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The Social Embeddedness of Knowledge: Problems of Knowledge Sharing and Organisational Learning in International High-Technology Ventures

by
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Abstract

The growing importance of knowledge-based competition has prompted many firms to build international cooperative ventures for skills acquisition and knowledge building. Based on an empirical study of a close collaboration in the knowledge intensive area between a British and a Japanese high-technology firm, the paper examines how the socially embedded nature of knowledge can impede cross-national collaborative work and knowledge sharing. The paper uses Michael Polanyi's concept of 'tacit knowledge' in a much wider societal context. It develops a conceptual model for analysing the main differences and 'points of friction' between the British 'professional' and the Japanese 'organisational' models of organisation of knowledge in high-level technical work. It shows how the dominant form of knowledge held in organisations, its degree of tacitness, and the way in which it is structured, utilised and transmitted can vary considerably between firms in different societal settings. The study demonstrates a strong presence of 'societal effects' on the knowledge base of the firm and how this might impose a limit on knowledge sharing and organisational learning across national boundaries.

JEL

O32, L22, L63

Keywords

Knowledge transfer, technology and organization, societal effect, tacit knowledge, organisational learning, global strategic alliances.

Note

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Preface

This paper by Alice Lam addresses one of the most important current debates in the economics of knowledge and learning: What is the role of tacit versus codified knowledge? How do they interact in the new context of the information and communication technological revolution? Does the balance differ between social and national systems? One weakness with this debate has been that it suffers from lack of specific data. Tacit knowledge cannot be directly measured by normal quantitative indicators - if it could it would not be tacit. The only way to get a better idea about its role in the economy is through painstaking case studies.

One of the pioneers moving in this direction has been Ikujiro Nonaka (Nonaka 1994 and Nonaka&Takeuchi 1995). Based on a series of case studies in Japan, Nonaka has argued that there is a specific Japanese model of learning that gives more emphasis to tacit knowledge (for instance when developing new products) than the Western model. According to Nonaka, the roots of these differences are to be found in the history of philosophy that in the Western case has created a strong bias in favour of codified and formalised knowledge as opposed to experience based and tacit knowledge.

In this context, I am happy to be able to present this paper by Alice Lam as a DRUID Working Paper. It brings the debate on tacit knowledge further ahead and it is fascinating to read. The paper follows up and tests the Nonaka hypothesis through a case study of technological collaboration between a Japanese and an English firm operating in the field of information technology. Basically, her study, based on interviews over a 4 year period, confirms the Nonaha hypothesis. Her study does not only demonstrate that there are significant differences between the B-firm and the J-firm, however. The specification of how the involved parties have experienced the differences, in the form of direct quotes from the main actors, gives the reader a good feeling of what is at stake. It tells you a lot about where the differencess come from, how they materialise and what the consequences are?

There is a great need for further studies of this kind and also for some involving other national and regional constellations (do the Asian tigers share the Japanese characteristics and is the English case different from what you would find in for instance a firm rooted in France, Germany and
Italy?). Such studies would be helpful both for the design of workable relationships in international inter-firm co-operation and for analytical purposes. Differences in how knowledge is produced, shared and used are at the very core of the concept of national systems of innovation. While advocates of techno-globalism emphasise that the process of learning in relation to a specific technology is becoming more similar across countries, it is important to find out to what degree differences will remain because of international specificities in the societal setting.

Bengt-Åke Lundvall

INTRODUCTION

The growing importance of knowledge-based competition has prompted many firms to build international cooperative ventures for skills acquisition and knowledge building (Teece 1987; Hamel, Doz and Prahalad 1989; Kogut 1988; Baradaracco 1991; Westney 1987). International 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 proposed the need to develop appropriate governance structures for promoting stability, trust and boundary permeability between partner organisations. For example, Killing (1988) analyses the performance problems of alliances arising from task structure and organisational complexity and suggests that alliances undertaking tasks that require the combination of skills and resources provided by both partners need more complex organisational arrangements. Drawing upon prior work in transaction economics and organisational 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) emphasises 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 organisations. 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 organisations as bundles of embodied knowledge which include technology, procedures, organizational structures and hierarchical relationships. Their analysis suggests that an organisation's knowledge architecture has a systematic structure of its own and hence differences in the knowledge architectures between organisations can inhibit knowledge transfer. Taking all these arguments a step further, one would expect the problems of knowledge sharing and transfer within a global context to be amplified because of the greater diversity of knowledge and organisational systems and their socially embedded nature. Given the different ways in which knowledge and skills are formed, organised and utilised 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 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 organisation 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 led to an asymmetry in its transfer.

