

Technology Management Under China's Economic Reforms

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Abstract

This paper describes the main features of China's economic and industrial reforms and considers the key strategic issues which determine effectiveness in the transfer and management of technology. It is based on investigations being carried out by a team of British and Chinese researchers. These involve studies within government and other agencies as well as case study analyses of state-owned and joint venture enterprises. A particular aspect of the investigations is that they concentrate on the situation in the traditional industrial areas of China which, unlike the Special Enterprise Zones, have not so far experienced the same levels of foreign investment and are seen as being more problematic in terms of their ability to absorb modern manufacturing technology. The paper addresses three key issues that have emerged as being relevant across the areas of study: i) the formation of enterprise groups as a means of developing and facilitating technology transfer, ii) the need for flexibility and diversification in response to emerging competitive and market conditions and iii) implications for industrial policy and enterprises of multiple imports of the same or similar technologies.

Background to China's Economic Policy Reforms and Research Objectives

Since China began its programme of economic and industrial reforms and opened its doors to the outside world in 1979, three main features of its industrial development can be identified:

- a steadily growing inward flow of foreign investment;
- a concerted effort by the government to revitalize the state owned industries; and
- a burgeoning private industrial sector.

China's stated aim is to sustain 10% growth per annum until the end of the century. In 1985, 80% of enterprises were state owned, but now more than 50 per cent are collectives, privately owned or foreign owned enterprises and joint ventures. About two hundred formerly state owned enterprises are now listed on the stock markets of Shanghai, Guangzhou and even some overseas exchanges. The role of foreign investment and imported technology and know-how has been important in industrial development in China and will continue to be so in the future.

This paper is based on part of a programme of research jointly carried out by a team of staff from the Business Schools of Aston University and the People's University of China since 1989. The work has addressed the following aspects:

- (1) Chinese manufacturing enterprise management and institutional structures;
- (2) technological competence in Chinese enterprises; and
- (3) technology transfer and management in state enterprises and joint ventures.

The next section introduces changes in the policy context which have led to the sharp increase in technology transfer into China and raised questions about the management of technology at the level of the enterprise. The following section develops a conceptual framework for examining three aspects related to technology management at the enterprise level. It also reports on the management issues which have emerged from the ongoing case study investigations in a number of enterprises. The final two sections then provide the preliminary conclusions and indications of future work.

Industrial Policy and Technology Transfer

China's policy on technology transfer has undergone a number of changes since the 1950s starting with turn-key projects, mainly supplied by the USSR, then with a shift to technology transfer from Japan, Western Europe and the United States during the 1970s, but mainly for large scale projects in heavy industries. A government review of the technology transfer policy soon after the declaration of the "open door" in 1978 found the earlier approach lacking in a number of respects. Earlier projects were large and expensive and the potential for developing Chinese technological capability based on these was limited. Further, purchase of new equipment was the only channel for technology transfer. Since then, under the "open door" policy and subsequent phases of liberalisation, there has been a diversification of technology transfer channels [1].

There has been accelerating growth in the number of foreign investment projects in China and each year has seen new records for the number of projects approved and their contract value. During 1992 for example almost 47,000 foreign investment agreements with a contract value of more than US\$68.5 billion were signed. This was more than the entire total over the previous thirteen years, during which period 44,000 foreign investment contracts were agreed with a value of US\$52.3 billion. [2]. This record was again exceeded in just the first nine months of 1993 when a further 63,000 projects were approved with a value of US\$83 billion [3].

The point should be made, however, that contract value provides only one indicator of the amount of investment in China and a more complete picture is provided by the actual utilised amount of the funds pledged. In 1992, for example, the actual amount used was US\$11

billion and in 1993 it was US\$20 billion. In 1994 the number and contract value of new projects declined sharply compared with the previous year, by 46% and 32% respectively, although the actual utilised investment rose by 49% [4].

As far as the transfer of technology is concerned the actual utilised funds provide some indication of the amount that is transferred via foreign investment projects since a significant proportion of such projects include technology imports. Not all technology is transferred through foreign investments, however, a substantial amount being imported by wholly Chinese owned enterprises. Technology imports have followed a similar pattern to foreign investments and in the first half of 1992 they reached an all time high of about US\$14 billion (120% increase over the same period in the previous year).

