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Aiding the technology manager: a conceptual model for intra-firm technology transfer

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Abstract

As many industrial companies are faced with competition characterised by product and market uncertainties, globalisation and rising R&D costs, the management of their *intra-firm technology transfer activities* is increasing in strategic importance. These activities are amongst the most problematic arrangements that exist in firms. Hence technology managers need to absorb, create, adapt, and transfer technological knowledge to various parts of the MNC under these conditions.

A conceptual model for intra-firm technology transfer is presented, based on empirical research undertaken with a leading UK cable producing MNC (BICC Cables Ltd) and based on a review of some key literature in this area. Major factors that can either 'help' or 'inhibit' this type of transfer process are presented. The model acts as a 'toolkit' aiding management by drawing out implications such as the development of trust and shared understanding, and the setting up of integrated project teams who are sensitive to transmitter and receiver organisation capabilities within the MNC.

The findings present two case studies highlighting the transfer of IT-based bespoke technologies that involve the R&D, manufacturing and marketing functions. This paper confirms that intra-firm technology transfer is an *interactive process* involving actors who possess different levels of competencies accumulated over time and that this process should command higher strategic significance in firms.

Keywords: Technology transfer; Interactive process; Toolkit; Broadcasting model; Common understanding

1. Introduction

This paper attempts to unravel the complex issues involved in the effective management of intra-firm technology transfer within a multinational company (MNC) environment. The paper offers a model, referred to as an 'broadcasting model' for technology transfer, which acts as a conceptual framework to explore a number of interesting organisational issues. This model is a useful aid for managers, which evaluates the technology transfer process 'within firms' that typically involves R&D and manufacturing function activities. A framework is constructed from a synthesis of the literature mainly in the technology management areas, which is then developed using insights from empirical evidence to present an 'interactive broadcasting model'.

R&D decentralisation has enabled firms to bring together technical, commercial and operating staff at business unit levels. Firms have shifted funding from corporate to business unit sources, with the intention of making R&D activities more market-driven (Coombs, 1996). This creates a range of complex issues that technology managers must deal with when transferring know-how to different parts of the firm. Importantly, this paper adds to the limited strategic debate regarding this type of technology transfer in the wider literature, where the major thrust has concentrated on transfers outside of the firm.

Empirical evidence is gathered from two in-depth innovation case studies conducted at BICC Cables Ltd in 1998. BICC Cables was, up until two other international cable companies acquired the company in 1999, the UK's largest cable-making company. BICC Cables was a leading company within the BICC plc Group of companies and had expanded by acquiring other cable companies mainly based in Europe. This company had

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an annual turnover approaching £ 1.3 billion and was employing about 10,000 people, up until the late 1990s when it was split up and sold by BICC plc.

The paper is structured as follows: Sections 2 and 3 provide a theoretical background relevant to this area of study by highlighting key issues concerning the management of knowledge across MNC boundaries and overviewing existing relevant models of technology transfer from the literature; Section 4 develops a conceptual framework 'broadcasting model' based on insights from the previous sections here; Section 5 deals with the empirical research design and data collection by briefly analysing two innovation case studies at BICC Cables Ltd; Section 6 presents an interactive intra-firm technology transfer model by testing and refining the initial model introduced earlier in the paper; and Section 7 points out some important technology management implications.

2. Management of knowledge flows across organisational boundaries

In many intra-firm technology transfers, much technological knowledge may be business-unit specific or even R&D department specific within a MNC environment. Hence most management teams face a number of challenges in having to overcome difficulties associated with the diffusion of knowledge across not only organisational boundaries, but also geographical boundaries. *Technology transfer* represents one of the most knowledge intensive and problematic relationships in a firm. Typical problems encountered here include business units not interested in R&D developments, which could be due to cost factors or poor communication between technology senders and receivers, or as a result of the 'not invented here syndrome' and problems simply arising from lack of resources. De Meyer (1991) contends that maintaining an effective MNC global R&D network might require the creation of a 'family atmosphere' through using mechanisms such as: *temporary assignments* to other laboratories; *constant travelling*; *rules and procedures* to reinforce company culture; and through *training*.

Szulanski's (1996) investigation into why intra-firm knowledge transfers can be so difficult points to issues such as: lack of motivation; lack of absorptive capacity; lack of retentive capacity of recipients; formalised structures and systems; lack of numerous individual exchanges; and an arduous (i.e. laborious and distant) relationship between the transfer partners. Jain and Triandis (1997) provide a useful set of general approaches that can help overcome some barriers to technology transfer. These are the *personnel approach* (temporary or permanent transfer of the owner of knowledge to the user group), the *organisational link-pins approach* (specialised transfer agencies used as intermediaries) and the *procedural approach* (early user involvement by means of procedures, e.g. multifunctional project teams).

