INTERNATIONAL TECHNOLOGY COLLABORATION FOR NEW PRODUCT DEVELOPMENT

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ABSTRACT

In recent years it has become increasingly common for companies to improve their competitiveness and find new markets by extending their operations through international new product development collaborations involving technology transfer. Technology development, cost reduction and market penetration are seen as the foci in such collaborative operations with the aim being to improve the competitive position of both partners. In this paper the case of technology transfer through collaborative new product development in the machine tool sector is used to provide a typical example of such partnerships. The research evidence on which the paper is based includes longitudinal case studies and questionnaire surveys of machine tool manufacturers in both countries. The specific case of a UK machine tool company and its Chinese partner is used to provide a specific example of the operational development of a successful collaboration. The paper concludes that a phased co-ordination of commercial, technical and strategic interactions between the two partners is essential for such collaborations to work. In particular, the need to transfer marketing know-how is emphasised, having been identified as an area of weakness among technology acquirers in China.

INTRODUCTION

In the industrialised countries, machine tool manufacturers develop and produce products with a high technology content to meet the requirements of their customers who increasingly are demanding machine tools with high performance, accuracy and reliability. Such machines, therefore, need to be sold at consequently high prices, which reflect the resource and labour content of development and manufacture. Machine tool manufacturers in developing countries, on the other hand, lack the capability to produce equivalent machines, but they do have the advantage of lower development and production costs. As a consequence, technology collaboration has therefore been seen as an effective means of increasing competitiveness by sharing the advantages of both sides' situations. An additional benefit of such collaborations is that each side has increased access to the other's markets.

Traditionally, technology collaborations have tended to be formed between firms from advanced economies. However, the situation described has caused the creation of partnerships across economies at different stages of development. For example, a number of technology collaborations have been established between foreign and Chinese machine tool companies. However, from our case study research and questionnaire surveys it appears that many collaborative ventures of this type have encountered difficulties in realising their objectives. For

example, problems can arise in communicating the design technology, market access through collaboration does not necessarily lead to increased sales, low labour cost does not guarantee product cost reductions and technological advantage does not always improve competitiveness in all markets. As a result, many well-intentioned technology based collaborations have failed.

This paper addresses the issues outlined above by focusing on an analysis of the operational features required in technology transfer collaborations for new product development. It identifies the links between the strategic objectives and operational aspects of collaborations and highlights the factors that must be in place for such arrangements to succeed. Evidence is drawn from the results of questionnaire surveys of machine tool manufacturers in China and the UK as well as case studies in the Chinese and UK machine tool industries.

THEORETICAL PERSPECTIVE

New product development is largely a market-related activity and commercial success or failure has a substantial influence on new product innovation (Robertson et al, 1972; Cooper 1980). Engineering driven product development, which only focuses on technical aspects while excluding consideration of market requirements, has been seen as inadequate (Cooper 1994). Thus, technical superiority and cost are identified as equally important factors in determining the outcome of the new product development process (Cochran and Thompson 1964; Booz Allen and Hamilton 1982).

An awareness of the importance of the market and how it influences the process of new product development requires that consideration be given both to technical and commercial factors. The company's resources need to be examined and used in such a way as to highlight its core strengths and external resources that may be exploited in order to reinforce the new product's competitiveness. Technology collaboration is already recognised as an effective means of exploiting the joint strengths of the respective partners' manufacturing operations but is now also seen as playing an important role in new product development. In this situation it requires linking together various resources and functions, both internal and external, where the best result can be obtained. In relation to this an integrated model for new product development has been identified (Rothwell 1992) which emphasises external collaboration while recognising the benefits derived from effective use of various resources.

It must be noted that new product development should not only be confined to the innovation process, rather it will include a broader context of innovation, development, further improvement and product introduction. This would endow the technology transfer process with two features:
i) Continuous transfer. New products such as machine tools need to be continuously modified and improved. The transfer of technology for new product development cannot therefore be a one-off process. As a consequence, the required improvements in technology also tend to create their own further problems requiring modification and revision, thereby making continuous transfer inevitable (Rosenberg 1976);
ii) Specific focus. Because of the limitations in each partners' capability, effective collaboration should seek to identify and make best use of each side's strengths so that the partnership arrangement can offer a greater contribution to the new product development process through

technology transfer. Each party therefore needs to locate its critical success factors and focus on these to gain competitive advantage (Kogut. 1991).