The Nature of Technology Transfer

There is much discussion and debate about what precisely constitutes 'technology transfer'. Much of the technology transferred under foreign investment agreements and technology imports simply amounts to a 'one shot' introduction of hardware and knowledge and earlier research has often tended to concentrate on straight technology imports into China [5]. Within the context of the authors' research technology, transfer is defined as a more complex long term process of developing technological capability [6]. There are a number of direct and indirect ways in which transfer may be facilitated including licensing, joint ventures, and direct exchange.

An important question which arises when conducting research of this nature is whether subsequent, repeat, transfers of hardware and software can still be regarded as 'technology transfer'. In previous technology transfer research it would usually be regarded as not. However, in a country as large as China, where technical communications are poorly developed, several enterprises may import the same or similar technology without having access to the previously acquired knowledge of others. In this situation, where each enterprise is handling what, to them, is a new form of technology, the term 'technology transfer' can still apply, and for the purpose of this research such transfers are included. In conducting the research, however, care was needed to ensure this wider interpretation was understood by the participating enterprises and other agencies involved. For example the Ministry of Machine Building Industry in China keeps separate data for 'technology transfer' (transfer of software or hardware with embedded software, but for the first time only) and 'equipment transfer' (subsequent transfers of hardware, regardless of whether it has any embedded software).

Of particular significance to this research are also the wide regional differences that have emerged and considerations to be taken into account as a consequence [7]. For example much of the growth in China's coastal areas is based on technology aimed at taking advantage of lower labour costs while in other parts of the country efforts are being made to craft technology transfer and development within strategic industries such as automotive

manufacture.

The diversity of technology transfer channels and the liberal policy regime have raised a number of issues in relation to the management of technology at the level of an industry and an enterprise. This paper addresses the following three technology management issues:

- formation of enterprise groups as a means of developing and facilitating technology transfer within industrial sectors;
- the need for flexibility and diversification as a strategic response to emerging competitive and market conditions, and
- implications for industrial policy and enterprises of multiple imports of the same or similar technologies.

Technology Strategy in Chinese Industrial Enterprises

Conceptual Framework

In examining technology transfer and its management, an important aspect is whether it has been effectively implemented technically. However, in an increasingly competitive environment commercial viability is an equally important consideration.

Both these aspects are affected by:

- (1) the technical and management capabilities in the enterprise;
- (2) whether the transfer was motivated by technology push or market pull;
- (3) market conditions (e.g. market size, competition and access to markets and customers);
- (4) the type of technology transfer agreement and the service provided by the supplier;
- (5) technology complexity, capital intensity and the end product's position in the supply chain;
- (6) government policies, incentives and services; and
- (7) availability of finance.

For examining technological capability at the enterprise level and the contribution it makes to the overall strategy of the enterprise the concept of the value chain is useful [8]. Technology development is one of the major activities in the value chain. It may contribute to the improvement of competitiveness by reducing costs or developing new products and providing access to new markets. In traditional Chinese enterprises, as technology transfer plays an important part in the process of technology development, the enterprise has to develop links with its suppliers as a means of developing a competitive strategy. More generally, an enterprise is typically part of a network of other enterprises which are suppliers of technology and other inputs together with customers, thereby forming a "value system". Figure 1 provides a conceptual framework for the examination of the case studies by placing an enterprise within the context of the network of linkages with suppliers and customers and the

policy framework. The figure also provides an overview of the research methodology being used in this project.

