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Valuing transferred machine tool technology: Relating value to product attributes and preferences of acquirers

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Abstract: The value of technology and the appropriate form of transfer arrangement are important questions to be resolved when transferring technology between Western manufacturing firms and partners in industrialising and developing countries. This article reports on surveys carried out in the machine tool industries in the UK and China to establish the differences and similarities between owners and acquirers of technology regarding the relative importance of the factors they evaluate, and the assessments they make, when considering a technology transfer. It also outlines the development of a framework for technology valuation. The survey results indicate that the value of product technology is related to superior technical performance, especially on reliability and functionality, and the prospects of premium prices and increased sales of the technology transfer based machine tools. Access to markets is the main objective of UK companies, while Chinese companies are concerned about improving their technological capability. There are significant risks, especially related to performance in the market, and while owners and acquirers have benefited in the short term, the long term collaboration required for strategic benefits has been difficult to achieve because of the different priorities of the owners and the acquirers.

Introduction

Valuing the technology is a crucial question in most technology transfer negotiations and collaboration arrangements (de Bruijn and Jia, 1993). Bennett et al. (1997a) have identified the main factors which make it difficult to determine a value of technology and form of transfer acceptable both to technology suppliers and acquirers. A ``technology valuation'' framework has been developed based on the influences of four components, owner's value, transfer value, substitute value and traded value. The framework and its components have been further refined and the application of the framework illustrated by case studies (Bennett et al., 1997b). In the following discussion, the technology supplier is referred to as the ``owner'' (of the technology) and the recipient as the ``acquirer''. This article concentrates on horizontal transfers of product technology by UK-based to Chinese machine tool manufacturers that have at least some complementary capabilities and could be actual or potential competitors. However, in most such transactions there will also be a varying level of transfer of process technology and other organisational knowledge depending on the characteristics of the technology being transferred, closeness of the relationship between owner and acquirer, openness of the owner and the capabilities and motivations of the acquirer. The framework is based on two simple premises regarding the objectives of technology owners and potential acquirers. For the owner, the value of a technology is related to the ``net benefits'' which can be gained by ensuring its best possible use. Therefore, an owner sells a technology, or more accurately shares it with the acquirer, because the net benefits of the chosen form of transaction are perceived to be greater than:

(1) not transferring the technology; or

(2) any available alternative forms of transfer and partners.

The acquirer enters into the agreement because the technology and the chosen form of transaction are perceived to provide greater net benefits than available alternative

technologies, transaction arrangements and partners. The net benefits for both parties contain quantifiable and non-quantifiable elements, both of which cannot always be specified objectively. The benefits associated with a technology transfer arrangement that are quantifiable in monetary terms could arise from:

* higher additional revenues from increased sales in existing markets (adjusted for loss of revenue from sales in the markets which would have taken place without the technology transfer);
* higher additional revenue from sales in new markets or market segments;
* lower manufacturing and other costs as a result of the shift in location;

or

* a combination of some or all of the above.

Some reasons for technology transfer such as the owners' argument that ``we ought to be in China" or the acquirers' ``we must acquire CNC technology" are very broad and non-quantifiable though underlying them is the expectation that there will be some tangible gains. The net quantifiable benefits are, then, the benefits identified above less the ``costs" associated with the transfer. Some costs are measurable and can be easily demonstrated as being directly related to the transaction (for example, the costs of carrying out the negotiations, training and acquiring complementary equipment). Other costs, such as those associated with organisational changes, may be difficult to identify, quantify and link precisely with the technology transaction. The owner's and acquirer's shares of the net benefits depend on the precise transfer and related arrangements for sharing the costs, benefits and risks (see Bennett et al., 1997b; 1997c). The owner of the technology and the potential acquirer clearly have different perspectives with regard to the net benefits that can be gained from a transfer transaction. These perspectives are affected by the potential gains and costs associated with the transfer arrangement, as indicated above, and the availability of alternative technologies or partners. The framework reflects these considerations by identifying four types of value (Figure 1).

``Owner's value" is the worth of the technology to the owner based on the stream of net income it is expected to produce in the absence of the technology transaction as well as any technological and strategic advantages its ownership offers. In determining the net income, it is necessary to take account of the costs of 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).

