TECHNOLOGY TRANSFER THROUGH INTERNATIONAL MANUFACTURING NETWORKS: VALUING TECHNOLOGY FROM AN OWNER'S PERSPECTIVE

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ABSTRACT

Technology is a key part of organisational knowledge and gives its owners their distinctive capabilities and competitive advantages. However, to best use these assets technology often needs to be transferred and shared with others through a form of technology collaboration. This raises the important question of how technology should be valued when it is being transferred. Technology valuation has become a critical issue in most transfer transactions. Transfer arrangements and terms of payment have a significant effect on the generation and sharing of joint benefits in commercial, technical and strategic aspects. In this paper the concept of "owner's value" is explored by highlighting its structure and components and assessing the importance of factors affecting value. The influence on technology valuation of the transfer arrangement, the associated terms of payment and the interaction between the shared benefits, cost and risks are discussed.

INTRODUCTION

The transfer of technology through collaborative network arrangements is being seen increasingly as a means whereby companies can globalise their operations. To owners, technology is a key part of their organisational knowledge which gives them their distinctive capabilities and competitive advantage. In order to best use their technological resources companies often need to share their know-how through a form of technology collaboration. By facilitating joint use of technology future additional value can be generated that will provide a return to the technology owner in exchange for its transfer.

This raises the question of how to establish a "value" for technology when it is being transferred between owners and acquirers in manufacturing networks. In many transfer cases it has been experienced that technology has not been appropriately valued, resulting in commercial loss or a strategic 'U' turn. Technology valuation has consequently become a critical issue in most transfer transactions. The underlying premise is that transferring technology not only produces benefits but also has associated costs and risks. The amount of return to be generated, and the extent of the costs and risks, are heavily influenced by the form of collaboration. Formulating appropriate collaboration arrangements and the subsequent management of manufacturing operations are important considerations to ensure acceptable sharing of joint value from a commercial, technical and strategic point of view. However, difficulty is often experienced in balancing these potential benefits, costs, and risks and in formulating effective operational

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arrangements to ensure the achievement of best additional value. Problems result from inadequate value concepts (or measures) in which value is often equated to cost or price and, more importantly, there has not existed a framework for technology valuation.

This paper focuses on an analysis of the value of technology from the owners' point of view. The concept of owner's value is explored by highlighting the structure of its components and assessing the importance of the factors that affect value. The influence on technology valuation of the transfer arrangement and terms of payment and the interaction of the shared benefits, cost and risks are discussed. The implications of having effective management of operations for creating future value is also highlighted and a framework for technology valuation from the owner's view perspective is developed. The paper is based on the findings of a research project funded by the UK Engineering and Physical Sciences Research Council (EPSRC). Empirical data were collected from the machine tool industries in the UK and China. The evidence includes longitudinal case studies and questionnaire surveys of UK machine tool manufacturers who have established technology collaboration partnerships in China. Paired cases (including both partners) are used to provide an in depth example of the dynamic process of technology valuation.

THE VALUE ISSUE IN INTERNATIONAL TECHNOLOGY TRANSFER

The issue of technology valuation is particularly relevant within the context of technology transfer through direct investment rather than external transfer through the trade channel. Under perfect conditions, firms do not transfer their technology if the full value of such a strategic resource is not reflected in the exchange. It is only when the perceived transfer benefits outweigh the costs and risks that the owner would wish to share its technology through collaborative operations (Dunning, 1991).

Compared with retaining technology for own-use, sharing it with others can create more benefit by extracting additional value through gaining access to new or expanding markets. Increasingly, firms need to combine diverse kinds of technical and market knowledge from multiple sources. Different aspects of know-how are complementary and their joint value is significantly greater than the sum of their individual values. Firms therefore use collaborative arrangements to obtain access to local complementary expertise and markets as well as providing a means of facilitating organisational learning.

The importance of technology in global manufacturing has already been acknowledged (De Toni et al, 1992). However, little consideration has been given to the problem of valuing technology within the context of international collaborative operations. The main features concerning the management of collaborations have been identified as uncertainty (relating to the skills and resources required and the sequencing of tasks) and co-ordination (identifying common objects that link task groups together). On the other hand, interaction between shared returns, cost and risks, together with the operational arrangement for different forms of collaboration have not been reported. There is related work concerning value, but this is limited in scope and focuses on "pricing" or "costing" technology products rather than valuing technology in transfer transactions.

COST ELEMENTS AND STRUCTURE

Expressed in monetary terms, owner's value will be based on the cost associated with generating the technology and delivering it to a particular point along the value chain. This would comprise

the development, production and distribution costs together with the cumulative costs of any other upstream activities and the opportunity cost considerations. Depending on the circumstances there may also be a transfer cost and a notional profit from transferring the technology to a collaborating organisation. Table 1 provides an example of the cost structure for a technology product: a CNC machine tool. In the cost breakdown the least certain element is development cost since the owner needs to decide how the overall development costs should be spread across each product it produces.