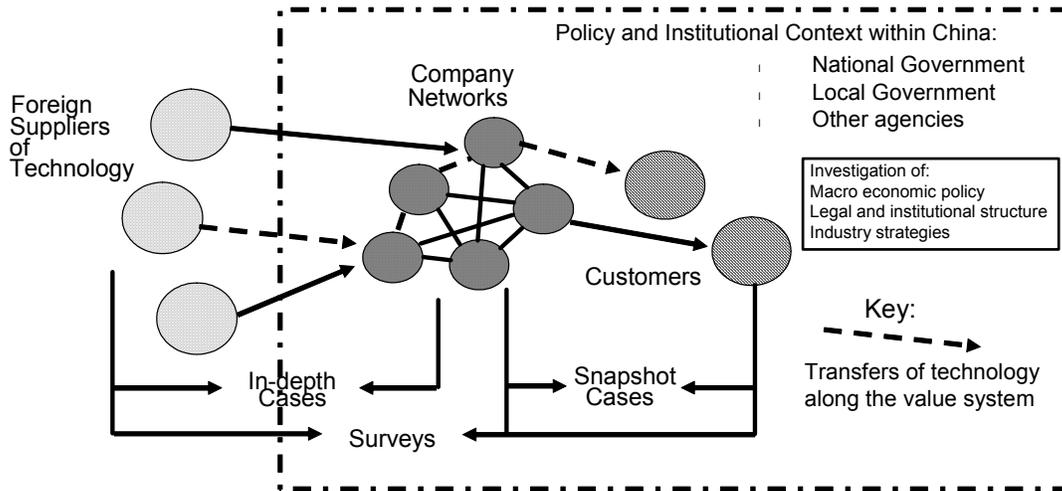


Figure 1 Conceptual framework for case study examination and project methodology

In industrial operations where the production of parts, sub-assemblies, and final assembly can be easily separated there is usually an established and easy to use technology available. The value of parts is often high in relation to their bulk and weight and the coordination function will be well organised by a single enterprise or group. Technology can be transferred to a country offering cost advantages but will usually be fairly basic. In terms of the network illustrated in Figure 1, the advantages of such operations are the close coordination between the enterprises in the value system. The supplier of technology may also be the customer, thus reducing the problems of coordination, management of technology and finding markets.

A similar situation exists where the technology supplier provides a well established technology such as an assembly line for producing end-products with low variation, such as television sets. The key links are with suppliers of the essential components which the recipient firm cannot produce. For consumer products, or end products such as minibuses, links with the market are not very complex.

Other types of technology transfer, such as that necessary to upgrade the manufacture of automobile engines for example, offers a sharp contrast to the above. Here production is a capital intensive and complex process with high development costs. Engine production requires a complex network of suppliers of materials, components and tools. It is also in the middle of the supply chain for the final product which itself requires a large network of suppliers. If the engine plant is not part of an integrated enterprise producing vehicles, a number of coordination and strategy issues also arise.

- 1) The firm's configuration of functions, services and capabilities (e.g. logistics, technological capability etc.) may not enable production of engines to the required specifications and in sufficient numbers.
- 2) The market for the engines is a problem. Present customers of the existing engine models may not be the right customers for the new engines. The new product may be too expensive and too high a quality. Other potential customers are established automobile manufacturers operating in joint ventures. They will typically have developed their own engines or will have established suppliers of engines designed specifically for their vehicles.
- 3) Therefore for such a venture to succeed, an engine manufacturing company may either have to integrate forward into making vehicles or, before making the investment decision, have clearly established customers. In the terminology of the value chain and value system, acquiring the technology to upgrade the engine requires the establishment of a new value chain. The coordination function for the value system is also more difficult when compared with that for the off-shore type operations. In addition with a new and complex technology, there are problems of implementation, requirement of specialist imported inputs and software inputs.

Enterprise group formation

The creation of enterprise groups was an important part of the Chinese government's economic reforms during the 1980s and represented a radical departure from the traditional arrangement where every enterprise was an individual workshop under the control of industry ministries and local bureaux. About 2,000 groups had emerged by the end of 1989 [9]. In terms of structure, around 20 percent of enterprise groups were formed around one big enterprise and brought about by mergers, share purchasing, responsibility contracting and leasing. The development of groups has been part of the Government's plan to rationalise manufacturing and improve its efficiency. In the automotive industry for example there were over one hundred automobile assembly factories by the end of the 1980s, more than the combined total of Japan, the United States, Germany, Britain, France and Italy. The formation of the Jiefang and Dongfeng Automobile Groups based on the old Number 1 and Number 2 Automotive Works has started to resolve the problem of small-scale overlapping production of medium sized trucks.

Case examples of enterprise groups

Bei Nei Group - This group comprises a network of factories making engines and components and is one of a number of diesel engine manufacturers given approval to develop automobile engines by the Ministry of Machine Building Industry [10]. At Bei Nei, product technology has been transferred from the former Soviet Union, Germany and Japan. More recently product and process technology has been transferred from General Motors in the USA in the form of a facility for manufacturing a new four cylinder light petrol engine. The

group is highly dependent on the BN492, an engine of old design, used in light trucks and 'jeeps' and its formation has facilitated shared knowledge about this engine which is made in several plants. The GM engine is eventually intended to replace the BN492, although cost of production due to low production volumes has proved a barrier to finding customers and, paradoxically, sales need to be improved before costs can be decreased.

Sales along the value chain had been considered a possibility since GM is a partner in a joint venture company making light trucks and cars in Shenyang [11]. However, the research team's subsequent investigations at the joint venture revealed that several technical and commercial difficulties stood in the way of this opportunity. Most newer vehicles made in China involve foreign JV partners so this has created problems of market access for indigenous engine manufacturers. Creating horizontally integrated groups does not prove to be the solution in such cases since they do not facilitate access to downstream customers, the manufacturers of end products.

