Embedded Firms, Embedded Knowledge: Problems of Collaboration and Knowledge Transfer in Global Cooperative Ventures*

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Abstract

Research on global cooperative ventures has tended to focus on governance forms and task structures. This study highlights the importance of knowledge structures and work systems in influencing the success of collaborative ventures. Based on an empirical analysis of a close collaboration in the knowledge-intensive area between a Japanese and a British high-technology firm, it illustrates how the socially embedded nature of knowledge can impede cross-border collaborative work and knowledge transfer. The research has applied and extended Michael Polanyi’s concept of ‘tacit knowledge’ in a much wider context. It develops a conceptual framework for analyzing the main differences and ‘points of friction’ between the Japanese ‘organizational’ and the British ‘professional’ models of the organization of knowledge in high-level technical work. It shows how the dominant form of knowledge held in organizations, its degree of tacitness, and the way in which it is structured, utilized and transmitted can vary considerably between firms in different societal settings. These differences are shown to have contributed to project failures, weakened the technological relationship between the partner firms over time and led to asymmetry in knowledge transfer.

Descriptors: knowledge transfer, technology and organization, tacit knowledge, cross-cultural management, cooperation, strategic alliances

Introduction

As competition in the global market intensifies and the pace of technological change accelerates, firms increasingly build cooperative ventures in order to sustain and enhance their competitiveness. Particularly in the high-technology industries where a single company rarely has the full range of knowledge or expertise needed for timely and cost-effective product innovation, forging cooperative links with external partners has become a necessary part of firms’ strategies for cost and risk reduction, and more importantly for access to knowledge and capabilities unavailable internally (Teece 1987; Hamel et al. 1989; Kogut 1988; Badaracco 1991; Westney 1988). In addition, because industrial competence is now more widely dispersed geographically (Teece 1992), firms are finding themselves having to build cooperative relationships with partners across national boundaries.
Global cooperative ventures are, however, extremely difficult to manage, prone to instability, and their failure rate has been high (Perlmutter and Heenan 1986; Hergert and Morris 1988). The potential difficulties facing partner firms are even greater in collaborative ventures involving technology transfer and knowledge sharing, such as joint R&D and product development. Much of the existing literature has attributed the difficulties to problems of control, risk and competitive tension endemic in such cooperative relationships and has proposed the need to develop appropriate governance structures for promoting stability, trust and boundary permeability between partner organizations. For example, Killing (1988) analyzes the performance problems of alliances arising from task structure and organizational complexity and suggests that alliances undertaking tasks that require the combination of skills and resources provided by both partners need more complex organizational arrangements. Drawing upon prior work in transaction economics and organizational theory, Osborn and Baughn (1990) argue that the quasi-hierarchical form of governance structure is preferable for international joint R&D because it allows greater control over complex judgemental tasks, and aids the transfer of non-codified technological know-how. In a similar vein, Powell (1987) emphasizes the importance of developing stability mechanisms and managing boundary permeability in reciprocal interdependent cooperative ventures. Although these studies have provided theoretical and practical insights into how the choice of governance forms can influence the effectiveness of cooperative efforts, they have only given a partial analysis of the nature of the problems firms face and have neglected many deeper issues related to knowledge sharing and technology transfer within a global context.

This paper argues that, for firms engaged in collaborative ventures involving intensive knowledge sharing and technology transfer, many of the difficulties encountered cannot easily be resolved through the appropriate design of governance structures. This is because many of the problems lie not in structural barriers but in the nature of knowledge itself and its social embeddedness. Following Polanyi (1962, 1966), Nelson and Winter (1982) argue that a large part of human knowledge is context bound, highly firm-specific and tacit in nature; and that there are limits to which it can be effectively articulated and transferred. Badaracco (1991) uses the term ‘embedded knowledge’ to denote the fact that some of the knowledge being created around the world is not migratory because it is highly embedded in complex social interactions and team relationships within organizations. Unlike migratory knowledge which can be easily encapsulated in formulas, manuals and blueprints, embedded knowledge is extremely ‘sticky’ and it moves only very slowly. Rebentisch and Ferretti (1995) depict organizations as bundles of embodied knowledge which include technology, procedures, organizational structures and hierarchical relationships. Their analysis suggests that an organization’s knowledge architecture has a systematic structure of its own and hence differences in the knowledge architectures between organizations can inhibit knowledge transfer. Taking all these arguments a step further, one would expect the problems of knowl-
edge sharing and transfer within a global context to be amplified because of the greater diversity of knowledge and organizational systems and their socially embedded nature. Given the different ways in which knowledge and skills are formed, organized and utilized in different societal settings, its degree of ‘tacitness’ and ease of transfer can differ. Incompatibility in the knowledge structures and work systems between partner firms can generate many difficulties and conflicts in joint work. The different degree of tacitness of knowledge can also cause asymmetry in knowledge transfer.

Based on an empirical analysis of high-technology collaborative ventures between a British and a Japanese firm, this study illustrates how the socially embedded nature of knowledge and organization systems can impede joint work and the effective transfer of knowledge across national boundaries. The study focuses especially on joint technology development involving intensive knowledge sharing and exchange between the engineers of the partner firms. It examines how the diversity in the organization of knowledge and technical work has caused difficulties in collaborative work and inhibited the formation of integrated work teams. It also illustrates how the different degrees of tacitness of knowledge between the partner firms have caused difficulties in knowledge sharing and have led to an asymmetry in its transfer.

The next section provides a conceptual framework outlining the key concepts and perspectives adopted in the study.

The Socially Embedded Nature of Knowledge and Firms: A Conceptual Framework

There is a large body of research in comparative management which has established persistent, significant national differences in the way work is organized and structured. This argument has been conceptualized as the ‘societal effect’ (Maurice et al. 1980), the ‘neo-contingency framework’ (Sorge 1991), or ‘national business systems’ (Whitley 1990). The main argument is that social institutions influence firms’ strategies and work practices in a systematic way, with the result that firms’ structures and processes reflect distinctive national patterns. Following the basic tenet of this earlier research, this section develops a conceptual model for analyzing different societal approaches to the organization of knowledge.