Since technological strength and cost advantage as well as commercial benefits have been identified as critical factors for success, most technology collaborations between companies in developed and less developed countries focus on these factors. The objective of such collaborations is to enhance competitiveness by developing high-technology products at low cost. In practice, different strategic approaches are formulated, various forms of collaboration are exploited, and broad transfer contents extending beyond the realm of particular tangible products and techniques are also considered (Zhao et al 1998). However, as was mentioned above, many collaborative projects have not yielded the intended benefits. The critical question is what operational measures are required to make such collaborations work?

INVESTIGATION METHODOLOGY

In carrying out the research, empirical data were collected from the machine tool industries in the UK and China. The evidence comes from longitudinal case studies and questionnaire surveys of machine tool manufacturers in both countries. The specific case of BSA Tools Ltd and its Chinese partner the Changcheng Machine Tool Works (CJC in Chinese) has been used to provide an in depth example of the operational development of a successful collaboration.

The questionnaire survey findings are drawn from:

i) A survey of UK (and UK based) machine tool companies who have transferred, or are going to transfer, technology to China or sell machines in China.

ii) A survey of Chinese machine tool manufacturers covering most of the key enterprises who have imported, or plan to import, technology through various forms of collaboration.

In the Chinese survey 58 companies responded from among the 100 key machine tool manufacturers to which the questionnaire was sent. In the responses details of 79 "technology transfer experiences" were provided. In the UK questionnaire survey 11 companies responded from among 34 members of the Machine Tool Technologies Association who it is known are currently transferring technology or selling machine products to China. The questionnaire elements that are relevant to this paper include transfer objectives, benefits, costs, and transfer features influencing product competitiveness. Participants were asked to assess the importance of these factors and to evaluate the transfer results from their actual experiences. The degree of ‘importance’ of these factors has been scaled, with 6 meaning ‘imperative’ and 1 meaning ‘not important’ or ‘irrelevant’. Scores in-between refer to varying degrees of importance. The rating of the transfer results have been scaled, with 10 meaning ‘completely satisfied’ and 1 meaning ‘not at all satisfied’. Scores in between refer to varying degrees of satisfaction.

OPERATIONAL ASPECTS OF TECHNOLOGY TRANSFER ARRANGEMENTS

The results of the questionnaire survey among UK machine tool machine tool manufacturers highlighted the low satisfaction from their transfer experiences, especially when assessed against the importance rating given to each expected transfer objective. See Table 1.

The table shows that in every case the suppliers' expected transfer objectives were actually achieved with no more than 50% satisfaction. Most significant is that the results in connection with the cost reduction objectives were least satisfactory. On average, only 33% satisfaction was achieved, although each individual company did have varying degrees of satisfaction.

Table 1 Assessment of the importance of transfer benefits and degree of satisfaction from previous transfer experiences.

Suppliers' objectives	**Importance of objectives**	**Degree of satisfaction from actual transfers***
Market entry or increased sales	5.30	44%
Enhancement of strategic position locally	5.00	50%
Reduction in production costs	4.40	28%
Meeting local customers' requirements	4.20	39%
Improvement of after sales service	4.10	50%
Acquisition of low cost local components	3.40	28%

* 100% refers to complete satisfaction.

From the case studies in the UK and China three operational factors have been identified as the main causes of the unsatisfactory results reported through the survey results.