Technology transfers inside firms will have different levels of expertise or know-how transfer, as much knowledge may already be embedded in the technology. This gives rise to the issue of making distinctions between tacit and explicit knowledge. Howells (1996) concludes that more elements of *tacit knowledge* may in reality be, if not formally liable to codification, at least able to constitute an 'organisational routine' that can be transferred between individuals or groups in a more structured framework that forms part of the firm's *accumulated* knowledge base. Here, it is important to stress that technological knowledge is not the same as information. Knowledge is developed and organised out of a procession of information based on beliefs, values and commitment of individuals involved. Information only becomes knowledge once it is understood and its value is learned and this knowledge is a property of individuals. In the context of technology transfer here, information flows can be viewed as facilitating and developing a common understanding.

3. Overview of a selection of technology transfer models

A number of technology transfer models have typically focused on transfers between firms, between public research establishments and private sector firms and collaborative agreements between educational establishments, industrial organisations and government. The limitations with a number of the models, is a lack of concentration on transfers 'within the firm' and these models remain rather general and do not elaborate on the dynamics of the intra-firm transfer processes. What a number of models have not recognised fully is that intra-firm transfers are *two-way iterative processes* and not simply one-way linear processes.

Common features found in typical technology transfer models include the establishment of manufacturing goals and objectives and the alignment of policies and actions of the manufacturing infrastructure with these goals and objectives. The Bommer et al. (1991) model presents four components of technology, which have increasing levels of sophistication as follows: (1) *Technoware* — object-embodied technology; (2) *Humanware* — person-embodied technology; (3) *Inforware* — document-embodied technology; (4) *Orgaware* — institution-embodied technology facilitating integration of the previous three components.

Levin (1997) states that the major challenge for management is to use the technology transfer process as a vehicle for creating a *learning organisation*. The inner workings of a technology transfer process, involving

establishing relationships, communicating with people at the right levels and transferring the necessary know-how or expertise, can be viewed as a *set of routines* used in organisational learning. Gilbert and Cordey-Hayes (1996) develop a model that follows the processes of knowledge as it might be transferred within an organisation to lead to the development of a *set of routines*, which are reflected in the behaviour and practices of the organisational members and becomes part of the core routines, so that assimilation (or learning) occurs. The first step of this model is 'acquisition' of knowledge, the second is 'communication', the third is 'application' and the fourth is 'assimilation', where the key to the process of transfer is seen as the assimilation of results and efforts of applying the knowledge gained.

4. Developing a conceptual framework model for technology transfer

Now concentrating on the diffusion of knowledge and the types of communication channels used, a helpful starting point is to think in terms of a 'broadcasting analogy' for the intra-firm technology transfer process. Here those aiming at the diffusion of a new technology are referred to as the *transmitters* (or broadcasters), which could be an R&D group, who erect the radio masts and send out what they deem to be appropriate signals about the nature of the technology. This broadcasting may be deliberately aimed at pre-selected *receivers*, for example business units or production departments, or the broadcast may aspire to attract as many listeners as possible (Boden, 1991). The type and quality of the broadcast *message*, combined with the strength and effectiveness of media used to transmit are critical variables here. Certain organisational issues such as the formality of communications that exist and the degree to which informal relationships influence technology transfer activities can affect the broadcast message. For example in a study of some ICI business units in the UK, by Trott et al. (1995), it was found that informal networking was encouraged by ICI via the provision of an 'open management style' and matrix organisational structure.

The 'broadcasting analogy' framework raises some important considerations that have not been adequately addressed in the models outlined in Section 3. One consideration is 'motivation' (*the hidden agenda!)*. So what benefit can the transfer of a particular technology bring to people and how can they be motivated to collaborate? Another consideration is the 'attention span' of the receiver (*'sound bites'*). So can the transfer hold the attention of the receiver in order to overcome any transfer difficulties?

A 'communication system model' presented by Shannon and Weaver (1949), in *'The Mathematical Theory of Communication'*, raises some interesting questions also applicable to technology transfer:

1. Is the message received the same as the message sent?
2. Is the message received understood?
3. Is the message received acted upon as intended?

In relation to understanding messages received, Cohen and Levinthal (1990) describe 'absorptive capacity' as the ability of an organisation to assess and use knowledge that is largely determined by prior-related knowledge, where the organisation is capable of identifying new and valuable information that is understood and turned into knowledge.