Beijing Peony Electronic Group - Based around the Beijing TV Factory this group was formed via mergers with a screen factory and the Dong Fong TV Factory. Both the latter two factories were weak but the merger has helped to improve their efficiency. The group's strategy is i) enlargement ii) quality improvement iii) export expansion. Its success partly results from a partnership with Panasonic for technology transfer (product and process). Since the group was formed it has established a new communications equipment company to make paging machines and operate networks. It has also formed a joint venture with a Korean company (Goldstar) to develop and manufacture a new range of lower cost televisions. Television set manufacture is fiercely competitive and the formation of a group enables greater economies of scale.

The Beijing Peony Electronic Group has capacity to produce 1 million television sets per year and its current annual output is 800,000. Most are sold in China under the brand names 'Peony' and 'Mudan' and the group has almost 9% market share. Its main competitors are TV factories in Tianjin ('Beijing' brand), Nanjing ('Panda' brand), Shanghai ('Goldstar' brand) and Mianyang, Sichuan Province ('Cheng Hong' or 'Rainbow' brand). The Mianyang factory, which is also part of a group, is considered to be the greatest threat. It produced 1.7 million TV sets in 1994 and has the capacity to produce 2 million. Its output has enabled the cost of production to be brought down and prices are consequentially lower than for competitor brands.

Flexibility and diversification as a strategic response to emerging competitive and market conditions

Under centralised planning the concepts of flexibility and diversification were virtually non-existent but the industrial reforms quickly placed new demands on enterprises that forced them to become more flexible and adaptable. However, these demands could only partially be answered using techniques and technologies from established market economics and China's

unique flexibility requirements necessitated a special approach [12]. A particular consequence of the reforms, which makes special demands of Chinese enterprise management, is the trend towards diversification into new business areas. This has been prompted by a number of factors including:

- 1) the greater operational autonomy that had been acquired by Chinese enterprises.
- 2) the establishment of a 'socialist market economy' where demand pull now determines the output from an enterprise.
- 3) the reduction in military equipment requirements which has adversely affected numerous enterprises in the aerospace, electronics and mechanical equipment sectors.
- 4) the need to find work for 'redundant' employees who are no longer protected by enterprises social obligations.
- 5) the rationalisation of enterprises which has taken place under enterprise group formation.
- 6) the reduction in state funding of academies and institutes which has caused them to seek alternative sources of revenue.

The extent to which diversification has occurred within enterprises and industries is so great that some ministries are now responsible for large areas of the economy that are not within the official scope of their administration. There are some extreme examples. For instance an entire watch factory, under the Ministry of Light Industry, has completely turned itself over to retailing and has become a departments store, and the Capital Iron and Steel Works, under the Ministry of Metallurgical Industry, has become a conglomerate involved in producing a wide range of goods and services.

Case examples of flexibility and diversification

Chengdu Aircraft Industry Corp. - CAC was originally founded to manufacture jet fighters and military production still represents about 80% by value. However, cuts in orders have necessitated a move towards the manufacture of civilian products as a means of utilising capacity. Within its core business diversification has involved a contract with McDonnell Douglas to produce MD82 noses, necessitating improved quality and increased efficiency. Outside its core business diversification includes production of: automobile press moulds, motorcycles, dry cleaning machines, hydraulic engineering products (eg car jacks), water heaters, satellite dishes and wheelchairs. Some of these are market-led and others are technology-led products.

In the case of CAC its diversification activities are part of a seven year product development programme supported by the Chinese government. It has been set a specific target to reduce its military production to 60% by the end of the programme period.

Chinese Academy of Sciences - The Academy, described as China's supreme natural sciences academic organ, is a comprehensive centre for research. It comprises 122 institutes employing 50,000 technical and scientific personnel [13]. Originally funded wholly by the

Government, the CAS was set-up to conduct basic research but its brief was later enlarged to include applied research and production, which could generate income to offset cuts in government funding.

The Institute of Semiconductors under the CAS is an example of a body which has been required increasingly to become self financing. It manufactures and markets laser devices for use in fibre optic communications. More recent cuts in Government funding, together with the tendency for more research to be carried out by enterprises and private institutes, have compelled CAS institutes to become even more commercially minded. This in turn has encouraged the Institute of Semiconductors to diversify, often by forming joint ventures. For example one joint venture, with a Japanese company, produces passive infra-red detectors (PIRs) for use in security equipment. Other more recent examples of diversification have involved a move into services. They include a joint venture with a British company to provide a commissioning service for engineering projects. The institute has also become involved in providing advice on the installation of hotel security systems.