Transfer features

Transfer features refer to the operational mechanism whereby technology is transferred in specific forms (e.g. through drawings or hardware), the transfer "package" (e.g. the whole technology or only part of the know-how) and means (e.g. training and support). As technology transfer is a process of transferring know-how for production and use, the time required for transfer and the effort necessary for learning and absorption depend on the degree of sophistication of the technology and the technological gaps between suppliers and acquirers. Compared with many other types, machine tool manufacturing technology requires more systematic know-how and skills to ensure the accuracy and reliability of the whole machine. Moreover, tacit know-how cannot be transferred in the form of drawings, nor routine instructions, but only through an experience-based learning process (Tsang 1995). The transferability of machine tool manufacturing know-how is recognised to be lower due to its lower degree of standardisation and high complexity and simultaneous information processing. The importance of transferring tacit knowledge in such cases has been recognised by Grant and Gregory (1997). The transfer features therefore played a critical role in the process for acquirers to accumulate experienced knowledge.

Cost reduction

From the case studies, the requirement in all markets for a high quality/performance to price ratio for machine tool products was recognised by both partners in technology collaborations and raises the importance of cost reduction in addition to technology development as a key factor to improve product competitiveness. This was borne out by the questionnaire survey results, which

also showed that, for suppliers, cost reduction is one of the major objectives in co-producing products with Chinese partners.

In practice, however, the technology transfer based collaborative product has been found to be more expensive to produce than was originally envisaged. Based on their actual transfer experiences the cost advantage and the quality/performance to price ratio was assessed by the suppliers' as *not satisfactory* (average score of 2.3) and by the acquirers' as *fairly satisfactory* (average score of 3.7). The limited scope to use low-cost local resources has been identified as a key reason for the failure of collaborative projects to fulfil their target of reducing product cost. From an operational perspective this limited scope has been shown to be due to:

i) Continued need to import components. The need to supply high technology content "key components" from abroad limits the scope for cost reduction because they represent a substantial percentage of total material costs. Among these key components there is a large proportion of bought-out parts that are supplied by subcontractors and commercial suppliers.

ii) Limited manufacturing activity. Because it is a high cost activity assembly, rather than machining and other forms of material processing, is the major element in many collaborative arrangements. However, there are other activities also involving a high percentage of labour cost, such as product design and development, and some parts machining requiring a large manual element. Manufacturing overheads, including indirect labour, are also a significant contributor to overall cost.

Marketing strength

Future sales of technology transfer based products is key to the success of collaborative ventures. However, marketing has been found to be excluded from most technology collaboration arrangements. To many suppliers access to, or increased sales in, the local market is their most important objective for transferring technology, but in practice the market activities are left up to the technology acquiring side and success in achieving sales is largely dependent on the local partners' marketing capability. Compared with their technical capability, marketing received much lower consideration when technology suppliers' choose their partners (see Table 2).

Table 2 Suppliers' assessment of the importance of factors in determining potential partners and extent to which they are considered in practice

Determining factor for choice of partner	**Importance of factor**	**Extent to which factor is Considered among all Transfer experiences**
Better quality of potential partner's currently-made product	5.2	40%
Better quality of potential partner's production equipment	4.9	20%
Higher technological level of potential partner's products	4.5	40%
Better marketing capability of potential partner	4.4	not considered
Potential partner's awareness of supplier's product brand name	3.7	20%
Potential partner has higher local market share	3.5	20%

Because the marketing infrastructure in many Chinese machine tool companies has not been established, and in others it is not well developed, acquirers have encountered many difficulties in selling technology transfer based products against strong competition in the local market. Unless marketing know-how is included in the transfer package, acquirers' improved technological capability is largely negated by the weakness of their marketing ability. This prevents them from gaining the anticipated financial returns from the transferred technology, which in turn causes collaborative ventures to fail.

CASE STUDY: TECHNOLOGY COLLABORATION BETWEEN BSA AND CJC FOR NEW PRODUCT MANUFACTURE AND DEVELOPMENT

Case description

BSA (a UK company) and CJC (a Chinese company) are both in the medium size category of machine tool companies. 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. Approximately half its output quantity is conventional machines and half is CNC machines. CJC has captured 24% of the Chinese market for CNC turning machines.