The owner's value of the technology is influenced by the ``substitute value", which is the price the acquirer could expect to pay for similar technology. This may be either the price of alternative technologies from other suppliers or the cost of the acquirer developing competing technology. In principle, if the owner's technology is exactly the same as available alternative technologies, and this is well known, the owner will be unable to charge a price for the technology higher than the substitute value. However, this will not be the case if the owner's technology has differentiation advantages. Further, transfer of technology typically requires some continuing support from the owner. Therefore, there is likely to be differentiation between potential suppliers in their commitment to the transfer and the amount and quality of support provided.

``Transfer value" represents the major part of the net benefits resulting from the technology transaction. The tangible benefits arise if technology transfer based machine tools add value for the machine tool buyers. A proportion of this value is captured by the acquirer, or the acquirer and the owner jointly, through higher sales volumes and/or higher prices of the machine tools. In addition, the acquirer may also gain strategic and technological advantages from the transaction in relation to its competitors.

``Traded value'' is the gain that the acquirer can derive if the technology is soldon by the acquirer, although in many cases the selling-on of technology may not be permitted by the owner. Alternatively, traded value can be interpreted as the addition to the net worth of the acquiring company as a result of the technology transfer. This increase in net worth could be reflected, for example, in the purchase price of the company if it is bought by a third party or in its share price if the acquirer is a listed share holding company.

The four value components introduced above have a bearing on whether a technology transfer can be agreed, the sharing of benefits, costs and risks and the form of the agreement. The focus of the research has been on the transaction between the owner and the acquirer. Therefore development of the framework has concentrated on the owner's and the transfer values with the two other value components influencing the price of the technology and the form of transfer arrangement through the decision-making processes of the owner and the acquirer.

It is clear from the above discussion that the value of machine tool product technology is related to the attractiveness of the product to customers which in turn affects the level of sales of the machine tool and the price customers are willing to pay for it. The technological capability to produce the machine tool also has a broader value to the acquirer. The purpose of this paper is to use survey data to further develop the technology valuation framework by elaborating the relationship between the value of a product technology and the product attributes and acquirer and customer preferences.

Methodology

Development of the technology valuation framework is based on empirical data gathered from company case studies and questionnaire surveys of three groups:

(1) UK (and UK-based) machine tool companies who have transferred or are potential transferrers of technology to China;

(2) Chinese machine tool manufacturers, covering most of the key enterprises in the industry, who have imported or plan to import technology through various forms of transfer arrangements, and

(3) a selection of companies in China that use Chinese and foreign as well as co-produced machine tools.

The results reported here are largely based on questionnaire returns from the Chinese and UK machine tool companies. Questionnaires were sent to 100 key machine tool manufacturers in China. Of these, 58 companies responded and reported details of 79 technology transfer experiences. In the UK, questionnaires were sent to 34 members of the Machine Tool Technologies Association (MTTA) that are either currently transferring technology or selling machine tools in China and therefore assumed to be potential transferrers. Of these, 11 companies completed the questionnaires. Further inquiries, including follow-up telephone calls to non-respondents, indicated that almost all UKbased companies currently engaged in technology transfer had returned completed questionnaires and the non-respondents were not potential transferrers of technology in the near future. The focus of the investigation was on:

* the transfer objectives of foreign and Chinese firms;
* product features that were thought to be important in appraising machine tools;
* differences in product features between imported machine tools, those made in China with local technology and Chinese made with imported technology;
* importance of different types of know-how required for effective technology transfer;

* assessment of the level of such skills in China; and
* preferences with regard to different forms of transfer arrangements.

Findings from the Chinese machine tool user survey and case studies have also been used to supplement the results reported below. Altogether 30 companies completed the Chinese user questionnaire. They were selected from the sectors of Chinese industry that demanded high performance machine tools such as the automotive industry and high precision machinery manufacturers. Respondents were asked to assess the importance of factors affecting technology transfer and evaluate the transfer results from their actual experiences on a six-point Likert scale, with a score of 6 meaning imperative, 1 meaning not important or irrelevant and scores in-between indicating degrees of importance. For product features and transfer results, a more refined ten point Likert scale was used to enable the respondents to distinguish with greater ease between the performance of imported and domestically made machines (with or without foreign technology).