Table 1. Average cost structure for a CNC machine tool product

Cost breakdown	Percentage of total
• product development cost	6%
• production cost	69%
of which - labour cost	- 18%
- material cost	- 51%
• distribution cost	9%
• overhead	16%
Total	100%

The problem of valuing transferred technology is different from that of costing a product for sale. There is a fundamental difference between valuing technology and product costing since a product is made to satisfy customers' needs while technology is developed to produce benefits for the owner. When technology is transferred the owner would, by sharing with others, lose some of the intellectual resource from which expected benefits are created. The owner therefore needs to ensure that all the expected benefits can be gained when valuing the technology. Further, considering the competitive importance and strategic advantage of technology to the owner, of which some elements cannot easily be quantified, the question of establishing value is made even more complex.

In order to establish the owner's value the cost structure of the technology rather than product should developed. Figure 1 shows a model of the cost structure of machine tool technology based on the case studies. It has been validated with assistance from the project's collaborating companies.

From the owner's perspective the cost of technology can be separated into two types. First, there are the costs incurred externally through bought-out parts, materials and commercial items. Market prices for commercial items are normally well established, so their influence on the cost of technology is informed. For bought-out parts the technology "owner" (the machine tool manufacturer) needs to provide design details to suppliers in the form of drawings and specifications. Nevertheless, these costs are also influenced by market mechanisms so references can more easily to be determined.

The second type of costs are those that are incurred internally by virtue of the fact that they are linked with the owner's 'proprietary' activities. These costs are more difficult to measure because many of them are in the form of know-how and skills. More specifically, some of these are 'tacit' and form the core of the owner's technological competence. These know-how and skills, according to their features, can also be categorised into two types:

i) Innovating types such as design, development, process planning and tooling know-how.
ii) Operational types such as processing, sub-assembling and final assembly skills.

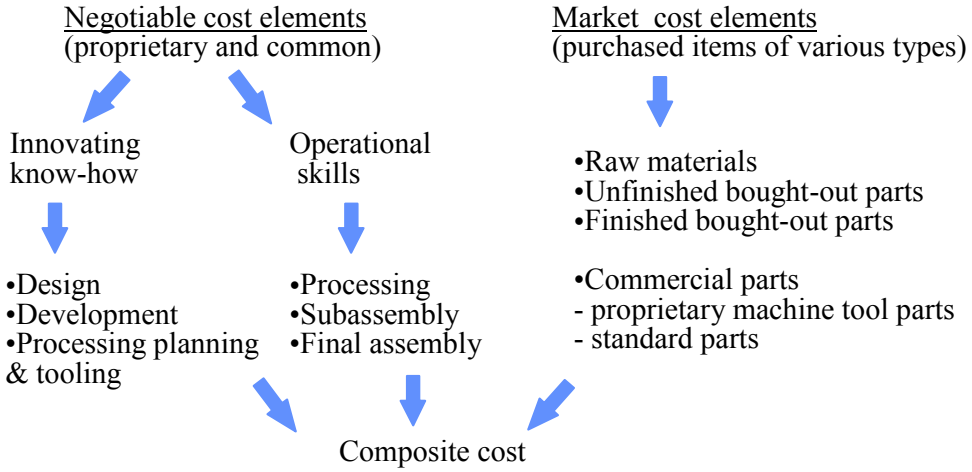

Figure 1. The cost structure of machine tool technology

The innovating components are critical to creating new ideas and improving and updating technological capability while the operational parts are more experiential based expertise and skills to assist with ensuring the high reliability and accuracy of products and to improve working efficiency. Owners would normally consider that innovating know-how is more strategically important than operational skills. If a "key" technology is to be transferred then value should reflect the owner's intellectual investment in its development, together with an adequate return. If the proprietary innovating know-how is to be transferred the technology owner would consider an even higher level of return. From an owner's point of view all these components need to be considered and the relative importance of each must be assessed. Table 2 shows the assessment of the UK companies based on responses to the survey. It can be seen that "quality" of the technology (i.e. its strategic importance and 'reputation') was considered more important than factors such as 'cost' and 'scope' (e.g. content of transfer and applications) and demonstrates that determining owner's value is not a straightforward cost calculation.

CONSIDERATION OF VALUE GENERATION AND COST/RISK SHARING

The above assessment is based on the "existing" value of technology. However, the owner also needs to consider the future additional value that can be captured downstream in the value chain through its collaborative operations. Such future value will be shared between the partners and generated though their joint efforts.