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

THE SOCIALLY EMBEDDED NATURE OF THE KNOWLEDGE OF THE FIRM: A CONCEPTUAL FRAMEWORK

The concept of embeddedness, as used by Granovetter (1985), refers to how behaviour and institutions are affected by networks of social relations. In this paper, the concept is used to analyse the nature of the knowledge of the firm from two perspectives: the organisational and societal. At the organisational level, the concept of embeddedness concerns the extent to which the knowledge of the firm is embedded in organisational routines, work practices and networks of human relations (Nelson and Winter, 1982; Kogut and Zander 1992; 1996). In other words, it refers to the degree of 'tacitness' and collectiveness' of the knowledge of the firm.

At the societal level, the notion of embeddedness refers to how societal institutions influence and shape the structure of knowledge within the firm (Granovetter 1992; Tsoukas 1996). There is a large body of research in comparative management which has established persistent significant national differences in the way work is organised and structured. This argument has been conceptualised 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 organisation of knowledge.

The model presented here attempts to explain how the nature of knowledge, its distribution and ownership, and patterns of utilisation within the firm are closely interconnected with the way work is organised and coordinated, which in turn is shaped by different societal models of skills formation, labour markets and occupational structures. 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 organisations 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. Boisot argues that different societies, for various historical and cultural reasons, have displayed preferences for different levels of codification and forms of knowledge exchange.

Western culture, according to Boisot, has extended spatially across the globe and it has developed a marked preference for codification and abstraction of knowledge. In contrast, Japanese society has displayed a marked preference for restricted codes and hence the build up of a shared context is critical for communication and information exchange. The basic argument put forward by Boisot is that, the codification and diffusibility of knowledge is systematically related.

Boisot's study highlights the general patterns of relationships between societal culture and institutions, codification of knowledge and its diffusion. The framework developed in this paper attempts to explain in much more concrete terms how the configurations of the knowledge of the firm, its degree of tacitness and codifiability is shaped by different societal models of knowledge formation, labour markets and occupational systems.

The nature and organisation of the knowledge of the firm can vary along three major dimensions. 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 organisations 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. So an important question is what makes 'tacit knowledge' a more important part of the knowledge system in some organisations 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 organisations 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 'organisational' model versus the British 'professional' model.

The organisational 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 the individual may only have limited causal understanding of the knowledge underlying the action and hence is not able fully 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 organised around a set of rules and a myriad of relationships which enable the organisation 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 knowledge-in-use is embedded in specific organisational routines and operating procedures understood and shared by members with common experience and values. Hence much of the knowledge held within the organisation is also 'tacit'.

In contrast to the organisational model, the professional model of knowledge formation is commonly associated with the existence of an external labour market where the acquisition of general and standardised 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 standardised 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 is 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 easily be severed from its prevailing context, this type of formal knowledge is more explicit and discrete and thus characterised by its relative ease of transfer.

A second dimension along which the organisation of knowledge can differ concerns its structure, that is, how knowledge and skills are distributed and utilised within the firm. This is closely related to the way work is organised and coordinated, and the career and job classification systems prevailing in different societies. The structure of the knowledge of the firm can vary from one that is highly diffused and group-based to one that is task specific and individual-based. The contrasts between the organisational and professional models are striking here. The organisational model is characterised by the absence of an external occupational labour market and rigid job classification systems. This allows flexible utilisation and deployment of human resources within the firm. 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 organisation is, however, quite different. Job allocation within the firm is closely related to the formal demarcation of skills and occupational boundaries commonly applied in the external labour market. The key principle for organising 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 specialised job path throughout their career. This approach encourages the development of deep and specialised 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 specialising 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. One primary task of the firm, as noted by Grant (1996), is to develop effective mechanisms for coordination and knowledge integration. The mechanisms for coordination, however, can vary from one that is highly tacit and human-network-based to one that is explicit and document-based. The main method used is determined by the extent of 'common knowledge' present in the organisation, the level of trust and implicit shared codes which the system is able to generate and the degree of external mobility of individual knowledge and expertise. The Japanese organisational model is characterised by a strong preference for human-network-based coordination and knowledge transmission. The diffuse job structure permits the mutual intrusion of job territories between individuals and functional groups, leading to the accumulation of a stock of common knowledge and shared implicit 'coding schemes'. Nonaka and Takeuchi use (1995) the term 'redundancy' to describe the way in which the Japanese form of work organisation enables individuals to accumulate 'extra' knowledge not specifically related to their specific tasks and thus helps to generate trust and team cooperation. The practice of long-term employment and intensive on-the-job training further facilitates the formation of a stable shared context. Within such a system, knowledge is utilised and transmitted through intensive and extensive interaction between group members. Coordination is achieved through mutual adjustment and is not dependent upon the need for communication in explicit codes. Knowledge is generated and stored 'organically' in team relationships and organisational routines. 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 specialisation and ownership of knowledge. Knowledge is stored independently in the individual 'experts' within specific functional groups. The pattern of division of labour and clear demarcation of job boundaries reduces the opportunities for the different individuals and functional groups to accumulate common knowledge and develop shared codes. Within such a system, effective coordination cannot be achieved without the systematic codification of personal knowledge into an explicit form.