Identifying the technology transfer objectives

Technology valuation is not simply a matter of calculating costs and prices; rather it requires a broader consideration of the contributions a technology transfer may make to improving the financial, technical and strategic positions of the owner and the acquirer. Defining the objectives of technology transfer is therefore the first step in valuation. Table I summarises the results of an earlier study by the authors and shows the financial, technical and strategic objectives of both suppliers and acquirers (Bennett et al., 1997c). Each side may have different specific objectives within each overall objective (see Table I). Table I indicates that there is some overlap between the financial, technical and strategic objectives. For example, higher sales in the local market may contribute to the financial objectives of greater sales revenue and profitability, but they may also build up a strong market share and therefore contribute to the strategic market position of a company. Development of a local supply chain to provide good quality components at competitive costs is a technical objective, which also offers a strategic advantage.

For a technology transfer arrangement to be acceptable to both parties it is necessary for their objectives to be substantially compatible. Table I shows that some objectives are compatible in the short run (e.g. increased sales in the local market). Some objectives may lead to compatibility in the future (e.g. the owners' objective of developing a lower cost production base and supply chain and the acquirers' objective of gaining access to the world market). Some objectives may appear to be divergent. For example, the owners' ``cost reduction'' objective does not appear to be compatible with the acquirers' ``development of technological capability''. However, collaboration with a lower cost and technologically capable partner could be a part of an owner's global strategy.

Table II shows the relative weighting attached to four specific objectives of acquirers of foreign technology. All four objectives have weights well above the average of 3.5 on a Likert scale from 1 to 6. Acquirers give higher weighting to technological capability and long-term strategic development. Therefore technology which makes a greater contribution to meeting these objectives is likely to be valued more highly by acquirers. The responses also reflect the tendency of Chinese industrial enterprises to put greater emphasis on technological capability at the expense of market and commercial considerations.

Identifying benefits

The introductory discussion identified the generation and capture of greater joint net benefits and their shares by owners and acquirers as the main reasons technology transfer and notes that the value of technology cannot be measured without assessing the transfer benefits.

These can be grouped into financial returns, technical improvement and strategic development.

Financial returns

For most Chinese machine tool companies an increase in financial returns is an important immediate benefit from acquiring technology. Technology transfer is expected to generate increased financial returns through greater revenues because of the higher price of the machine tools and/or increased sales. Table III shows the price differences between equivalent CNC machine tools of foreign and Chinese origin expected by UK machine tools makers and Chinese machine tools makers and users. All three groups have similar expectations on price differences for general purpose machine tools, whereas there are much greater differences in price expectations for special purpose machines. To the extent that the expected price differences reflect perceived capability gaps, UK companies perceive the gap for special purpose machines to be much larger than do both Chinese machine tool makers and users. Despite their higher prices, however, foreign machine tools have been selling increasingly well in China in recent years and have captured an overwhelming market share. As a result, according to the China Machine Tool and Tool Builders Association (CMTBA), the Chinese manufacturers' market share of CNC machine tool sales fell from 70 per cent in 1990 to less than 40 per cent in 1997.

Table III shows that foreign technology based machine tools made in China carry a significant price premium over Chinese machines based on local technology, while the price premium carried by imported machines is even higher. The reason for such large price differences and the growing market share of imported machines is that users rate imported and foreign technology based machine tools much higher than Chinese machines in terms of product quality and performance. This is borne out in Table IV in which it is shown that foreign technology provides higher satisfaction in improving competitiveness through quality and performance features such as reliability, processing consistency, accuracy, productivity, functionality and appearance. The aim of the acquirers therefore is to manufacture foreign technology based machine tools in China to specifications and quality similar to imported machines and therefore to offer a substitute for imported machines. However, Table III shows that the price premium for technology transfer based machines is still significantly lower than that for imported machines. There are two possible explanations of this. The first is that the customers may not have the same level of confidence in the quality and attributes of the domestically made product as suggested by the evidence in Table IV. The second is that the cost of manufacture in China is likely to be lower because of cost savings from increased localisation, and the customers expect the lower cost to be reflected in the price. As over 75 per cent of technology transfer experiences of acquirers were with general purpose machine tools, the following analysis of product features and price differences focuses on general purpose machines.

The ratios of performance ratings between imported and Chinese machine tools range between 1.72 (for ``Appearance") to 1.19 (for ``Ease of use and maintenance"). These ratios are obtained by dividing the performance rating for each product feature for imported machines (from column (b) in Table IV) by the performance rating for Chinese machines (from column (d) in Table IV).