Conceiving of the firm as a bundle of knowledge and expertise, the model presented here attempts to explain how the nature of knowledge and expertise, its distribution and ownership, and patterns of utilization within the firm are closely interconnected with the way work is organized and coordinated, which in turn is shaped by different societal models of skills formation, labour markets and career systems. It further suggests that the codifiability of knowledge, that is, the extent to which knowledge can be structured into a set of identifiable rules and procedures for communication, and its ease or difficulty of transfer, can vary greatly between organ-
organizations in different societal settings. This approach echoes Boisot’s (1995a) more general analysis of the relationship between the codifiability of knowledge, societal culture and institutions.

The nature and organization of knowledge can vary along three major dimensions. The first is the dominant form of knowledge in use and its degree of ‘tacitness’. The notion of ‘tacit knowledge’ was first expounded by Michael Polanyi (1962). Based on the simple observation, ‘We know more than we can tell’, Polanyi argued that a large part of human knowledge is occupied by knowledge that cannot be articulated — ‘tacit knowledge’. This is particularly true in the case of operational skills or know-how acquired through practical experience and observation rather than formal learning. It is indeed a common situation in our daily lives that a person is able to do something and yet unable to explain how it is done. To put it in Polanyi’s (1962: 49) words, ‘the aim of a skilful performance is achieved by the observance of a set of rules which are not known as such to the person following them’. ‘Not known as such’ here means that the person is unable to give a useful explanation of the rules, and hence the knowledge underlying the skill is ‘tacit’. The type of knowledge in use in different organizations can range from highly tacit to fully articulable knowledge (Winter 1987). As noted by Nelson and Winter (1982: 78), ‘tacitness’ of a skill, or rather of the knowledge underlying the skill, is a matter of degree. An important question, therefore, is what makes ‘tacit knowledge’ a more important part of the knowledge system in some organizations than others. It seems that the approach or method of skills formation and knowledge acquisition plays an important part in determining the dominant form of knowledge held in organizations and its degree of tacitness. For analytical purposes, it is possible to make a distinction between two contrasting societal models of (high-level) skills formation, namely the Japanese ‘organizational’ model versus the British ‘professional’ model.

The organizational model is closely connected with the existence of an internal labour market where skills are mainly formed through firm-specific on-the-job training (OJT) on a long-term basis. Within this approach, the learning principles are similar to those of apprenticeship, where individuals accumulate skills and knowledge through practical hands-on experience or learning by doing. Knowledge accumulated through this process, referred to as ‘knowledge of experience’ by Nonaka (1994), tends to be highly ‘tacit’ and context bound. It is tacit at the individual level because the emphasis on ‘action’ or ‘doing rather than formal theoretical learning means that the individual may only have limited causal understanding of the knowledge underlying the action, and hence is not fully able to articulate it. ‘Knowledge of experience’ is also context bound because such knowledge is accumulated and developed according to the specific requirements of the firm. It is organized around a set of rules and a myriad of relationships which enable the organization to function in a coordinated way. Barley (1996) refers to this as ‘the distributive nature of contextual knowledge’ within a community of practice. In other words, the knowl-
edge-in-use is embedded in specific organizational routines and operating procedures understood and shared by members with common experience and values. Hence much of the knowledge held within the organization is also 'tacit'.

In contrast to the organizational model, the professional model of knowledge formation is commonly associated with the existence of an external labour market, where the acquisition of general and standardized knowledge applicable to different contexts is important. The main method of skills formation is through formal education and training in learning institutions, leading to a certified qualification. Knowledge acquired through formal training, referred to as 'knowledge of rationality' by Nonaka (1994), tends to be more abstract and theoretical. It is also more standardized and tends to develop in line with the 'best practice' of the profession, rather than the specific requirements of the firm. Unlike 'knowledge of experience', which is quite specific to particular contexts and rarely formulated in a logical consistent way, formal theoretical knowledge is generic, highly rationalized, and internally coherent (Whitley 1995: 85). It is also context free in the sense that it can be used in different situations and purports to apply to a wide array of phenomena. Unlike tacit knowledge which cannot be easily severed from its prevailing context, this type of formal knowledge is more explicit and discrete and thus characterized by its relative ease of transfer.

A second dimension along which the organization of knowledge can differ concerns its structure, that is, how knowledge and skills are distributed and utilized within the firm. This is closely related to the way work is organized and coordinated. The structure of knowledge can vary from one that is highly diffused and group-based, to one that is task specific and individual-based. The contrasts between the organizational and professional models are striking here. The organizational model emphasizes the flexible and fluid utilization of skills and knowledge. Within this approach, job boundaries tend to be broad and ambiguous. Individuals undertake a wide range of jobs and duties through job rotation; a good example is the rotation of R & D engineers to work on the production floor to broaden skill development and encourage knowledge transfer. Job rotation gives individuals the opportunity to develop a broad range of skills and knowledge outside their own specific functions and expertise, and encourages the development of contextual and integrative problem-solving skills (Aoki 1988). It also facilitates group learning and collective sharing of knowledge and helps to reduce the social distance between different categories of the workforce. As a result, the knowledge structure becomes very diffuse and there is a considerable overlap and transmission of knowledge across individuals and jobs. The professional model of work organization is, however, quite different. It emphasizes individual specialization and job differentiation. The key principle for organizing work is to make best use of any particular talents or expertise in specific areas. Within this approach, job boundaries are clearly delineated and each individual follows a narrow and specialized job path throughout their career. This approach encourages
the development of deep and specialized knowledge at the individual level, but the scope of knowledge and experience tends to be rather limited and specific to the task performed. As a result, there is much less overlap of knowledge across individuals or job boundaries, making it more difficult to achieve cross-functional integration. For example, engineers specializing in upstream conceptual design may not be able to appreciate the relevance of downstream operational knowledge to their specific tasks. The professional model generates a knowledge structure that is highly individual-based and task-specific.