Fig. 1 illustrates a basic conceptual framework model for technology transfer, which will be used to test the empirical research findings presented in Section 5. This is a simple 'broadcasting model' for the technology transfer process, which shows a message (that has particular *modes of transfer*) being sent to a receiver from a transmitter. Here the 'feedback mode', from the receiver to the transmitter, provides some knowledge of using the transferred technology. This aspect also helps to analyse how the firm may be performing in relation to end customer expectations. Other important aspects emphasised by this framework model that are relevant considerations for technology managers are: how can information flow between transmitters and receivers lead to a degree of understanding between these parties; and is there some degree of coherence and similarity about the message that was intended and was received.

5. Empirical findings from BICC Cables case studies

5.1. General background

The empirical research investigated the *interactive nature* of intra-firm technology transfer via the conceptual framework model. The interactive nature of transfer-

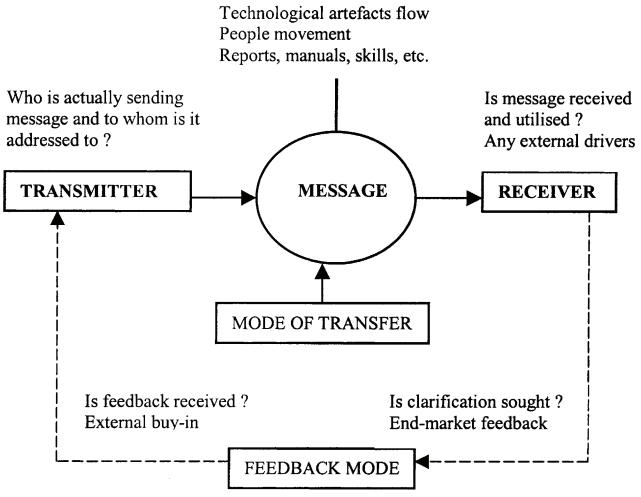

Fig. 1. Introducing a technology transfer broadcasting model.

ring technology from one firm domain to another (e.g. R&D to Production) involves understanding the interrelationships among different processes. These processes can involve an evaluation of certain types of tasks that are used in organisations, as well as analysing how organisations can create the strategies that allow them to quickly adapt to the changing environments.

The empirical research was conducted around two case studies of managing intra-firm technology transfer in 'BICC Cables Ltd' One case study involved the innovation of an IT based package at a corporate R&D centre in Southern England. This corporate R&D centre is referred to as 'Infolab' and the IT package is referred to as 'System X', for the purposes of this paper. 'System X' is a technology that enables BICC Cables to offer customers a quick response to enquiries concerning cable designs and costs, as well as impacting upon the working routines of the cable designers in different parts of the company. The second case study is concerned with the development of an IT hardware/software system that integrates with existing cable production lines and their operational and business level systems. Here the R&D centre responsible for the development and delivery of the technology are referred to as 'EMS', based in the North of England, and the technology package is referred to as 'System Y'. The 'BICC Cables' businesses receiving both technological projects (System X and System Y) are based in the UK, mainland Europe and Australasia.

5.2. Data collection

Many technology transfer projects initiated within 'BICC Cables' have not been generally well documented in the past. Hence in terms of effectively managing the technology transfer process, it was necessary to ascertain how the different levels of the transfer process and different perceptions of the people involved contributed to the success or failure of the projects.

The empirical data was gathered from conducting 12 semi-structured interviews (with senior and junior managers from technical, production and commercial functions) and some information was received from postal questionnaires, archival records and visits to BICC factories. All findings were presented to the BICC staff that had been interviewed, for their feedback comments, as well as to academics in order to ensure an even theoretical relevance.

5.3. Research results

The main research questions were seeking to address such issues as: the exact contents of the technology transferred (i.e. artefact, knowledge, skills); all the actors involved from internal to external people; the method of transfer used (operational data, people transferred, training, prototype demonstrations, etc.); the main barriers to technology transfer; and the relative fortunes of each project (project implementations and marketing opportunities). The major finding from both cases studied yields the following summary of the key intra-firm transfer issues arising (see Tables 1 and 2).

5.4. Mapping common themes

Jones and Jordan (1998) state that many Technologists appear to manage their knowledge on an *individual basis* and this includes tacit knowledge. This can create a situation where companies can become highly vulnerable to losing knowledge as a result of individuals leaving the company altogether. Case study 1 ('System X') confirms this point, where it appears that the loss of staff at the technology transmitter organisation, during the development phase of the project meant that there was some loss of tacit knowledge that resulted in subsequent problems in dealing with the receiver unit sites. This case also shows a lack of willingness to make any personal networks and contacts to work more effectively, especially in the early phase of the project.