The weighted average (calculated by weighting the performance ratios for each product feature by its importance for competitiveness in column (a) in table IV) of these performance ratios is 1.46 whereas the expected price ratio for general purpose machines is 1.86. The ratios of performance ratings between technology transfer based and Chinese technology

based machines range between 1.38 (for appearance) to 1.12 (for ease of use and maintenance). The weighted average of the performance ratios is 1.24 whereas the expected price ratio again for general purpose machines is 1.34. The above figures indicate that for imported machines, the price premium is much higher than the performance differential, while for technology transfer based machines the gap between the two is much lower.
Possible explanations of these differences are:
* that the benefits of the better performance of imported machines are perceived to be proportionally greater than the differences in performance ratios;
* that there may be other product features not identified by the respondents which affect the price premiums;
* that the price difference reflects the market power of imported machines in the absence of comparable local substitutes; or
* that, as noted above, there is less confidence in the performance of technology transfer based machines and customers expect a share of the cost savings from manufacturing locally.
Later investigations will use statistical analysis to examine the relationship between price differentials and product features in more detail. Also in future work, performance and price ratios discussed above and the assessment of costs and risks considered below will be used to develop an indicator of value for product technology as an aid to decision making. The ``value analysis'' concept (see Shillito and De Marle, 1992) has some relevance in this respect. When a product is being developed the functions and features that should be included and the level of performance are important considerations. Each function or performance level influences the value of the product, but there will be costs and risks associated with it. Value analysis attempts to develop a composite indicator of the value of the product to aid decision making on the functions to be included and the level of performance to be attained. For an existing product technology being transferred, the product features and performance are given and there are no incremental costs associated with the technology development. The financial return on the technology transfer depends on a combination of the price premium attainable and adequate level of sales. To the extent that it is the technical superiority of the products that explains the growth of imports of CNC machines, technology transfer based machines would expect to gain sales partly at the expense of domestic manufacturers and partly from imports.
However, the case studies indicate that the situation is complicated by:
* the tax advantages offered to some users purchasing imported machine tools; and
* the marketing disadvantages faced by technology transfer based machines.

Technical improvement

It is clear from the above discussion of financial returns that these depend on the superior technical performance of the technology transfer based products and the perceptions of the potential customers about the performance of these products. Given the existing gap in product feature performance (see Table IV), Table V shows the extent to which acquirers are satisfied with what they have gained from technology transfer. The results show a high level of satisfaction with the product features in comparison with expectations that ranged from 70 per cent for processing productivity to 76 per cent for reliability which was also considered to be the most important feature for competitiveness (Table IV).
Technical improvement also plays an important part in strategic development and is therefore discussed below.

Strategic development

Acquirers look for the benefits they can capture from transferred technology for their long-term strategic development. Strategic advantages include attainment of a strong and stable market position and customer base, acquiring operational and development capabilities in key technologies, developing a chain of suppliers which reinforces the enterprise's competitive advantages and, based on these, gaining a technical and market lead over competitors. The strategic benefits may not occur immediately, but through a phased incremental improvement. In some cases, owners and acquirers may enter a technology transfer arrangement primarily for broad strategic reasons with limited prospect of financial returns in the short term. Nevertheless, actual strategic development requires eventual improvement in competitiveness and technical and market success. Table VI shows the acquirers' assessment of the relative importance of competitiveness improvement objectives and their level of satisfaction in attaining these objectives in their technology transfer experiences. Some of the objectives include market, technology and strategic elements, which are not always easy to separate. For example, ``Upgrading technological level and quality of product'' is a technology objective in the first instance but with the intention of offering a more attractive product in the market and a contribution to improving the technological capability which is significant strategically.

The evidence in Table VI shows that the emphasis placed by acquirers is on development of product and process technological capabilities and they also appear to have attained the highest levels of satisfaction on these. The domestic and export market sales increases, improvements in manufacturing and cost reduction are considered to be relatively less important and the level of satisfaction on these is also lower. With the greater emphasis on technological capabilities, acquirers may be underestimating the importance of market and efficiency improvement objectives. Any long term improvement in competitiveness will depend on the nature of the technology transferred and the relationship between the owner and the acquirer. Acquisition of the ability to make a product by itself is rarely sufficient for developing technological capability as development of such capability is a complex and long-term process with various levels of technological competencies such as ability to use the technology, adapt it, stretch it and eventually to become more independent by developing, designing and selling it (Lall, 1992; Bohn, 1994; Barbosa and Vaidya, 1997).