This takes us to a third, related dimension of variation: the method of coordination and knowledge transmission. The diffuse and overlapping nature of knowledge within the organizational model means that the knowledge and expertise required for task performance are not 'owned' by any specific individuals, but is 'embedded' in groups and teams. Knowledge is utilized and transmitted through intensive and extensive interaction between group members. Coordination is achieved through mutual adaptation among members with common knowledge and shared implicit 'coding schemes' accumulated through group interactions. Knowledge is generated and stored 'organically' in team relationships and the mode of coordination is human-network based. This type of knowledge is not amenable to systematic codification and can only be accessed and transferred through intimate social interactions (Kogut and Zander 1992: 389). In contrast, the professional model encourages individual specialization and ownership of knowledge. Knowledge is stored independently in the individual 'experts' within specific functional groups. The clear demarcation of job boundaries makes it difficult for the different functional groups to accumulate common experience and develop shared codes. Hence, systematic codification of individual knowledge into an explicit form is essential for coordination and communication. Moreover, within the professional model, the concentration of knowledge in individual experts puts the firm in a highly vulnerable situation when individuals leave. It becomes necessary for the firm to develop systems for abstracting knowledge from the individuals and storing it in written procedures and documents so as to retain it and make it accessible to a wider circle of individuals (Bonora and Revang 1993). This form of knowledge storage can be described as 'mechanistic' and the dominant mode of coordination and knowledge transmission is document-based. Knowledge stored in codified form is more transparent and readily accessible. It is inherently more diffusable than uncodified knowledge (Boisot 1995b).

The above has provided a conceptual framework illustrating how the structure of knowledge and its degree of tacitness can differ between organizations in different societal settings. The rest of the paper provides empirical evidence to illustrate the contrasts between the Japanese organizational and the British professional models of organization of knowledge in high-level technical work. It gives an analysis of the operational problems and difficulties generated by the incompatibility between the two systems. It also examines the effects of these differences on collaborative work and dis-
cusses the extent to which the differing degree of tacitness of knowledge might lead to asymmetry in knowledge transfer. Before proceeding to the empirical analysis, a brief outline is given of the background of the study and the research method used.

A Japanese–British Technological Partnership: Background and Significance of the Study

The case examined in this study is an example of a technological partnership in a knowledge-intensive industry. The Japanese and British partner firms are both global competitors in the electronics industries. The Japanese firm (hereafter referred to as J-firm) acquired a majority stake in the British firm (hereafter referred to as B-firm) about five years ago. However, the relationship between the two companies is not one of a successful organization taking over the ‘unsuccessful’. It is more of a horizontal collaborative relationship: both companies have been major international competitors and there is a high degree of mutual respect between them. Prior to the acquisition, the two companies already had a strong trading relationship and a technology-sharing agreement in operation. Like most Japanese acquisitions abroad, J-firm’s acquisition of B-firm was strategically rather than financially motivated (Kester 1991). The key motive was to sustain the collaborative relationship: it was prompted by a need to defend a vital strategic alliance forged over the years in the face of an impending takeover of B-firm by a third company. Although the acquisition has brought about a greater degree of mutual interdependence between the two firms and broadened the scope of their collaboration, it has not led to the integration of B-firm into the management structure of J-firm. This is partly due to a strategic need to preserve the unique capability and resources of B-firm and partly because of political sensitivity. Prior to the acquisition, there was an implicit agreement that B-firm would be run and managed as a European company with a high degree of autonomy. The relationship between the two can be characterized as collaborative rather than integrative. The collaboration is driven by a strong technological as well as strategic logic: there is an expectation that it would enable the two firms to take advantage of the complementarity of each other’s knowledge and expertise to achieve synergistic benefits and raise their competitiveness in the global market. It is characterized by a strong desire for knowledge sharing and knowledge creation: a strategic partnering described as ‘knowledge links’ by Badaracco (1991). The successful collaboration thus depends on their ability to develop an organizational infrastructure and working relationship to forge the ‘knowledge links’. It hinges on the effective management of joint product development and mutual exchange and transfer of knowledge and expertise. This, according to Rebentisch and Ferreti (1995), calls for a certain degree of ‘fit’ or ‘compatibility’ between the knowledge and work systems of the partner firms. However, my previous research in British and Japanese electronics indus-
tries highlights very different approaches to the organization of knowledge and technical work between the two countries in this sector (Lam 1994, 1996), many features of which can also be found in the two firms in the present case study. For example, Japanese electronics firms put strong emphasis on using multi-functional project teams with a high degree of cross-functional knowledge integration in product development. This approach requires flexible division of labour and knowledge flow across functions, in particular, between R&D and manufacturing. The Japanese integrated approach contrasts sharply with the 'sequential' approach commonly found in the British electronics firms where the product development process is organized along the principle of clear division of labour and functional specialization. Within this approach, the different phases of product cycle are relatively independent and distinct from each other, and the degree of knowledge integration is weak. These differences are deeply embedded in the divergent skills, work roles, and careers of engineers. The Japanese model of engineering skills formation, being primarily organizational-based, emphasizes the mastery of a wide-range of knowledge and skills through a slow process of structured job rotation and on-the-job learning. It stresses overlapping division of labour, with much essential knowledge and expertise residing in work groups and team relationships rather than the individuals. In contrast, the British system stresses professional specialization, clear delineation of job boundaries and individual acquisition and ownership of specialist expertise. These differences cannot be easily reconciled as they are closely embedded in the divergent skill formation systems, labour market structures and technological heritage of the two societies (Lee and Smith 1992; Meiksins and Smith 1993).

Given the above contrasts, two questions are raised in this study: (1) How can the two firms effectively coordinate and manage joint technological development? What operational difficulties and problems might be encountered? (2) To what extent does the incompatibility between the knowledge and work systems of the two firms inhibit effective knowledge sharing and transfer?