Implications of multiple imports of the same or similar technologies

The rapid expansion of the Chinese economy has been accompanied by a flood of imported technology. It was mentioned earlier that a feature of Chinese industry has been the proliferation of small-scale enterprises with overlapping production. This in turn has led to multiple imports of the same or similar technology.

Whether these multiple imports are the result of a specific intention or simply because of division of responsibilities for policy between different levels of government is not completely clear. However, a debate has been prompted in China about whether multiple imports of technology create a healthy competitive environment or inefficient and haphazard industrial growth. The situation also demonstrates the clash that exists between different economic ideologies, with one advocating the retention of strong central planning and the other favouring more decentralisation.

Examples of industries with multiple technology imports

Colour TV manufacture - Here there have been multiple imports of product and process technology from Japan, Europe and the USA. By 1989 there were 113 colour television production lines installed in China [14] and 12 million sets were produced and only 5.4 million sold during 1991 [15]. Weaker companies have come under pressure from stronger ones, the difference often being based on the origin of the technology transferred. In general, firms acquiring their technology from Sanyo have been less successful (such as the Chengdu TV factory in Sichuan and the Dong Fong factory in Beijing) while those using National technology have been more competitive (such as the Beijing Peony Group and the Mianyang factory). Many of the weaker companies have virtually ceased production, while others, such as Dong Fong, have been absorbed by stronger ones.

Minibus manufacture - The main technology transfer project in this industry has been from Daihatsu to the Tianjin Minibus Works which has now been extended to include the Charade car. Other Japanese minibus producers such as Isuzu and Suzuki, have more than one co-operation in China; hence there are many factories producing minibuses but with relatively few Japanese companies involved. The market for minibuses continues to increase so, unlike the CTV industry, saturation point does not yet appear to have been reached.

Part of the reason for there being multiple imports into several factories is that, in common with TV production, almost every province in China wanted to develop its own automotive industry and, as a consequence, there are now 125 automobile makers in the country. The Chinese Government has allowed this situation to persist because, among other things, it encouraged competition between manufacturers. At the same time, however, it has criticised the inefficient use of resources that can result, so now a programme of rationalisation has begun [16,17].

Conclusions

Formation of enterprise groups provides scope for importing large scale complex technology such as automated production lines but the difficulty of finding markets implies that enterprises may have to develop cooperation at a number of levels with technology providers and end product manufacturers to ensure commercial success. The case of Bei Nei illustrates this very well, where a technically sound product has so far failed because insufficient account was taken of market factors.

Constraints on diversification include managerial capability and permission to operate with freedoms not normally given to state enterprises. The opportunistic diversification found in a number of enterprises is understandable at an early stage of industrial reorientation but it is necessary to make strategic assessments of the diversification options. The success of the diversification approach needs a longer term view which leads enterprises away from less profitable, technology led, opportunistic, activities to those which are more profitable and within their resource constraints.

In some industries (eg television and minibus manufacture), multiple imports of similar technologies have created a market situation which occurs at the early stage of a product life cycle. It has been argued that multiple imports of technology are wasteful. However, advantages may emerge from the competitive situation and subsequent restructuring of industries.

After a period in which the Chinese government appeared to allow a 'free for all' in terms of enterprise creation and technology transfer, there are now signs that a strategy is being developed where a relatively small number of enterprises are the focus for development of a particular industry. The automotive industry has been among the first to be subject to such a

strategy and the electronics industry seems to be formulating a similar approach. Obstacles to rationalisation will be difficult to overcome, however, such as the reluctance of provincial governments to lose control of factories and the social responsibilities felt by managers which lead them to protect jobs.

Government policy has important implications for the willingness to undertake technology transfer and the methods for technology transfer at the enterprise level. For example, joint ventures are favoured over other methods of technology transfer because of preferential policies on taxation, exchange controls etc. Purchase of hardware is preferred over licensing only (i.e. buying technology without hardware) because this approach leads to the sort of short-term results that have often been demanded under China's "contract responsibility system".

Future Work

The three technology management issues described in this paper have emerged as a result of the research team's preliminary investigations within government and other agencies as well as several enterprises and groups. Subsequent investigations have focused on the longer-term developments within selected industries, such as machinery and electronics, using the described framework. The studies are also being extended forwards and backwards to include end-customers and foreign suppliers of technology.

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