Authors on the ``resource based'' view of the firm recognise that organisational knowledge gives it distinctive capabilities and competitive advantages (see Grant and Baden-Fuller, 1995; Conner and Prahalad, 1996).

Technology is an important part of organisational knowledge. However, the core knowledge in this respect is not the existing product technology but the processes and capabilities for innovation (see Schendel, 1996). Therefore, without longer-term collaboration with the owner to include new product technologies and acquisition of process and R&D capabilities, or alternative sources of these capabilities, the strategic benefits for the acquirer would be limited. Table VII shows owners' assessment of the importance of some competitive improvement factors and their level of satisfaction with these. The results in the table indicate that overall owners assess the competitive improvement performance to be disappointing with the Likert scores being significantly below the average of 5.5 for the range 1 to 10. The highest scores are for ``enhancement of strategic position in market'', ``improvement of after sales service'' and ``market entry or increased sales''. Discussions with case study companies indicate that ``enhancement of strategic position in market'' is concerned with becoming established as a domestic producer so that the company is not disadvantaged by import restrictions or high tariffs against imports in the future. As for acquirers, developing a strong strategic position in the market and the possible use of the collaboration as a low cost

production base as a part of a global strategy cannot be achieved in the short term but would require continuing technological collaboration with the acquirer and the development of a strong customer base and supply chain.
In summary, acquirers' emphasis on technological capability and owners' emphasis on improved market sales and position may lead to problems in arriving at mutually acceptable long term transfer and collaboration arrangements for strategic development. In most cases, it appears that the emphasis is on relatively short-term objectives, so strategic benefits for both sides are therefore likely to be limited.

Identifying costs and risks
Table VIII summarises the main types of costs associated with the transfer. The owner will have incurred costs in developing the technology being transferred. However, as noted earlier, for a developed technology the initial cost of development is not relevant in determining the value of the technology being transferred. The main cost considerations are the incremental costs of the transfer arrangement and substitute value considerations. The incremental costs associated with the transfer could be separated into transfer and operational costs. Transfer costs are associated with the setting up of the transfer arrangements and include:
* the costs of communications and transport and payment for consultancy and legal services required for the completion of the transfer arrangements;
* technical and other training and the purchase of other necessary equipment, spare parts and fittings; and
* the cost of organisational changes such as establishment of a joint venture.
The contract price paid by the acquirer is a payment to the owner. It will therefore be based on the owner's costs and the owner's objectives with regard to the expected financial returns and strategic development. Some of the training, organisational and technical changes may occur over a period of time and therefore the transfer costs may be incurred well beyond the period of setup.
Some of the costs, for example purchasing necessary equipment and organisational changes, have been referred to as consequential costs in Table VIII as they are necessary for effective technology transfer but not directly related to the conduct of the transaction.
The operational costs are related to the actual implementation of the technology transfer and include items such as:
* additional costs of development or adaptation of the technology;
* supply of components to enable the acquirer to manufacture the product; and
* manufacture and supply of components or sub-assemblies to the acquirer.

In addition, there are likely to be some consequences and costs that may be quite significant but difficult to quantify. These include valuable resources devoted to negotiations and making changes in the management and organisational structure of the whole enterprise on the side of the owner or the acquirer. Technology transfer is time consuming. According to Chinese machine tool enterprises, setting up and implementing technology transfer arrangements took just over two years on average. Owners may also become involved in substantial restructuring if some production activities are shifted to the acquirer.
Risk is also an important consideration in technology transfer. Unexpected problems may be encountered and the actual transfer benefits may be less than the owners and acquirers expected. There are three main types of risks: technical, market and collaborative. Technical risks are to do with the ability of the acquirer to absorb the technology and use it effectively to produce the final product to the required specifications. Market risks are to do with:

* market conditions which may also be affected by government policy, for example on tariffs and taxation; and
* the ability of the partners to market and sell the product.

