between the acquisition gains and costs (See Figure 1). In the steel industry the technologies transferred are mainly the process technologies, and the gains and costs of the acquirer's expectations are determined by the characteristics of steel making. These are shown in Table 1 and compared with the machine tool industry.

As steel-making technology is basically process technology, product specifications are relatively simpler than in the machine tool industry and there are no differences in specifications and standards between the foreign and Chinese steel industries. As a major kind of industrial material, the assessment and measurement of steel products is straightforward and therefore it is relatively easy for Chinese engineers to master operating skills. In spite of this, some projects are operating in an unfavourable environment, e.g. with market and financial difficulties. Factories may be running normally in terms of technological performance, regardless of the sophistication of the equipment. However, the nature of batch and continuous production means that large-scale operation is necessary for economic production and therefore projects in this industry tend to be very capital intensive.

In summary, the expected gains from the point of view of products made by technology in the steel industry are simpler than those in machine tool industry, which are mainly:

i) New product technologies

ii) Make better quality end-products

iii) Result in lower costs and more economic output

Table 1 Comparison of Characteristics of Steel and Machine Tool Industries

Characteristics of Transferred Technology	**Steel Industry**	**Machine Tool Industry**
Nature of Technology	Process	Product
Product Specifications	Simple	Complicated
Quality Measurement and Quality Assessment	Simple and Easy to measure and perception	Complicated and difficult to measure and perception
Product Quality Aspects	Material Constitution, Shape	Reliability, accuracy, speed, efficiency, easy of operation and control…
Quality Reliance mainly on	Facilities and operation control	Design and skill
Type of Production	Batch and continuous production	Piece by piece
Areas of Training requirements	Machinery operation	Manufacturing and assembly
Tacit knowledge needed for mastering the technology	Less intensive	Intensive and need longer time

The nature of the costs for introducing technology is the same in both the steel and machine tool industries. Concerning organisational changes, because most of the technology introductions to date have been made by state-owned enterprises (few investments are from foreign companies), there have been, up to now, relatively fewer changes caused by technology introduction in the steel industry. Due to the large scale of a project in the industry, the one-off cost of building a facility is much higher than in the machine tool industry.

3.3 Strategic alliance considerations in the steel industry

Previous studies in the machine tool industry have revealed that in order to exploit the transfer value of a technology as sufficiently as possible it is important to have a long-term strategic consideration and to establish a close technology based relationship [4]. In the steel industry there are very few foreign technology transfers into China through multinational enterprises, direct foreign investments or joint ventures; therefore there are, as yet, very few experiences of technology collaboration between China and foreign enterprises in this industry.

Because of the above, the "alliance" way of thinking which increases transfer value seems to be open to question in the steel industry. However, there is still evidence, which favours a closer relationship between technology supplier and acquirer in order to exploit fully the transferred technology.

Take Baoshan Steel in Shanghai and another steelworks in north China as examples. They are, coincidentally, both totally new steel companies. All the major equipment of these two steelworks was imported from abroad. In the initial phase of Baoshan Steel, equipment was imported from a Japanese steel making company. Some people complained that part of that equipment was used instead of being brand new, as they considered it should be. However, because the equipment was from another steel making mill it was possible to transfer managerial knowledge simultaneously with the installation of the equipment. Baoshan exerted a great amount of effort to introduce that managerial experience and, through intensive training and assimilation of the experience with the local culture, a new management culture formulated. After three phases of construction and successful operation, Baoshan has become the best steel enterprise in China in terms of economic performance and serves as the most advanced and fastest growing steel company in China.

The steelworks in north China insisted on introducing the most advanced equipment in the world for all its production lines. But all its equipment was bought from machinery companies instead of steel making companies. In spite of the expertise in technology and operating skills the supplying company possessed, there was no management experience of the steel making industry that could be transferred. The Chinese buyer even hired managers from abroad (from Germany) to help manage part of the bought-in equipment, but it failed because of the difficulty in matching cultural differences. In addition, other unfavourable factors have meant the company is now in a very difficult financial situation.

Case studies such as these show that the order of priority for their objectives when introducing foreign technology can change in the minds of company managers. Originally the novelty of the technology was firstly emphasised in the two companies. However, now, more emphasis is placed on economic results and market implications.

4 CONCLUDING DISCUSSION

Investigations in the steel industry in China show that the previously identified framework for valuing technology is basically appropriate to the steel industry; however the industry still has its own characteristics. It is a basic material industry with process technology as the major object of technology transfer. The industry is by nature capital intensive and generally has very large scale single production facilities. Product specifications are relatively simple and operation skills are easier to master. Technical questions arising from product complexity are relatively fewer than in the machine tool industry, but problems often appear from the market and financial management.

A large gap exists when valuing steel technology between the owners and potential buyers of the technology. Using the marginal cost concept may help in re-examining the owner's costs. A great deal of potential also exists for expanding the "transfer value" concept through market and financial knowledge transfer for the establishment of closer managerial relationships between owners and acquirers.

References

[1] Bennett D J, Vaidya K G, Zhao, H Y and Wang X M (1997) "Globalized Manufacturing and Technology Transfer Strategies – The development of a Technology Valuation Model", in Mueller H, Persson J-G and Lumsden K (Eds.) The Creation of Prosperity, Business and Work Opportunities Through Technology Management, Proceedings of the Sixth International Conference on Management of Technology, SMR - The Swedish Society of Mechanical Engineers, Naval Architects and Aeronautical Engineers, Stockholm, Sweden (pp 63 - 74), 1997.

[2] Bennett D J, Vaidya K G and Zhao H "Evaluation Models for Global Manufacturing: The Valuation of Technology when Transferred from the UK to the China Machine Tool Industry", proceedings of Workshop on International Manufacturing, Cambridge University, September 1996.

[3] Bennett D J, Zhao H, Vaidya K G & Wang X M "Transferring Manufacturing Technology to China: Supplier Perceptions and Acquirer Expectations", Integrated Manufacturing Systems: The International Journal of Manufacturing Technology Management, Vol. 8, No. 5 (pp 283 - 291), 1997.

[4] Zhao H, Bennett D J, Vaidya K G, Wang X M & He J S "International Technology Transfer Strategies: Transfer Value Considerations Within the Context of Collaboration Arrangements", in LeFebvre, L A, Mason, R M and Khalil, T (Eds.) Management of Technology, Sustainable Development and Eco-Efficiency, Elsevier, (pp 299 - 308), 1998.