The data were collected primarily by in-depth individual interviews with about 50 staff, both in Japan and Britain. The majority of them were engineers and project managers directly engaged in joint technology development projects and exchange programmes between the two firms. Interviews have also been conducted with top management in both firms. About 20 interviews were first carried out in 1992 and further interviews with another 30 staff were carried out between 1994 and 1995. Some of the key staff were interviewed twice over the period. This has enabled the researcher to track the development of the collaborative relationship over time. The interviews were conducted in Japanese and English, each interview lasting for about 90 minutes to 2 hours, and all were transcribed. The interview sample is shown in Table 1.
Table 1
The Interview Sample

<table>
<thead>
<tr>
<th>Categories</th>
<th>J-firm</th>
<th>B-firm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Engineers and managers directly engaged in collaborative work</td>
<td>13</td>
<td>13</td>
</tr>
<tr>
<td>Staff on exchange programmes (mostly engineers)</td>
<td>10</td>
<td>5</td>
</tr>
<tr>
<td>Coordinating managers from Japanese parent based in B-firm (all)</td>
<td>3</td>
<td>-</td>
</tr>
<tr>
<td>Top management and senior personnel staff</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>Total</td>
<td>29</td>
<td>21</td>
</tr>
</tbody>
</table>

Contrasting Forms of Organization of Knowledge and Technical Work: Empirical Evidence

The interviews identify major differences between the knowledge and work systems of the two partner firms along the three dimensions discussed above. These differences are most vividly reflected in the ‘points of friction’ in their joint work. It should be noted that many of the divergent characteristics are not unique to the case study firms but reflect general differences in the organization of knowledge and technical work commonly found between electronics firms in the two countries (Lam 1994, 1996).

Differences in the Knowledge Base of Engineers: ‘Knowledge of Rationality’ vs. ‘Knowledge of Experience’

It is commonly assumed that the knowledge base and competence criteria of engineers are universal. However, evidence from the study shows that the dominant form of knowledge on which engineers’ skills and expertise are based, and its degree of tacitness, vary significantly between B-firm and J-firm.

Although both partner firms in the study employ predominantly graduate engineers in design and development work, their approaches to work differ greatly. Overall, the engineers in B-firm base their specialist expertise primarily on abstract theoretical knowledge acquired through formal training. In contrast, their Japanese counterparts rely heavily on practical know-how and problem-solving techniques accumulated in their workplace. These differences are clearly manifested in the way they carry out product development. While B-firm engineers adopt a logical and consistent approach based on clearly defined procedures and rational planning, J-firm engineers tend to emphasize action and experimentation using their judgemental skills and operational know-how. Such differences often lead to mutual criticisms and frustrations among the interfacing engineers. For example, many B-firm engineers simply could not see the logic of the Japanese approach; many described the lack of rigorous planning among the J-firm engineers as a ‘scatter-brain effect’.
'You’ve got two ways of doing something. You are either very much more rigorous about the way you design it and try to ensure you do it right, or you just have a scatter-brain effect and just hope something will work. This is the way I see J-firm. . . A lot of people do lots of little things and its like waiting for revolution.'

A number of B-firm engineers seconded to work in J-firm made the remark that ‘there was a lot of make do work’ in J-firm. Others commented that J-firm young engineers were ‘almost like apprentices’ because they did not seem to engage in much logic design.

J-firm engineers, in contrast, were frustrated by the lack of practical know-how and concrete detailed knowledge among their British partners:

'They can read the specifications but I am not sure they have the ability to make the product. I think we have far more technical capacity — we’ve got the know-how. On this project, we have to supply them with a lot of our know-how but it’s really difficult. There’s so much of it which simply cannot be captured only by reading the documents . . .'

Another project manager in J-firm, engaged in a major collaborative project, made the following observation:

'These people are supposed to be engineers, but the way they approach their design is somewhat . . . I mean its quite different from the way we do things here. They are not concerned about the details. The design itself is quite logical but the actual movements of the circuits — there’s still so much verification work to be done, for example, the noise generated by this machine — you need to have the know-how acquired through practical experience to deal with it. I don’t think they have the experience . . . At the end of the day, we are the ones who’ve got the know-how to come up with a design that can be turned into a real product. Theirs is no more than a piece of abstract theoretical design . . .'

The contrast between the knowledge base of these two groups of engineers is partly a result of the different engineering qualification system in the two countries, and partly a reflection of the different skills formation and utilization practices in the workplace. In Britain, the route to engineering skills formation shifted dramatically during the 1960s from the traditional part-time and evening work-based study towards an emphasis on formal university education (Finniston 1980). This trend has been reinforced by the attempt of the professional institutions to raise the occupational status of engineers by restricting full professional membership status to graduate engineers. The exclusiveness of membership has meant that the acquisition of formal academic knowledge through university education has come to occupy a central place in the engineering qualification system in Britain. This has led to a general perception, among the graduate engineers, of the superiority of theoretical knowledge to practical experience, and is closely associated with the delineation of job boundaries between engineers and technicians in the workplace. Further, in most British universities, the engineering degree courses emphasize early specialization and are mainly devoted to engineering science. Students typically reach the graduation stage with a knowledge of engineering science and of analytical tools, but
they usually have little experience and practical engineering skills (Finniston 1980). Firms often recruit these graduates straight into highly specialized work roles, utilizing their general theoretical knowledge and analytical ability in upstream conceptual design functions. Also, because of the high job-mobility rate among the graduate engineers, most employers neither have the incentive to provide them with practical on-the-job training nor the opportunities for expanding their scope of experience (Causer and Jones 1993; Lam 1994). As a result, the knowledge base of the majority of British engineers tends to be highly theoretical and specialized, and their work role is limited primarily to upstream conceptual design and development activities.

In Japan, the approach to engineering skills formation is quite different. It has historically placed a high value on the importance of developing the practical skills of engineers in the workplace. This is due, in part, to the fact that industrial development in Japan was historically based on imported technology, and Japanese engineers have played an important role in translating imported theoretical knowledge into concrete operational details for shop-floor workers (Morikawa 1991). Thus, Japanese firms have always placed a strong emphasis on developing the on-site practical knowledge of their graduate engineers in order to facilitate technology transfer. This, coupled with the long-term nature of the employment relationship, means that skills formation in the workplace rather than university education is the most important source of engineering skills in Japan. The university degree in Japan is far more general and broad-based than that in Britain. It seeks to develop the basic analytical and conceptual aspects of engineering upon which firms build technology-specific knowledge and skills (Chung 1986). Unlike in Britain where employers seek ‘to buy’ readily available specialized expertise from the external market, Japanese employers prefer ‘to make’ their own technical staff through intensive and extensive on-the-job training (Lam 1993). Young graduate engineers are not expected to be immediately useful. They normally spend their initial years in a wide range of peripheral technical tasks and gradually accumulate their knowledge and expertise through allocation to a wider range of more complex tasks. The key method of skills formation is through learning by doing and working together with the more experienced staff. The type of knowledge transmitted through this method tends to be judgemental, diffuse and not formulated in a strictly logical consistent way. It is more informal and tacit. It concerns primarily recipes for action or concrete problem-solving techniques rather than logical thinking or internal theoretical consistency. Hence the ‘scatter-brain effect’ perceived by the British engineers.