As 'BICC Cables' had, by the early 1990s, acquired a number of businesses from other cable producing companies around the world just before the conception of the 'System Y' project, this created problems of integrating the different technological capabilities of the acquired units. After the problems encountered with rolling out this bespoke solution, 'BICC Cables' had more recently started to evaluate the specialised or distinct capabilities of overseas subsidiaries in the aim of developing technological know-how to achieve production excellence. This involves leveraging superior know-how of the subsidiaries across the firm and could be viewed as a 'reliable process competence' (Mascarenhas et al., 1998), involving the transfer of skills across functions and countries, where an operating system is transferred to an acquired organisation.

The 'System X' and 'System Y' projects, as well as other technology transfer experiences, had led 'BICC Cables' to recently develop the notion of internal customers and markets in the R&D arena more strongly than before. Previously, as stated by a technology director, the R&D staff had some difficulties with the notion of viewing other departments as internal customers who must be satisfied. This stemmed from the way the R&D staff perhaps isolated themselves under the umbrella of one centralised R&D function, rather than a more decentralised R&D function. Subsequently this led to the creation of barriers in a range of internal technology transfer projects. Kerssens-Van Drongelen et al. (1996) point to the view that in many R&D organisations, the largest part of the knowledge is stored in the least traceable and accessible medium. This medium is the '*brainware*' (in people's minds, such as experience, intuition,

Table 1
Summary of 'System X' case study findings

Case 1		System X
Technology transmitter	-	'Infolab' (BICC corporate R & D facility), Southern England
Technology receiver	-	'BICC Cables' UK and world-wide based business units with cable designing and manufacturing facilities.
The technology	-	IT Knowledge-based system (hardware and software package) interfacing commercial departments data, manufacturing data and cable design rules.
	-	Enabled Designers to rapidly check availability of different cable design specifications and to modify existing designs on computer screen as well as significantly reducing the enquiry processing times for end customers.
Method of transfer	-	Project meetings and problem-solving tasks.
	-	Some user involvement and limited training.
Key issues arising	-	Lack of regular contact between Software Engineers and Cable Design staff (especially at receiver unit sites).
	-	Transmitter dealt with multiple parameters (wide range of cable designs from site to site).
	-	Disruption caused by changes in project managers and software designers in early phase of project at Infolab.
	-	Sales/marketing input still not fully exploited in this project.
	-	Some cable designers were slow in adopting to new working routines.
	-	System X has potential to make some aspects of the cable design process more interesting.

Table 2
Summary of 'System Y' case study findings

Case 2		System Y
Technology transmitter	-	'EMS' (BICC R & D facility in a Business Unit site), Northern England.
Technology receiver	-	'BICC Cables' UK and world-wide based business units with cable manufacturing facilities.
The technology	-	IT hardware and software based package used to interface with existing production management and business management systems.
	-	Aims to improve the management of production line systems and impacts at machine operator levels.
Method of transfer	-	Installing 'System Y' on site with limited training provided at EMS for some receiver units staff.
	-	Receivers developed new set of skills to acquire this technology on site.
	-	Few project meetings.
Key issues arising	-	'System Y' has integrated with existing IT type systems where the Receiver organisations have had difficulties in changing their routines quickly, with respect to production and business planning tasks.
	-	EMS's highly skilled staff have encountered difficulties in transferring the 'know-how' embedded with the technology.
	-	The differences in the range of existing cable production process plant from site to site acts as a barrier to the transfer of 'common IT systems'.
	-	Some useful impacts at the machine operator level (eg. Colour touch-screen and automatic control features).

a person's educational background), which makes it difficult to deploy the knowledge optimally. More importantly this makes the company very dependent on individual researchers. Hence decisions made in the firm's R&D function and technology strategy more widely, determine the possibilities and barriers to sift, store, open-up, convey, search for, and apply potential knowledge.

6. Presenting an intra-firm technology transfer broadcasting model

The interactive model presented in this paper is not meant to represent a formalised operational type model, but is more of an expanded conceptual framework of the intra-firm technology transfer process. Based on the previously summarised literature, discussions with BICC staff and observations gained in a MNC where the empirical data was gathered, an interactive broadcasting model for technology transfer is developed.

The broadcasting model already introduced in Fig. 1 is now redrawn in Fig. 2, illustrating the main refinements to the model.