The objective for CJC in collaborating with BSA is to obtain the advanced technology the company has to offer. BSA's objective on the other hand is to improve product competitiveness by combining technological and cost advantage. Through the collaboration BSA would be able technically to achieve greater competitive advantage and, together with CJC, could developed the product at lower cost. The technology collaboration agreement between the two companies was signed in 1997. 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. In the initial stage of the project the terms of payment agreed is that BSA provides technology free of charge in the form of drawings and in return purchases machine carcasses supplied by CJC at reduced cost. The transfer arrangement is based on four phases.

i) In phase one the basic machine is manufactured and sold by BSA with machine carcasses made and supplied to BSA by CJC.
ii) In phase two complete machines are made by CJC.
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 being paid to BSA.

BSA's main activities include provision of drawings, key parts, training and technical supervision to CJC, as well as final assembly on the basis of carcass supply from CJC and selling products in the world market. CJC's responsibilities are for machining parts and assembling carcasses and for complete manufacture in the later phases. In relation to new product development both parties would jointly be involved in design and development. The focus of this will be to produce designs that would benefit from the opportunities offered for cost reduction from:

i) Local "in-house" manufacture of parts by CJC.

ii) Purchase of proprietary and commercial parts by CJC from local suppliers.
iii) Local assembly by CJC.
iv) Joint selling of the newly developed products in local and world markets.

PROSPECTIVE BENEFITS FROM THE COLLABORATION

Financial aspects

The collaboration arrangement has been designed to ensure there is immediate financial benefit to both parties. In many technology transfer based collaboration arrangements, the acquiring partners have suffered financially because they have lacked the marketing skills to sell more expensive co-produced machines in local markets. This in fact has become one of the main causes of failure of many collaborative ventures. From the start BSA gave first priority to the issue of market sales and in phase one remains fully responsible for the sale of products in all markets, so taking advantage of its established name and reputation throughout the world. Additionally, by sourcing materials (parts and machine carcasses) at lower cost, greater commercial benefits can be derived through either increased sales by offering lower prices or by maintaining prices and selling at higher margins. Meanwhile, CJC can also achieve its commercial objectives by supplying carcasses to BSA rather than trying to sell finished machines.

Technical aspects

The substantial benefits for BSA are in terms of cost reduction. There are three aspects of the collaboration from which this is derived:

i) The purchase of carcasses from CJC which would otherwise be manufactured by BSA at higher cost.
ii) The purchasing of other parts from CJC which otherwise would be supplied by subcontractors at higher cost.
iii) The effective use of each partner's expertise for co-design and co-development.

CJC on the other hand obtains advanced knowledge and skills in the following ways:

i) By learning process programming know-how and acquiring assembly know-how and skills from the process planning and build specifications.
ii) By acquiring product design and development know-how from drawings provided by BSA and co-design and co-development exercises.
iii) By gathering quality control and production management knowledge through training and phased project planning.

Strategic aspects

The collaboration brings considerable strategic benefits to both partners. BSA has the opportunity of exploiting the commercial potential of its technology by reducing cost, increasing sales in existing markets and developing new markets. It also benefits from the complementary knowledge of CJC when co-designing and co-developing the new products. CJC gains access to leading edge technology for a specific product, thereby enabling it to optimise its future product development. Since the machine being chosen for the collaboration is relatively smaller in size and

lower in value compared with the other products in BSA's product portfolio, the strategic benefit for both partners is the opportunity to develop a highly competitive new machine range in terms of performance price ratio, and consequently to a create a new niche in both the world and Chinese markets.

OPERATIONAL FEATURES OF THE COLLABORATION

Joint competitive strength

The collaboration is fundamentally based on the enhancement of joint competitive strength by exploiting each party's advantage. BSA (the technology supplier) and CJC (the acquirer) have, respectively, the benefits of technological and cost advantage. Moreover, each one's respective advantage is the other's disadvantage. By jointly using their complementary advantages they can achieve a competitive position that would otherwise be out of reach of each partner on its own. In line with this strategy the operational approach to the collaboration places emphasis on how best to employ each party's strength along with its capability for improvement so as to achieve sustainable enhancement of joint competitiveness.