Contrasting Knowledge Structures and Organization of Product Development: Task-Specific Sequential Structure vs. Diffuse-Overlapping Structure

The contrasting methods of skills formation and utilization practices are also underpinned by the patterns of division of labour and the distribution
and integration of knowledge in the work systems of the partner firms. These differences are most vividly reflected in the way the two firms organize product development and manage the flow and integration of knowledge across the different phases of the product cycle.

In B-firm, product development is organized on a sequential and hierarchical basis. It is characterized by a high degree of role specialization and functional differentiation with separate groups responsible for different stages of the product cycle. Staff responsible for upstream product planning and concept creation are separated from those carrying out development. These people are clearly delineated, in turn, from those engaged in downstream process engineering and production. Projects go through several stages in a logical step-by-step manner, moving sequentially from one stage to the next after all the requirements of the previous stage have been completed. The knowledge and expertise required for each stage is discrete and self-contained. Product development is led, and driven, by a small group of ‘talented’ technical experts. These people are primarily responsible for the generation of new product concepts which will then be taken forward and broken down into concrete details for development and production by separate functional groups further down the line. Within this approach, the flow of knowledge tends to be unilateral and hierarchical. There is a concentration of knowledge and information in a small group of experts at the top of the work hierarchy.

The approach adopted by J-firm differs significantly. It can be described as ‘integrated’ or ‘overlapping’. It is characterized by tight horizontal linkages, flexible division of labour and by a reciprocal flow of knowledge and information across functional boundaries and different phases of the product cycle. In J-firm, responsibility for product planning lies in the hands of the product development groups rather than specialist product planners, and the boundary line between planning and development is blurred. In particular, J-firm puts a strong emphasis on forging a close link between the upstream concept design and downstream process engineering and manufacturing. Product development in J-firm is typically undertaken by a multi-functional project team comprising members of diverse backgrounds, including planning, design and development, testing, quality assurance and production. The essence of this approach is to draw on the knowledge and experience accumulated in all phases of the cycle. The flow of knowledge is bilateral and continues throughout the whole development process. Product development in J-firm is characterized by a diffuse and decentralized knowledge structure. It is driven by knowledge generated continuously through cooperation and interaction among the diverse team members.

The above contrasts are clearly visible in the work roles and responsibilities expected of individual engineers. B-firm’s sequential approach operates on the basis of clear delineation of task responsibilities and individual contribution. It encourages the accumulation and ownership of deep and specialized knowledge at the individual level. In contrast, the overlapping approach in J-firm requires shared division of labour, mutual intrusion of
job territories and collective learning. Several B-firm engineers seconded to work in J-firm complained about 'not being left alone to do [their] own thing'. Some were frequently frustrated by 'not knowing whereabouts in the process [their] responsibility ends...'. Others felt extremely uncomfortable about the 'intrusion' of Japanese colleagues into their job territories:

'In our company, if you have a plan, if it is worth doing, you write it down, you have a meeting, you decide on it and then you do it and then you'd have periodic reviews and if it turns out to be a waste of time it gets scrapped. It was always proprietary, your own work, no-one else's, you're not competing. Where we are now [in J-firm] it's all... someone else has got to see my product. It's like 'oh let's see, I thought that's quicker than this one...'.

In contrast, J-firm engineers working in B-firm often found it difficult to operate effectively because of 'not knowing how my tasks fit into the whole'.

The differences between the two approaches are also reflected in the size and composition of the project teams dispatched by the partner firms to work on joint projects. While the teams from B-firm tend to be much smaller, comprising a few specialist product planners and engineers who, to put it in their own words, 'are primarily responsible for developing the front end of product specifications and requirements'; J-firm often sends a large team of diverse members including staff in development, design, manufacture, and validation. The team from B-firm are often overwhelmed by the size and diverse backgrounds of the members from J-firm with whom they have to deal. The following remarks by the project managers and engineers from B-firm are revealing:

'They have much larger teams than we do for doing an equivalent kind of work. For instance, we might have a group of five people and they would have a group of 15 people doing almost the same work...'.

'...for the project that X was managing there was I think maybe 12 people, average, working on this project in England over the three years. And then for a similar type of project in Japan, J-firm had many more people. Just the project that was about a quarter the size of our project was this team of 20...'

'...the Japanese tend to get everybody involved. For example, obviously this project involved a lot of their different groups, like their DA group and the liability groups, and technology groups, and circuit groups, etc. — lots of different bits. And before they commit to anything, all the groups have to be involved. Whereas we tend to make the decision, then go back and sort it out later with all the different groups... It's very frustrating and we don't know how to cope with the long discussion that goes on...'.

The different project team composition also reflects the level of influence exercised by the different functional groups and the type of knowledge that is valued and perceived as relevant. In B-firm, a sharp distinction is drawn between upstream concept design ('thinking') and downstream production ('doing'). The engineers who specialise in upstream 'thinking' activities,
who take the lead in product development, tend not to perceive downstream 'doing' knowledge as directly relevant to their work. In contrast, in J-firm, the boundary between 'thinking' and 'doing' is blurred. It emphasizes the tight integration of upstream and downstream engineering activities and the early involvement of downstream staff in product development. It is a common practice for J-firm to include quality and manufacturing staff in their product development teams. Indeed, the manufacturing function in J-firm has a high profile and strong influence in product development. However, on a number of joint project-planning meetings, the team from B-firm who saw their main roles in upstream concept design, felt reluctant to deal with the quality and manufacturing staff from J-firm. This has generated a great deal of ill-feeling among J-firm's team members. A J-firm project manager commented on the problem:

"... they see manufacturing as a completely separate process, this is their way of thinking. But for us and indeed most Japanese companies, manufacturing and development are closely tied up with each other and we cannot draw a clear line between the two. In actual fact, our organizational structure is set up like this. They were unhappy to see our engineering staff from manufacturing attending the meeting... The way they treated our members from manufacturing was problematic."