It was clear that the *messages broadcast* (technologies transferred) in the two cases studied here were deliberately aimed at pre-selected *receivers*. However the long-term aim of these projects was to 'broadcast signals' to a wider receiver network. Thus BICC Cables had to establish if there is group wide access to these broadcast

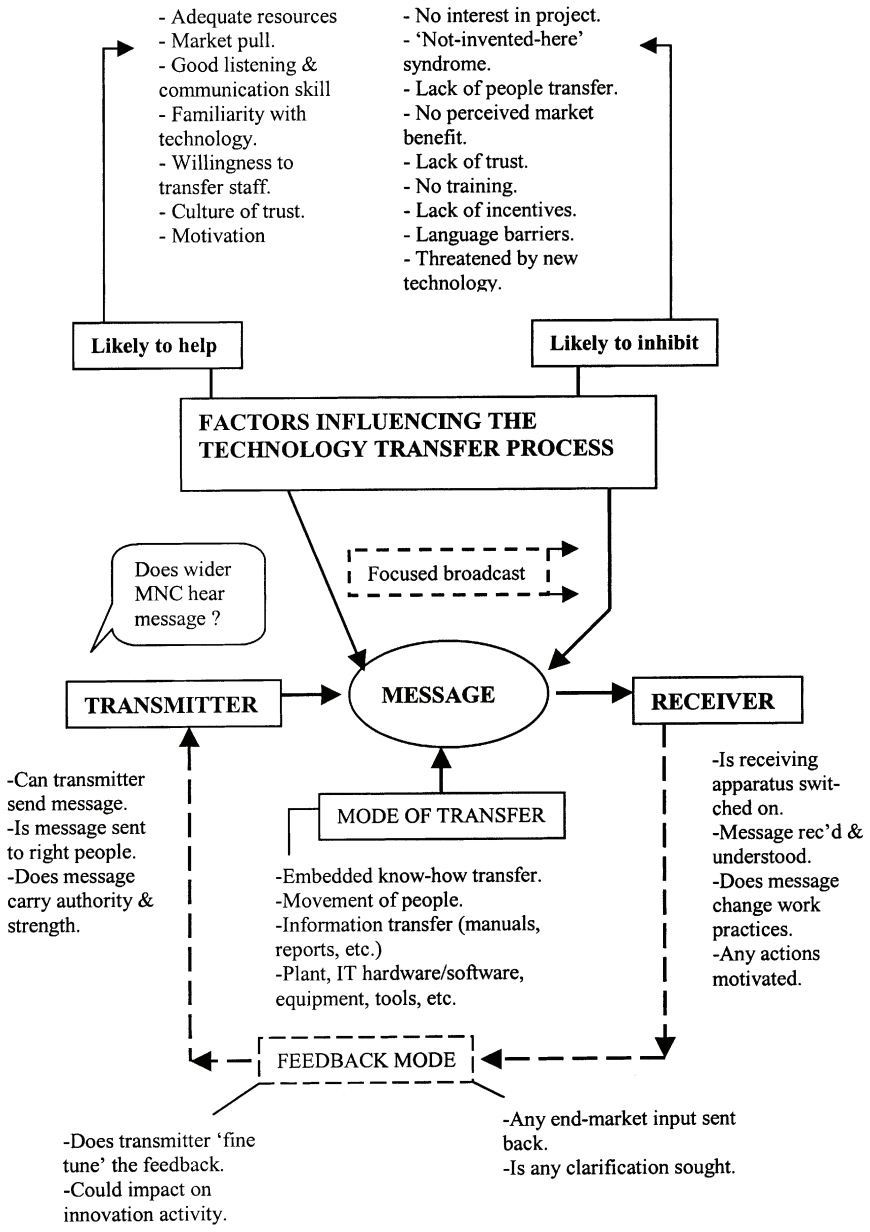

Fig. 2. Interactive 'broadcasting model' for intra-firm technology transfer.

messages. Hence the refined model refers to this aspect on the diagram now. When analysing the impact and relative success of transferring the two technologies studied here, it is useful to think in terms of whether the transmitter can send the message and whether the receiver receives and understands the message. Reference to these statements is shown under both the 'transmitter' and 'receiver' blocks on the diagram. An assessment of a *successful transfer* is thus, referring to whether or not the technology being transferred actually achieved operational status at the 'receiver destination' and if it was incorporated into a manufacturing or business system there.

The iterative nature of the technology transfer process within the firm also raises the question of whether the character of the receiving organisation changes during or after the diffusion of technology to it. Hence different signals may be appropriate at different stages of the technology transfer process. It was clear that some changes in working practices had to be implemented at the receiver sites as a result of both these technology transfer projects. Also the iterative nature of the transfer process extends to any clarification sought by the receiver, or any 'fine tuning' of the *feedback mode* by the transmitter, which is referred to on the diagram. The 'mode of transfer' block in the diagram, shown connected to the 'message' block, also stresses that in addition to people, knowledge and artefact transfers, *embedded know-how*

transfer is an integral component of the message. Know-how, as already stated earlier in the paper, must be learned and acquired. The difficulties associated with embedded know-how transfer here are referring to: knowledge on how to use a technology; what the technology is capable of; the tacit components of knowledge embedded in the technology; and difficulties in interpreting technological codified knowledge.