The collaborative risks are to do with the breakdown or poor working of the relationship between the owner and the acquirer which reduce the technical and commercial effectiveness of the venture. Table IX lists the risks and distinguishes between the ones that are specific to either owner or acquirer and the ones that are common to owners and acquirers. The indicators of risk levels in Table IX have been calculated as the differences between the satisfaction score for the transfer results achieved and the maximum satisfaction (i.e. a Likert score of 6) expressed as percentages. As the scale ranges from 1 representing zero satisfaction to 6 representing 100 per cent satisfaction, each unit of Likert score above 1 is equivalent of 20 per cent and any score can be represented as a percentage. For example, for acquirers the Likert score for level of satisfaction on ``supply of key components'' of 3.64 is (3.64 ± 1) ┐ 20) or 53 per cent The risk indicator of 47 per cent shown in Table IX has been obtained by subtracting the satisfaction level of 53 per cent from 100. It is significant that owners are concerned about the market risks associated with the acquirers' ability to win orders and are also sceptical about the cost advantages related to manufacturing in China. By comparison, they are less concerned about maintaining control of their technology. The owners perceive the level of all common risks (with the exception of ```goodness' of collaboration'' to be higher than the acquirers. The biggest differences are on ``the quality of end-product'' and "market sales of end product". These reflect the owners' specific concern on the ability of the acquirer to win orders.

Factors contributing to the realisation of transfer objectives

Factors contributing to the realisation of objectives in technology collaborations stem from the strengths and capabilities of suppliers and acquirers (for example their manufacturing capabilities, effective distribution channels and quality of management) as well as features of the technology being transferred (such as newness of design, cost effectiveness and superior performance in comparison with competing products). For technology valuation it is essential to:

* identify the most important contributory factors for realising transfer objectives; and
* determine how best to use these factors through the technology transfer arrangement that may include longer-term collaboration.

Table X shows the relative importance attributed by the acquirers to aspects of technological capability. Because the main motivation for technology transfer is the acquisition of product technology, it is not surprising that product design and quality are considered to be the most important aspects of technological capability, though process elements to improve product quality and manufacturing methods and reduce costs are also relevant.

Table XI shows the importance of a number of transfer features for achieving the overall transfer objective of acquirers. As would be expected, acquirers put the greatest emphasis on the level of technology and transfer of key know-how. This also reflects acquirers' perception that lack of access to advanced technology is the main obstacle they face with less appreciation of the management and marketing capabilities required to exploit the technology. The owners will only be willing to supply advanced technology if the transfer is part of a continuing collaboration between owners and acquirers and the former are convinced of the continuing benefit they would receive from the arrangement.

Measurement of technology attributes

Given the transfer objectives and factors contributing to the achievement of objectives, the value of acquired technology would be based on the extent to which these objectives have been met through the contributing factors. As previously mentioned, superior foreign technology provides better product performance and quality leading to higher sales of the product at a premium price. The purpose of acquiring technology is to narrow the gap so acquirers expect imported technology to provide attributes that would contribute to higher performance and better quality products with improved efficiency.

Table XII shows the improvement in product feature performance for technology transfer based machines. By expressing the score for satisfaction for each feature as a percentage of maximum satisfaction (with a score of 1 representing zero satisfaction and 6 representing 100 per cent satisfaction), the table shows the degree of satisfaction in comparison with expectations. Statistical regression analysis to be reported elsewhere shows that reliability and functionality are the most important attributes contributing to the price premiums for imported and technology transfer based machines over comparable Chinese machines.

Owners also recognise the importance of technical attributes that affect the value of their technology. However, they also take account of broader attributes of their technology. Table XIII shows the owners' assessment of the importance of broader factors in determining the value of technology to be transferred. As would be expected, the strategic importance of the technology to the owner is the most important consideration. The second most important factor (inclusion of training and technical support) represents the additional costs of supporting the transfer and the third factor reflects the marketability of the technology.

Forms of transfer arrangements and collaborations

About 53 per cent of technology transfer arrangements reported by Chinese machine tools manufacturers are collaborative ventures between owners and acquirers (i.e. co-production or subcontracting agreements or joint ventures). A further 23 per cent are licensing agreements, which are also continuing relationships between the two parties with varying levels of collaboration. The collective gain as well as the sharing of benefits, costs and risks between the respective parties varies depending on the specific form of collaboration. The valuation of technology, therefore, cannot be isolated from the specific transfer arrangements within which it is being transferred. Table XIV shows that acquirers are generally in favour of collaborations with higher commitment and more technical support from their partners. This preference can be explained by the perceived reduction in technical risk as well as the sharing of the market risk in the closer forms of collaboration. According to the Chinese machine tool companies, transfer benefits actually obtained depended on the form of collaboration. UK companies on average appear to have the strongest preferences for co-production and one-off sale of technology followed by licensing. However, evidence from the case studies shows that the preferences of each owner are affected by its own circumstances and the nature of technology. Co-production enables owners to maintain close collaboration with the acquirer without financial commitment and also enables the owner to retain some control on the use of the technology and the quality of the end product. Therefore co-production may be preferred for relatively advanced technologies. One-off purchase and licensing are likely to be preferred for relatively mature technologies or where substitute technologies are available to the acquirer. Bennett, Vaidya and Zhao (1997) provide a more detailed discussion of the different forms of collaboration.