The different degree of integration of downstream operational knowledge in product development has also meant that different priorities and criteria are taken into account by the partner teams. Whereas the team in B-firm is often concerned about general business criteria such as cost and markets, the team in J-firm tend to take into account specific technical criteria such as product functionality, quality and manufacturing feasibility. These differences have frequently led to mismatched expectations and conflicts in many of the joint projects.

Methods of Coordination and Knowledge Transmission in Product Development: Document-based vs Human-network-based

The contrasting knowledge structures and organization of product development have also led the two firms to adopt different methods of coordination and knowledge transmission throughout the product cycle. Within B-firm, product development moves sequentially through the different phases. Each stage is governed by rigorous formal planning and scheduling. The knowledge and information required for each stage is discrete and resides independently in the individuals within the specific functions. Coordination across the functions is achieved via passing on detailed documents and full specifications from one phase of the project to the next. The smooth operation of this system requires systematic codification and structuring of knowledge into a form that can be easily communicated and transmitted across the individuals and functional groups. Knowledge residing in the individuals within specific functions will have to be 'externalized' and translated into procedures, guidelines or specifications for transmission to other members of the organization. Tacit knowledge, as far
as possible, will have to be codified and made explicit so that it can be easily understood and accessed by those who do not share a common experience or background. In other words, relevant knowledge is extracted from the individuals and groups and stored within the organization in written procedures and documents.

In contrast, the overlapping approach in J-firm is highly dependent on intensive human-network-based communication and knowledge sharing. Project coordination is achieved via frequent reciprocal communication and mutual adjustment. It is less dependent on formal planning and rigorous review at each stage, but requires project team members to engage in intensive communication and interaction throughout the product development cycle. Within this approach, knowledge required for overall project achievement is stored 'organically' in team relationships and behavioural routines. It is coordinated and transmitted through intensive human interaction and extensive networking throughout the organization. The observation made by a B-firm engineer, that '[in J-firm] there's nobody who is an expert ... it's a case of who knows what', sums up well the diffuse nature of knowledge in J-firm. Further, in J-firm, the overlapping work roles and sharing of common experience helps to reduce the social distance between project members, enabling them to develop a 'common code' which facilitates the rapid transfer of tacit knowledge. This human-network form of knowledge transmission makes the system less dependent on detailed documentation and written procedures.

B-firm engineers who are used to operating in a document-based environment felt helpless when confronted with the situation in J-firm, where written procedures do not seem to exist:

'In the West there is more of this tendency to turn around jobs so we've invented quality procedures, quality manuals, process manuals so that somebody coming in at a medium management or engineer level can very quickly get into the way things are done. Here's a manual, here's the procedures, here are the forms. In J-firm, we join at a medium level, but we don't have any of that early background and there are no manuals to help us ...'

In B-firm, design knowledge generated by the upstream staff is transmitted in detailed and 'complete' specifications and blueprints. However, in J-firm, design specifications tend to remain flexible until the final phase; it is open to mutual adjustment and modification throughout the project cycle. As a J-firm engineer put it:

'Our designers do not normally insist on their own ideas. The specification is normally never 100 percent. I would say it's only about 50 or 60 percent. The remaining bit is open to discussion and adjustment later on among the various members ...'

Such mutual adjustment and human-network coordination is viable within a system where project members share common knowledge and mutual tacit understanding based on common corporate experience. These attributes are sustained by the practice of long-term stable employment which ensures that shared knowledge is retained within the firm. For many of the B-firm engineers, who do not share such common site-specific knowledge,
and are used to working according to precise written documents, the ‘flexible’ specifications seem ambiguous and misleading. The following remark by a B-firm engineer illustrates the problem:

'It [the specification] would be ambiguous quite a lot of times and that could actually be quite misleading. So I think a lot of the people in my group would tend to work things out for themselves rather than asking questions, because it didn't always come back very clear.'

From the other side, a project manager in J-firm also commented on the difficulties they encountered in articulating their ideas to their foreign partners:

'We need to find a way to improve our communication with our partners in B-firm. Having worked together, it made me realise that part of the problem is that our engineers are not really good at producing documents. Our design and development are all done with great accuracy but we find it difficult to explain clearly "what we are trying to do at this stage" and "how and why the design is done this way but not the other way". Unlike communicating to other departments, we find it difficult to express ourselves clearly to our partners overseas. This has caused them "indigestion".'

The contrasting modes of coordination and knowledge transmission highlight the effects of the different degree of tacitness of knowledge applied by the engineers in the two firms. They also reinforce the different capacity of the two organizations in codifying and articulating the knowledge generated. Knowledge transmitted through human networks is clearly context bound, less encodable and not immediately transparent to outsiders. In contrast, document-based knowledge is much more discrete, explicit and readily transferrable.

Effects on Collaboration of Contrasting Knowledge Structures and Organization of Technical Work

The differences in the organization of knowledge and work in different societal settings are of more than just theoretical interest. They can impede global collaboration. The evidence of this study shows that the incompatibility between the British professional and the Japanese organizational models of knowledge structure has not only persistently generated tensions and conflicts in the joint work between the two firms, but, more seriously, has resulted in project failures. It has also weakened the technological relationship over time and caused the adoption of a second best, ‘arm’s length’ approach to collaboration. There is also evidence that the differing degrees of ‘tacitness’ of knowledge between the two firms have brought about asymmetry in knowledge transfer.

Poor Project Performance and Failures

The interviews with project managers and engineers engaged in collaborative work show that the majority of the joint projects between the two firms have either progressed much slower than expected, been terminated half
way through, or resulted in failure. Although project performance tends to be influenced by a complex array of factors, there is substantial evidence from the study that the differences in the organization of knowledge and work between the partner firms have been a major cause of poor project performance. Many of the managers and engineers interviewed repeatedly pointed to problems of poor communication, misinterpretation of specifications and the clash between their approaches to product development as major causes of poor performance in their joint work.