6.1. Factors influencing the technology transfer process

There are a number of key factors that can influence the technology transfer process within a firm. These factors (as illustrated in Fig. 2) can simply be presented in the form of two branches on the diagram, where one branch illustrates the 'factors likely to help' and the other branch illustrates the 'factors likely to inhibit' technology transfer.

6.2. 'Likely to help' factors

Although not directly evident in the two cases studied here, the 'market pull' factor is always *likely to help* the transfer process. Where there is a strong end customer 'marketing pull', a business unit cannot ignore this pull and is likely to figure out ways to get the 'transmitters' to develop the technology required. Another key factor is 'adequate resources' which links in to the problem of lack of people transfer in the two cases studied here. If there are sufficient human resources available that can be transferred with the technology, this may help overcome a number of the problems outlined in this paper. Thus, the 'willingness to transfer staff' factor links in with the theme of creating a 'culture of trust' between the various organisations involved. Building trust requires the use of mutually understandable, explicit language and often, prolonged socialisation or two-way, face-to-face dialogue (Nonaka and Takeuchi, 1995). 'Learning in sociotechnical systems,[1] including organisational networks, is most efficacious when communication is continuous and enhanced by trust and reciprocity' (Rycroft and Kash, 1999, p. 62).

One factor that is very important in any mode of communication is 'good listening and communication skills', which seems an obvious criteria, but can often be overlooked or not considered to be highly relevant. 'Familiarity with technology', which is a factor that could be linked to prior knowledge, is confirmed as a factor that is *likely to help* in the technology transfer process. For example in the 'System X' case study one positive aspect of this project was that a Technical Manager who previously worked on the project as a technology *receiver*, was now working in the capacity of a technology *transmitter*. So this person's familiarity with the technology ensured that he had a better understanding of the business unit's generic and specific needs and concerns.

6.3. 'Likely to inhibit' factors

Now turning attention to the *factors that are likely to inhibit* the technology transfer process. There are firstly a number of common factors across the 'likely to help' and 'likely to inhibit' branches of the diagram (Fig. 2). These common factors are listed as, 'trust', 'people transfer' and 'market benefits', which have all been outlined earlier. 'No interest in a project' is also mentioned as a barrier to the smooth transfer of technology in the literature. Where there is a lack of interest from a number of individuals, this may confirm that some people *do not actually enjoy* collaborative work with other people. This could manifest into more serious problems later on in a collaborative arrangement and is also linked to the 'not-invented-here' syndrome. This factor refers to people in firms resisting embracing or adopting knowledge associated with a new technological development. Although not directly affecting technology flows, 'threatened by new technology' can be an inhibiting factor, where for example some 'System X' receiving staff may feel threatened by the computer technology that can ultimately affect their jobs.

From the case study findings of the 'System Y' project it was evident that 'language ' can still act as a barrier to the effective transfer of technologies. For instance, the reason why this factor inhibited the transfer was because the *transmitter* did not fully understand the nature of the existing manufacturing capability at the *receiver* site in Portugal. This misunderstanding arose since the existing manufacturing systems, to which 'System Y' would be integrated with, were not as modern or customised as some equivalent facilities in the BICC UK factory sites. What the receiver unit in Portugal required was different to what was actually sent out in terms of technological choices and this mismatch was attributed partly to the language barrier. Both cases highlighted that the language barrier can also extend to specialists speaking different types of *technological language*, when describing or co-ordinating their actions. This can arise due to the nature of the highly specific and localised technological knowledge held in different parts of a MNC. Lack of 'training' provision in both cases showed that this element is linked to the lack of people transfer discussed earlier. For example the Software Engineers working at the transmitter site for the 'System X' project could have provided more on-site training to the receiver unit staff. Thus enabling the 'transmitter' to learn about some of the practical constraints of the 'receiver unit' staff.

[1] The term 'sociotechnical system' refers to the idea that technologies and organisations involved in developing and using them are inseparable, and thus interrelate in a systematic fashion (Rycroft and Kash, 1999).