Enhancement of the opportunity to realise mutual transfer objectives

A successful collaboration results from a commitment leading to the realisation of both parties' objectives. Overall, BSA's and CJC's objectives are well matched but the question arises of how to guide the operation towards realising mutual transfer objectives. As mentioned earlier, combining together high technology and low cost advantage is the core for such technology collaborations. However, in many such cases problems have been encountered in that acquirers may not have access to adequate knowledge if transfer is driven by cost reduction objectives alone. This in turn often leads to failure in achieving an adequate return with consequently neither of the two parties' objectives being realised. To ensure the realisation of both parties' objectives the collaboration arrangement between BSA and CJC was designed as a comprehensive package.

Maximising the scope for cost reduction without compromising product quality

A problem has been found in many technology transfer experiences that higher rates of localisation lead to a poorer quality of end product. Therefore the key issue of cost reduction is how to maintain the quality while cost can at the same time be reduced. In machine tool manufacture, assembly is the most labour intensive activity, so this is the element where cost can be mostly reduced through technology transfer and it is no co-incidence that most collaborations start with local assembly. However, some companies have found that the quality of the end products being assembled locally cannot be guaranteed even when based on CKD or SKD kits.

BSA changed from the normal way of reducing cost through technology collaboration. Instead of starting with final assembly in the first phase it focused on machining, which in this industry is also labour intensive. In this way CJC's low cost advantage could be used while the end-quality of machines was still controlled by BSA. This is followed in subsequent phases by focusing on mechanical subassembly and final assembly costs and, for this, training was provided to allow problems to be revealed and solved effectively. Once there is sufficient understanding of product

further cost reductions will be achieved through co-design and co-development in which the design and development of a specific part or unit design is undertaken by CJC.

Effective technology transfer through co-development of new products

One of the advantages of co-development of new products can be identified as being the provision of an effective means for transferring technology. To the acquirer, co-development of a new product offers an excellent opportunity of learning, absorbing, developing and innovating. In the process of product development, experiences are accumulated and tacit knowledge is gained. The key design elements can be identified and captured by co-design activities. Better understanding of the machine's features can be obtained through design , modification and on-going development. Key know-how ands skills can be gradually learned and absorbed in the process of jointly developing and manufacturing new products. For CJC, the additional knowledge acquired in connection with co-developing new products relates to process planning and tooling know-how, which partners normally do not acquire in most other transfer arrangements.

Phased co-ordination of commercial, technical and strategic achievements

From a broad perspective the return from technology collaboration includes commercial, technical and strategic achievements. Therefore a phased co-ordination of these achievements is required. In the collaboration between BSA and CJC the arrangement was made to ensure a "win-win" situation for both parties, placing commercial achievement first. The collaboration was set-up to only exploit each party's existing competitive advantage. Initially, CJC is responsible for manufacturing parts and BSA takes responsibility for assembly and marketing to guarantee quality and sales by using its established reputation for high quality as well as its marketing expertise. CJC's financial return can be guaranteed by supplying machine carcasses to BSA within the collaboration, while BSA can achieve its own financial return from selling machines through its world-wide distribution channels. Technical achievement is gained in the next phase where CJC acquires more technological know-how by undertaking assembly and more processing. Thus, BSA's cost reduction target is further achieved along with CJC's capability improvement. Finally, strategic achievement is gained from the joint strength that enables a new high technology, low cost, product to be developed and a new market niche to be established. Financial, technical and strategic achievements interact and increase along with the process of technology transfer and new product development.

CONCLUSIONS

Technology transfer and collaborative new product development provides an opportunity for acquirers to learn, absorb and develop transferred technology and also allow suppliers to carry out effective cost reduction practice. The operational arrangement for such ventures is a key mechanism for successful collaboration. In the BSA/CJC case, operational features played an important role in ensuring that the collaboration objectives will be effectively realised. In line with the collaboration strategy the operational approach requires that emphasis is placed on best exploiting each party's complementary strength and continuous capability enhancement so as to achieve sustainable improvement through joint competitiveness. In particular, the research has

identified the need to transfer the marketing know-how of the supplier in order to derive maximum mutual benefit from the arrangement. However if, as in the BSA/CJC case, the marketing know-how is not transferred then marketing responsibility may need to be taken by the technology supplier.

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