Compared with one-off purchase of technology an ongoing collaboration produced better results for competitiveness improvement such as technological development capability, production management, upgrading the technological level of the product and enlarging

product range. One of the reasons for the differences in assessment is that some features may be connected with specific transfer arrangements and excluded from others. Such features could make a critical contribution to generating benefits and therefore substantially affect the transfer result. For example, all the ongoing collaborations included training whereas training was only provided with 58 per cent of the one-off transactions. Around 30 per cent of on-going collaborations involved arrangements for technology to be updated during the process of transfer but this was not the case for one-off purchases of technology. Transfer of ``key know-how'' also occurred less frequently for one-off transactions (35 per cent) while in co-production and joint ventures it was higher (50 per cent). As a consequence the transfer results are shown to vary under different transfer arrangements (see Table XV).

From the authors' case studies of machine tool companies involved in technology transfer projects, three distinct transfer strategies chosen by suppliers have been identified:

(1) a reactive approach which responds to requests for technology transfer from potential acquirers and tends to seek immediate benefits typically from one-off sales of technology or licensing agreements with limited continuing collaboration;

(2) a phased approach with the intention of achieving medium-term benefits, initially based on continuing collaboration under a licensing or co-production agreement over a specified period of time with a possibility of longer-term collaboration, and

(3) a strategic approach, developing a long-term close technological and commercial collaboration, such as an equity joint venture, with the intention of establishing a strong market position or using the venture as part of the company's global strategy.

A reactive or phased approach may also be an initial phase in developing a longer-term strategic relationship. Obviously the alternative transfer strategies require different levels of commitment and affect the extent to which suppliers share benefits, costs and risks with acquirers. The terms of payment, for example, are important in determining the shares of financial benefits and costs. Table XVI shows that acquirers have the strongest preference for payment for technology as ``share of returns from sales''. For technology owners, this is the least popular payment method. Clearly acquirers prefer to share the market risk. Such an arrangement would also ensure continuing commitment of the owners to making the venture succeed. The owners, however, are less willing to take the risk. Table XVII shows that the owners' preferences for particular terms of payment depend on their strategy, knowledge about local partners and their perception of local partners' competencies. In summary, evidence from the surveys shows that acquirers prefer closer and continuing collaborations as they lead to transfer of more advanced technology, its more effective use and the sharing of technical and commercial risks. This preference is not always compatible with the more cautious approach of the owners. The case studies show that such potential conflicts can be resolved by the two parties adopting a phased approach. In such an approach there is limited commitment at the beginning leading to closer collaboration and commitment at a later stage if the initial experience:

* develops mutual understanding and trust;
* yields satisfactory results; and
* benefits of further collaboration are thought to be promising.

All the major factors affecting the value of technology have been identified above and the survey results relating to them have been examined. In the final section, the contribution of the survey results to further development of the framework for valuing technology is considered.

Contribution of surveys to framework development

The overall aim of the technology valuation framework is to assist both owners and acquirers to reach a mutually acceptable value of technology, terms of payment and transfer arrangement. The above discussion indicates that there is no single value of technology in a transfer situation. The value depends on the features of the technology, the technical effectiveness of the transfer arrangement and the commercial exploitation of the technology. These in turn depend on the details of transfer arrangements, which can be separated into a number of stages set out below from the owners' perspective. Similar stages from the acquirers' perspective would be a mirror image of that for the owners.

Stage 1. Initial statement and scrutiny of owner's objectives
This should include assessment of the relative importance of the owner's market, technical and strategic objectives and the interdependence between the objectives.

Stage 2. An audit of owner's capabilities, resources and knowledge relevant for technology transfer The audit should include an assessment of the level of technology to be transferred and its comparison with available technologies, the company's transfer capabilities including the availability of resources for implementing the transfer process and the reputation of the company and its products.