The issue of 'lack of incentives' to collaborate highlights the need for higher levels of central corporate funding, to facilitate better technology transfer arrangements in MNCs. Increasing the incentives to transfer technologies across the MNC can increase the incentives to innovate by generating new technological and/or marketing opportunities, whilst the capability to innovate may be enhanced through access to new resources and complementary capabilities (James and Barker, 1998). As the 'BICC Cables' business units had in the past predominately invested in R&D projects individually, hence some business units were reluctant to let other business units gain the same benefits as them. Thus this points to the need to be looking beyond the use of formal financial incentives in technology transfer, where people in organisations may be better motivated to share if their expertise and knowledge is used and *acknowledged*.

7. Management implications for practice

In order to effectively connect individuals with different capabilities across geographical and organisational boundaries, management must design procedures to limit the barriers to technology transfer. This can be underpinned through the development of a culture of 'trust' as indicated in the paper earlier. In light of the empirical findings, it is clear that the building of trust requires that colleagues have a *confidence in the ability* of each other to make the right decisions. This confidence in other people's abilities can provide the reassurance about any points of doubts and leads to a willingness to respect the other party's sincerity. Hence *trust* leads to a shared *common understanding*, but is constructed by the actors involved and is context specific. As many technology managers are required to focus on environmental scanning, and longer-term strategic direction, they may overlook some important internal technological capabilities. This implies that they should better assess these capabilities to see what skills are lacking before they begin to look for internal partnerships within the MNC. Thus an evaluation of their organisation's capacity to learn from technology transfer might highlight inadequacies in this area, because staff have not been encouraged or taught to transmit or receive technological knowledge in the past. The 'broadcasting model' presented here illustrates a number of the key factors that should be considered by technology managers when they make these types of evaluations.

'The image of a communication model to describe transfers correctly implies that transfer is not a once-and-for-all, singular event. Rather transfer becomes an iterative arrangement that begins with an understanding of the business unit's markets, opportunities, and needs, and what the potential impacts of certain technologies upon these areas will be' (Ounjian and Carne, 1987, p. 199). Thus technology managers designing procedures to handle and better document technology transfer practices inside firms could use the 'broadcasting model' presented here to help capture more fully and clearly the dynamics, complexity, nature and potential of intra-firm technology transfer arrangements that enable effective management of this activity. As supported by the empirical findings here, the lack of people transfer acts as a serious barrier to technology transfer. An interesting aspect of this problem is that where there is little people to people interaction, one gets more and more out of the 'general (unspecified) technology diffusion range', as mentioned by Jung (1980). Furthermore, Jung (1980) adds that one gets out of the social activities of people around technology centres (when the centres are geographically dispersed well away from the business or manufacturing units), which tend to *disseminate technology without recognising it*.

If the 'broadcasting model' presented here is to work in practice, then one form of actively involving different business units is for management to set up *integrated project teams*. The basic requirement for this type of team is that the transmitter and receiver organisations involved in handling the technology transfer project, are all very sensitive to the different kinds of capabilities that exist in a MNC. This sensitivity issue is referring to the differences in knowledge backgrounds, competencies, language and skills etc. held by different groups in the MNC. As indicated by Galbraith (1990), in his study of 32 different intra-firm manufacturing technology transfers, intellectual resources (particularly the most qualified technical and managerial personnel) are often far less transportable than the relatively mobile plant and equipment in the physical construction of many products. Under these conditions careful attention must always be given to the economics and management of any transfer that involves critical skills and know-how. Hence careful planning and control must be undertaken.

8. Conclusions

The overall aim of this paper was to make a contribution to the identification and description of a conceptual framework that illustrates the interactive nature of technology transfer activities within the firm, involving innovation project case studies. The cases studied in BICC Cables illuminated some of the weak points in technology transfer arrangements, especially in the social-dynamic functioning of R&D and other organisations in firms. As shown here, intra-firm technology transfer is of considerable strategic importance, but its management is often poorly understood. It is important to remember that this paper presents empirical research findings from a single firm (although the study involved

analysing activities in different business units within one MNC) and this limitation means that the 'broadcasting model' developed needs to be further tested with other firms from different industrial sectors. However, given this limitation, the findings are relevant to other firms facing similar challenges. For example, IBM, Boeing, ICI, Pilkington and other large firms are faced with the challenge of managing intra-firm technology transfers between different global business operations where they have dispersed R&D and engineering centres, manufacturing operations and serve different national markets. The conceptual model developed in this paper is one of a few models that has concentrated on intra-firm level technology transfers and should therefore be of some practical use to Technology Managers in a variety of different sectors.