Table 2. Assessment of the importance of major factors in determining the value of transferred technology

Determining factors	Importance
Strategic importance to your company of the technology (proprietary)	5.22

Training and technical support included	4.78
Worldwide reputation of your technology/product	4.67
Content of technology transfer package (part or whole technology)	4.33
Costs of producing the technology	3.78
Applications of technology for partner to use (general or specialise)	3.78
Availability of competing technology in markets	3.67

Note: score of 6 means *imperative* and respectively, *very important* (5), *important* (4), *fairly important* (3), *not very important* (2), *not important* (1)

However there is always uncertainty regarding commercial, technical and collaborative success which may affect substantially the generation and realisation of future value. The owners of the technology will need to bear some of the risk in seeking future benefits through technology collaborations. They may also need to share some of the costs if the existing value of their technology is not fully covered by the initial return (e.g. in the form of an "up-front" payment). Future value, cost and risk interact and the extent of sharing between partners varies depending on the terms of payment and transfer arrangement (see Figure 2).

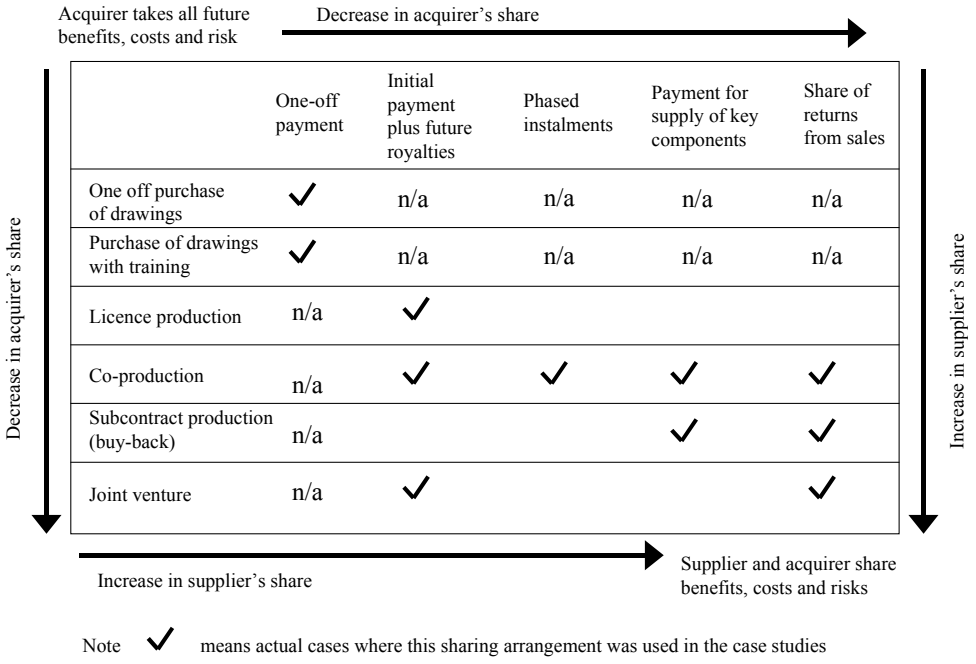

Figure 2. Sharing of returns, costs and risks under different terms of payment and transfer arrangements

Figure 2 shows that the looser the form of transfer arrangement and the earlier the return is gained, so there is less sharing of benefits, costs and risks between the owner and acquirer. In such circumstance the owner places the emphasis on the immediate benefits while the acquirer potentially obtains a higher proportion of future returns while bearing more costs and risks. Conversely, the stronger the commitment and longer the period in which the owner's return is achieved, so the sharing is greater.

The transfer arrangement not only determines the context within which future benefits, costs and risks are shared between partners, but, more importantly, it influences the effectiveness of the value-adding activities and consequently the amount of future value generated through the collaboration. One of the significant impacts of the transfer arrangement on the effectiveness of transfer arises from the level of complexity, "codifiability" and "teachableness" of the technology (Kogut and Zander, 1993) as well as technology gaps (Bohn, 1994). The time required for transfer and the effort necessary for learning and absorption are influenced by these factors. The case studies in the machine tool sector demonstrate that well planned technical training and support and an experience-based learning process for absorption and accumulation of knowledge is often required to meet these technical requirements. The transfer arrangement also has a profound impact on generating strategic benefits. From the UK survey, *to improve product competitiveness* and *to increase the company's reputation in the local market*, and hence *to increase market share* were identified as long term benefits to enhance the owner's strategic position. These technical requirements and strategic enhancements can only be achieved when an appropriate transfer arrangement is established, otherwise, as the case studies have shown, it often results in the local partner not being able to effectively absorb the transferred technology and consequently not making best use of it (Bennett et al, 1997). As a consequence, the quality of the end-product may be inferior and hence the targeted financial benefits may not be achieved.