One particularly telling example involves a joint project in which B-firm was contracted to design a product for the Japanese market based on the technology and product specifications supplied by J-firm. The project failed because B-firm was unable to deliver the final product despite having to remake some of the parts four times. The project manager in charge of the project in B-firm admitted that the mistakes were due to, to it put in his own words: ‘misunderstanding of specifications, misunderstanding what we were told in conversations, misunderstanding what we thought were technical agreements and so on’.

This particular case well illustrates how differences in the organization of knowledge and work between firms can inhibit knowledge transfer and obstruct collaborative work. To start with, the product specification supplied by J-firm was built on the assumption of an overlapping approach to product development. It was based on an expectation that the original design concept generated upstream would be subject to changes and modifications with the aid of downstream on-site knowledge as the project progressed. Hence, in many respects, the specification produced by J-firm was a flexible and ‘incomplete’ document allowing plenty of scope for adjustment and mutual adaptation throughout the product cycle. It was not a fixed blueprint containing ‘finalized’ knowledge. As a J-firm engineer put it:

‘... the specification does not cover everything. It’s not meant to be 100 percent. I would say it probably covers only about 50 to 60 percent of the design details. What normally happens is that we validate the quality of the design as we go along, various aspects of it can be changed under different circumstances.

The design team in B-firm who were used to a sequential and logical design approach based on completed specifications at the outset, however, found the specification from J-firm ambiguous and misleading. The project manager in B-firm, quoted above, commented on the problems they faced:

‘I think the difficulty is that the base specification — when we read them, we found them ambiguous in many senses. They are not like B-firm specifications. So what we did, we sought clarification from J-firm and we got a lot of clarification, but, we still made mistakes.’

Other project-team members complained that J-firm built assumptions into their specifications. One reported:

‘I think they build in assumptions. Because, as I said, we’ve had difficulty in understanding specification and we had a review with higher management recently on this
project — I feel they tend not to put themselves in our place and see the difficulties that we were faced with.'

The difficulties were further compounded by the fact that J-firm engineers, who have traditionally adopted a 'learning-by-doing' and experimentation approach to product development (referred to as 'low-level design'), were unable to articulate their ideas in a logical, consistent form, readily understood by B-firm engineers who were used to operating under what they described as a 'high level' design language. A J-firm engineer explained the difficulties encountered:

'Part of the problem is the differences in our design culture. They [B-firm] tend to start with "high-level" abstract design: creating a model on the computer to validate the function and this behavioural model is described theoretically in a specific language. Whereas in our company, in order to speed up the development process, we skip the abstract design stage and proceed straight to gate-level design. We put the whole thing together first and then do the validation... We do not have the so-called "high level" design language for describing the technology which we use.'

To sum up, J-firm's interactive way of working is highly dependent on collective knowledge sharing between upstream and downstream staff. Product development in J-firm is not led and 'pushed' by a priori design knowledge but is 'pulled' along by emergent on-site operational knowledge generated through learning-by-doing and intensive interaction among project-team members. This approach tends to create a great deal of 'tacit' knowledge which is not amenable to codification. It can only be effectively transmitted among members with common knowledge and shared 'coding schemes'. Insofar as the knowledge structures and coding schemes between the two firms differ, the transfer of such tacit knowledge has proved to be highly problematic.

'Diluted Technological Partnership': Arm's Length 'Interface Collaboration'

The poor performance of a number of major collaborative projects and the difficulties in reconciling the two contrasting systems have inhibited the two firms from developing a close technological partnership, despite growing market pressures for greater collaboration. Evidence from the interviews at two different points in time (1992 and 1995) suggests that the technological relationship has weakened rather than strengthened over time. Indeed, there have been very few genuine joint product development projects engaging mixed teams of engineers in common activities. The main method of working together has been that of an arm's length 'interface collaboration'. This typically involves a clear division of labour across the two partner firms. In other words, the partners each work independently on one part of the project and join forces at the end to link the separate development efforts into a final product. Most of the more recent collaborative work has been merely adaptive, such as modifying a product or process developed by one of the partner firms to suit local market requirements.
Overall coordination between the two partner teams takes place via a small number of interface managers or engineers at the senior level, who occasionally meet to exchange information and make critical decisions. Although top management in both companies felt that they could potentially have benefitted from forging a closer relationship by engaging in genuine joint development work, the operational difficulties encountered have thus far prevented them from doing so. The following remark by a senior executive from J-firm illustrates the point:

'As far as possible, we would rather not work too closely together. Our ways of working are very different, problems are bound to occur if we have joint project teams pursuing common activities. Yes, we have joint development projects but the way we do it is to divide up the work into separate parts, each with its own clearly defined objectives. We discuss how the whole project is to be carved up beforehand, and after that, each team is free to pursue its own project in its own way... In fact, some time ago, there was a proposal for setting up a joint team but that was quickly rejected by the top management because they simply did not believe it would work...'.

The above sentiment was echoed by a manager in B-firm:

'I think there's been one or two attempts to start off joint R & D projects, but it's very difficult... I think we could gain a lot by actually doing some genuine joint development projects, but I think it's going to be quite difficult to get to that stage. I think there's got to be a change in the way in which B-firm is managed... And I think it needs a change of culture almost.'

Although interface collaboration is the main method of joint work at present, it is potentially unstable and has many limitations. It confines the flow of information and coordination to a small number of interface points at the senior level in both firms, but, in practice, the span of issues involved in complex technological work tends to defy such few contact points. As one B-firm engineer put it: 'Development is very difficult and there are lots and lots of interfaces and lots and lots of things can go wrong'. This arm's length method of collaboration not only makes joint work difficult for the operating engineers, it also severely restricts the scope of technical collaboration between the two firms. Many project managers and engineers interviewed pointed out that this approach only works for certain types of development projects 'where things can be done in isolation'. For more complex technological work, carving up the project between two separate teams can be extremely inefficient and create many technical problems.