Stage 3. Initial assessment of owner's value of technology and transfer value of technology under alternative transfer arrangements The transfer value is realised from the manufacture and sales of foreign technology based machine tools in China to specifications and quality similar to imported machines. Survey results show that they could be sold at a significant price premium over machine tools made with Chinese technology but at prices significantly below those of imported machines. However, because of cost savings from increased localisation, the costs of manufacture would also be between those for imported machine tools and locally made machine tools.

The survey also shows that the price premium can be related to the performance attributes of the machine tools and the reputation of the brand name. A value analysis measure is being developed from the survey results to relate the price premium to:
* the major features of technology transfer based machines; and
* a composite performance index of machine tool features.
These measures, along with estimates of incremental sales and an estimate of the number of years for which the product would maintain its market position, can be used to obtain an initial financial value of the technology to be refined with the help of more precise and customised market research data if necessary.

In many cases, there will be congruence between the quantifiable benefits and the technical and longer-term strategic benefits. For example, the quantifiable benefits are directly related to market success, which also strengthens the longer-term market position and is based on effective transfer of technology and its use. However, in some cases the quantifiable benefits may not look promising or be highly uncertain but the technology collaboration may still be undertaken for presumed strategic advantages (for example, based on the broad argument that "we ought to be in China because it is the future" or ``because all our competitors are there"). In such cases, a judgement has to be made on the strategic value of technology transfer. Assessment of the incremental costs and risks would be useful in making such a judgement. Alternative transfer arrangements also have different implications for the sharing of benefits, costs and risks. For example, in a one-off sale, the owner faces virtually no commercial risks

after the transaction has been completed (though there could be the possible risk of the acquirer flouting the contract, for example by attempting to compete in the owner's markets outside the agreement). Whereas in a joint venture, the owner may be required to contribute a part of the capital expenditure and may only see a return on the investment if the venture is successful.

Stage 4. Initial assessment of the objectives, capabilities, resources and knowledge of potential acquirers of technology The owner's objectives should be compared with those of potential acquirers to identify the objectives of the acquirer which are:
* compatible;
* non-conflicting; and
* conflicting with those of the owner.

Initially, potential acquirers' objectives may not be known precisely. The survey results provide an initial indication of the likely objectives. If the owner's approach is reactive and one-off sale of technology with limited support is being considered, an elaborate assessment is not required. It is only necessary to ensure that the objectives are not conflicting and that the transfer agreement imposes the necessary restrictions to prevent misappropriation or future conflicts (e.g. competition in third markets).
For longer-term technology based collaborations, more thorough audits are required of the potential acquirers including their capabilities to absorb the technology and crucially to exploit the technology commercially. Management capabilities and access to financial resources and autonomy to make necessary investments are also important considerations.

Stage 5. Acquirer selection and negotiation of transfer arrangement Stages 1 to 4 are preparations for this stage in which the bargain is struck. The owner must first select the best available acquirer on the basis of compatibility of objectives, managerial, technical and marketing capabilities of the acquirer and the collaborative reputation of the acquirer.
The negotiation will involve the components of technology transfer which may include hardware and software, supply of key components, supply of drawings, supply of training and consultancy, arrangements for supply of components from other suppliers, phasing arrangements and agreements for future supply of technology. As noted above, the value of technology is the net benefit generated as a result of the transfer arrangement. However, the agreement and its components are not simply a means of sharing the net benefits generated. The net benefits depend on the effectiveness of the collaboration arrangement. For example, if an owner supplies drawings for a machine tool under a licensing arrangement with no subsequent support and the acquirer fails to absorb the technology, there will be no gain from the technology transfer. If the owner provides continuing technical support and the venture becomes a success, both the owner and the acquirer will gain.

Stage 6. Implementation of the technology transfer
The final stage is the implementation of the technology transfer. While effective implementation is crucial for the realisation of the value from technology transfer, details of implementation are beyond the scope of this article. It should however be noted that for realising value, implementation is not simply the transfer of technological capability but ensuring its commercial success. This is especially the case where the transfer arrangement is a longer term collaboration between the owner and acquirer.
The outcome of the stages identified above will be specific to the individual owner (and the acquirer). The aim of the framework is to provide guidance on assessing the value of

technology and the appropriate form of transfer arrangement. A guide to using the technology valuation framework is being produced in the form of a workbook. This identifies the major factors influencing the value of technology and provides guidance for assessment and measurement with consideration of both suppliers and acquirers.

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