The 'broadcasting model' presented here appears to be an important toolkit for management, especially when analysing the main factors that can influence the technology transfer process. The model is, of course, tentative and has the flexibility to be further developed to meet the individual requirements of different firms. It helps technology managers, in its present form, to serve as a guide and device for *organising thinking* in terms of anticipating any risks involved and how these risks can be handled and minimised. The model also aids managers by capturing the interactive nature of this communication process and identifying who in the organisation speaks to whom, with what authority and how frequently. The findings presented here contribute to a better practical understanding of an important strategic management concern. Important considerations often overlooked in other similar models that are highlighted here include motivation to transfer and the receiving organisation's ability to receive and use a technology. In other words, with respect to 'motivation', what benefits can the technology transfer bring to the actors involved in order to increase their motivation to collaborate? Also can a technology transfer hold the 'attention span' of the receiver organisation in order to help overcome and better anticipate any difficulties that might arise? The paper has taken a critical routine — the technology transfer process — in a critical knowledge intensive arena and fleshed out how it actually works. The conceptual framework presented allows scholars to better understand how this process functions in organisations, and it allows practitioners to focus on those key underlying factors which determine how to successfully implement this process.

In many large organisations there is likely to be a turnover among the project management level staff, especially where long-range projects are concerned. This emphasises the need for companies to better recognise the fluid boundaries that exist between organisations and the actors involved in technology transfer projects. There is also a need identified to better document this key activity so that such documentation can be accessed by other parts of the wider MNC for strategic purposes.

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References

Boden, M., 1991. DTI Evaluation of Technology Transfer Mechanisms: Literature Review on Technology Transfer and Decision-Making Processes in Small and Medium Sized Enterprises. PREST Report, University of Manchester.

Bommer, M.R.W., Janero, R.E., Luper, D.H., 1991. A manufacturing strategy model of international technology transfer. Technological Forecasting and Social Change 39, 377–390.

Cohen, W.M., Levinthal, D.A., 1990. Absorptive capacity: a new perspective on learning and innovation. Administrative Science Quarterly March, 128–152.

Coombs, R., 1996. Core competencies and the strategic management of R and D. In: Belcher, A., Hassard, J., Procter, S.J. (Eds.), R and D Decisions: Strategy, Policy and Innovations. Routledge, London, pp. 25–40.

De Meyer, A., 1991. Tech talk: how managers are stimulating global R and D communication. Sloan Management Review Spring, 49–58.

Galbraith, C.S., 1990. Transferring core manufacturing technologies in high-technology firms. California Management Review Summer, 56–70.

Gilbert, M., Cordey-Hayes, M., 1996. Understanding the process of knowledge transfer to achieve successful technological innovation. Technovation 16 (6), 301–312.

Howells, J., 1996. Tacit knowledge, innovation and technology transfer. Technology Analysis and Strategic Management 8 (2), 91–106.

Jain, R.K., Triandis, H.C., 1997. Management of Research and Development Organisations: Managing the Unmanageable, 2nd ed. Wiley, New York.

James, A.D., Barker, K., 1998. Comparing technology management issues in technology-orientated mergers and acquisitions and joint ventures. Paper presented at the R and D Management Conference 1998: Technology Strategy and Strategic Alliances, Avila, Spain.

Jones, P., Jordan, J., 1998. Knowledge orientations and team effectiveness. International Journal of Technology Management 16 (1-3), 152–161.

Jung, W., 1980. Barriers to technology transfer and their elimination. Journal of Technology Transfer 4 (2), 15–25.

Kerssens-Van Drongelen, I.C., de Weerd-Nederhof, P.C., Olaf, A.M., 1996. Describing the issues of knowledge management in R and D: towards a communication and analysis tool. R and D Management 26 (3), 213–229.

Levin, M., 1997. Technology transfer is organisational development: an investigation into the relationship between technology transfer

and organisational change. International Journal of Technology Management 14 (2-4), 297–308.
Mascarenhas, B., Baveja, A., Mamnoon, J., 1998. Dynamics of core competencies in leading multinational companies. California Management Review 40 (4), 117–132.
Nonaka, I., Takeuchi, H., 1995. The Knowledge Creating Company. Oxford University Press, Oxford.
Ounjian, M.L., Carne, B., 1987. A study of the factors which affect technology transfer in a multilocation multibusiness unit corporation. IEEE Transactions on Engineering Management EM-34 (3), 194–201.
Rycroft, R.W., Kash, D.E., 1999. The Complexity Challenge — Technological Innovation for the 21st Century. Pinter, London.
Shannon, C.E., Weaver, W., 1949. The Mathematical Theory of Communication. University of Illinois Press, Chicago.
Szulanski, G., 1996. Exploring internal stickiness: impediments to the transfer of best practice within the firm. Strategic Management Journal 17, 27–43.
Trott, P., Cordey-Hayes, M., Seaton, R.A.F., 1995. Inward technology transfer as an interactive process. Technovation 15 (1), 25–43.

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