It appears that the management in both firms are well aware of the limitations of the current arm's length method of collaboration. However, they have been persistently frustrated by the difficulties in reconciling the two different systems and the lack of a better alternative method for achieving greater synergy.
Asymmetry in Knowledge Transfer

The study has also identified another potential long-term problem in the collaborative relationship: asymmetry in knowledge transfer. This appears to stem from the different degree of tacitness of the knowledge base between the two firms, the contrasting methods of knowledge transmission and their differing ‘absorptive capacity’.

As already illustrated, the dominant form of knowledge in use in J-firm is characterized by its high degree of tacitness and is transmitted through an established network of human relationships. It is diffuse, contextual, less articulable and is not immediately transparent to outsiders. For B-firm staff to be able to appreciate and access this kind of tacit knowledge, they will need not only the language skills but, more importantly, to establish direct and intimate social relationships with staff in J-firm. In other words, the learners will need to become ‘insiders’ of the social community in order to acquire its particular viewpoint (Brown and Duguid 1991). Such a relationship cannot be established quickly. It requires the gradual building up of personal contacts and networks which can be costly and time-consuming. In stark contrast, it has proved to be much easier for J-firm to gain access and extract knowledge from B-firm. This is because the knowledge base of B-firm is more explicit and discrete. Unlike shared knowledge, which is diffuse and extremely ‘sticky’, individual expert knowledge is more visible and can be more readily transferred through the mobility of a small number of individuals. For example, a number of project managers and engineers on secondment to J-firm described how their ‘experience would rub off on them while they were talking to people in J-firm’. Further, in contrast to tacit knowledge, which cannot be easily articulated, a large part of the knowledge held in B-firm is codified and readily available in documents. Almost all the managers and engineers interviewed in both firms noted the asymmetrical flow of knowledge and information out of B-firm. Two B-firm staff made the following remarks when asked about information flow between the two firms:

‘... if anything, I think we have supplied more information than J-firm has, but in most cases there’s no reluctance to supply information. The only barrier is technical language, translations and that kind of thing ...’

‘... technical information regarding new technology... Management information, or more marketing information, that’s very much nett going to Japan. Little coming from Japan, a lot going to Japan.’

A senior manager in J-firm also noted the same and pointed out the reasons for it:

‘In terms of the amount of information, we are definitely getting more out of B-firm than the other way round. The reason is that most of the information is documented in English. It is all fairly well-documented and can be passed over just like that. Whereas in our company, most of the things are not documented. Even if they were, they are not in English in the first place.’

An additional factor contributing to the asymmetry lies in the differences
in the 'absorptive capacity' of the two firms — a term suggested by Cohen and Levinthal (1990). It is defined as the ability of the organization to acquire, assimilate and exploit outside knowledge. In the earlier part of this paper, it has already been pointed out that J-firm has a tendency to dispatch larger and more diverse teams to engage in collaborative projects, owing to its diffuse knowledge structure. In contrast, B-firm tend to rely on a small number of senior managers and engineers, where specialist expertise resides, for coordination and interfacing with J-firm. These differences have resulted in J-firm exposing a broader range of potential 'receptors' and being able to pick up more varied and richer knowledge and information. The diverse team structure in J-firm also aids rapid transmission and diffusion of the acquired knowledge back into the organization. However, in B-firm, the reliance on a small number of key experts as 'gatekeepers' could potentially limit the scope and range of knowledge acquired. This is because professional expertise entails 'perceptual filters' which may keep experts from noticing knowledge and information outside their specific domains (Starbuck 1992). Further, the small number of gatekeepers and the emphasis on individual ownership of knowledge within B-firm may also inhibit the transfer of knowledge across units and functions that are distant from the original interfacing points.

The asymmetrical knowledge transfer and information flow can potentially cause instability in the cooperative relationship. Insofar as cooperating partners are seeking joint knowledge creation on the basis of a complementary and equal contribution, asymmetry in knowledge accumulation can result in one partner becoming over-dependent and vulnerable (Hamel 1991; Pucik 1988). This tends to generate a sense of insecurity and suspicion among staff in the dependent partner which in turn can inhibit the development of an open and trusting relationship.

Conclusions

Previous research on global cooperative ventures has been preoccupied with governance forms and task structures. This study suggests that these factors are only partial determinants of partnership performance. It highlights the importance of focusing on the knowledge structures and work systems of partner firms, particularly in high-technology collaboration requiring the intense sharing and transfer of knowledge. Based on an empirical analysis of technological collaboration between a Japanese and a British firm, the study illustrates how differences in the organization of knowledge and work between firms in different societal settings can seriously inhibit collaborative work and impede effective knowledge transfer across national boundaries.

The research has extended and applied Polanyi's philosophical concept of 'tacit knowledge' in a much wider context. It develops a conceptual framework for analyzing different societal approaches to the organization of knowledge and illustrates how the degree of tacitness of knowledge can
differ between societal contexts. It argues that the difficulties in the transfer of knowledge arise not simply from the 'tacit' nature of knowledge itself, but from differences in the degree of tacitness of knowledge and the way in which it is formed, structured and utilized between firms in different countries. These differences not only can cause serious operational difficulties in cross-border collaborative work, but also can lead to asymmetry in knowledge transfer. Several previous studies have noted the asymmetrical transfer of knowledge between Japanese firms and their western partners (Hamel 1991; Inkpen and Crosson 1995; Pucik 1988). The majority of them have attributed asymmetry to differences in partner firms' learning intent and capacity, or to management structures. Evidence from this study, however, suggests that these are no more than secondary factors and that the root cause of asymmetry may well have deeper societal origins. While there are limits to which management can eliminate societal barriers to collaboration, a greater understanding and awareness of these issues may well help firms to devise appropriate long-term strategies for more effective global collaboration.

The evidence presented in this paper is based on one case study. This inevitably limits its scope for broad generalization. However, given the growing importance of knowledge-based competition in a wide variety of businesses and the increased propensity of firms to build global 'knowledge links', similar problems are likely to occur in other knowledge-intensive industries. It is hoped that the approach adopted in this study will provide a useful platform for future research on cooperative ventures across a wider range of industries and national contexts.

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