CASE STUDY: MANAGING A COLLABORATIVE OPERATION

Given the importance of achieving additional value from technology transfer, a critical task is to effectively manage the collaborative operation. The following case study shows the features of a collaboration arrangement that attempts to realise best additional value from the transferred technology.

Case description

BSA is UK company and CJC a Chinese company. They are both in the medium size category of machine tool manufacturers. BSA's major products include CNC single and multi spindle automatic turning lathes and turning centres manufactured to international quality standards. CJC is also a specialised turning machine manufacturer and has captured 24% of the Chinese market for CNC turning machines. The objective for BSA in collaborating with CJC is to improve product competitiveness by combining technological and cost advantage. CJC's objective on the other hand is to gain access to advanced technology in order to upgrade the products it can offer to customers.

The technology product is a CNC turning lathe of entirely new design. The form of collaboration comprises subcontracting, new product co-development and co-production. The transfer arrangement is based on four phases.

i) In phase one BSA provides technology free of charge in the form of drawings. Machine carcasses are made by CJC and supplied to BSA who manufacture and sell the complete machine.
ii) In phase two complete machines are made by CJC but are sold by BSA.
iii) In phase three BSA and CJC co-design and co-develop new versions of the machine.

iv) In phase four, carcasses of the newly developed machines are made in China by CJC for supply to BSA and complete machines are made by CJC for sale in the local market with royalties paid to BSA.

Features of the collaborative operation

The collaboration is based on the enhancement of joint competitive strength by best exploiting each party's advantage. In doing so the following operational approaches are employed:

(i) Emphasis is placed on how best to employ each party's complementary strength, namely BSA's technological advantage and CJC's cost advantage.

(ii) The process of transfer of technology is coupled with cost reduction practice so that a sustainable enhancement of joint competitiveness can be achieved.

(iii) The enhancement of the local partner's manufacturing activities is guided by its technical capability improvement, thereby maximising the scope for cost reduction without compromising quality.

(iv) The Chinese partner's involvement in new product development provides it with an effective learning, absorbing and experience-accumulating process.

Implications for technology valuation

From a broad perspective the future returns from technology collaboration include commercial, technical and strategic achievements. In this case the owner (BSA) has not tried to gain large immediate benefits. Instead, it has paid more attention to increasing future value by offering the technology to its partner free of charge. The owner's expected future benefits from the transfer are: supply of low cost components and machine carcass, good access to the local market through its partner's large market share, access to its partner's complementary expertise, low cost labour resources for new product development, and royalties from future sales.

The implications drawn from the case are as follows:

(i) The value of technology not only comprises existing value but also includes the future value added through the collaborative operations;

(ii) The amount of additional value differs depending on the effectiveness of the collaborative arrangement and operational management; and

(iii) When the future value of the technology is perceived to be more attractive the owner may forego a more immediate return. This is particularly the case when gaining an immediate return prevents the owner from sharing any future gains.

CONCLUSIONS: CONCEPTUAL FRAMEWORK FOR TECHNOLOGY VALUATION FROM AN OWNER'S PERSPECTIVE

Based on the above assessments the owner of technology needs to take a broad view of the value of technology and the following points should be considered in the process of technology valuation:

(i) Define the objective of technology collaboration and assess the importance of the objective within the context of the overall strategy for developing an international manufacturing network.

(ii) Identify the contributory factors for realising the objectives of transfer and assess the strengths and weaknesses in relation to these factors to highlight the complementary resources that the owner requires.
(iii) Assess the attributes of the technology that can lead to the enhancement of these contributory factors.
(iv) Assess the effectiveness of the transfer arrangements and operational approaches required to capture and use the technology attributes.
(v) Assess the corresponding costs and risks associated with implementing the required functions under particular collaboration arrangements.
(vi) Establish the balance between an immediate return and future additional value and assess the sharing arrangements for the associated costs and risks.

Technology is one of the competitive resources available to owners. The objective of technology transfer in international manufacturing networks is to effectively employ the critical factors together with complementary resources so that a greater future return can be generated. A judgement about the value of technology requires consideration of how the greatest return can be generated and captured through collaborative operations. Valuing technology goes beyond making a simple cost calculation. The importance of technology to the owner, the benefits from sharing its technological advantage, a comparison of future returns with current worth and associated costs and risks, and the strategic significance of the intended collaboration within the context of international manufacturing networks, all need to be considered. The determination of the owner's value reflects the perceptions of the above factors and the results of an overall strategic assessment.

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