Hence, the importance of written rules, procedures and detailed specifications. 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 diffusible 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 organisations in different societal settings. The rest of the paper provides empirical evidence to illustrate the contrasts between the Japanese organisational and the British professional models of organisation 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 discusses the extent to which the differing degree of tacitness of knowledge might lead to asymmetry in knowledge transfer and inhibits organisational learning across national boundaries.

Before proceeding to the empirical analysis, a brief outline of the background of the study and the research method used.

THE CASE STUDY : A JAPANESE-BRITISH HIGH-TECHNOLOGY COOPERATIVE VENTURE

The empirical evidence presented in this paper is based on an in-depth case study of a Japanese and a British high-technology collaboration in a knowledge-intensive industry. The 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) several years ago. The relationship between the two companies, however, is not one of a successful organisation taking over the 'unsuccessful'. It is more of a horizontal collaborative relationship and there is a high degree of mutual respect between them. 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 characterised by a strong desire for knowledge sharing and knowledge creation: a strategic partnering described as 'knowledge links' by Badaracco (1991). The success of the collaboration is highly dependent on the ability of the two firms to forge a close working relationship to enable the mutual sharing and transfer of technological knowledge and expertise. It hinges on the effective management of joint product development activities which require the close collaboration and interaction of a large number of engineers and technical specialists from the two firms. In other words, effective collaboration requires the two organisations to engage in an intensive process of organisational learning.

Close collaboration of this kind provides an ideal situation for observing the contrasts and potential 'points of friction' between the two different organisational systems based in two different societal contexts. Although the two firms operate in the same industry and are subject to similar technological and task contingencies, they are located in two very dissimilar societies and hence the influence of societal effects can be expected (Maurice et al 1980; Sorge 1991; Mueller 1994). Collaboration introduces 'disturbances' to the two socially embedded systems and thus brings to the forefront key aspects of divergence between the two systems.

The approach adopted in this study constitutes a new form of comparative organisational research. Unlike most of the existing comparative studies which tend to look at matched samples of organisations located independently in different countries, this study examines the interaction of nationally-based organisations across national boundaries. It allows the observation of the processes and, potentially the outcomes, of the interaction between two socially distinctive organisational systems. Interaction reveals differences between the two systems as perceived and experienced directly by the actors themselves, rather than imputed from the researcher's observation of organisational structures. This is particularly important for the purpose of this study which is to analyse the differences between the knowledge base of the two firms and their effect on joint work. Given the tacit nature of knowledge and its social embeddedness, the contrasts between the two systems cannot be easily deduced from the organisational structures. The interaction and points of friction as experienced by the actors in the collaborative process provides a more appropriate 'window' through which one may examine the differences. The problems experienced by the actors in their joint work also highlights the nature and scale of the problems generated, illustrating the practical outcomes of societal effects on global collaboration.

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 lasted for about 90 minutes to 2 hours and all were transcribed. The interview sample is shown in Table one.

Table 1 The interview sample

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

TWO CONTRASTING KNOWLEDGE SYSTEMS IN HIGH-LEVEL 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 organisation of knowledge and technical work commonly found between electronics firms in the two countries (Lam 1994; 1996)

1. 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 emphasise 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 utilisation 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 emphasise early specialisation 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 specialised work roles, utilising their general theoretical knowledge and analytical ability in upstream conceptual design functions. And 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 specialised, 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 specialised 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.

2. Contrasting knowledge structures and organisation of product development: Task-Specific Sequential Structure vs. Diffuse-Overlapping Structure .

The contrasting methods of skills formation and utilisation 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 organise product development and manage the flow and integration of knowledge across the different phases of the product cycle.

In B-firm, product development is organised on a sequential and hierarchical basis. It is characterised by a high degree of role specialisation 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 in turn clearly delineated 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 characterised 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 characterised 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 specialised 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 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 may be 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... Its' 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 emphasises 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 organisational 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 are 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.

3. Methods of coordination and knowledge transmission in product development: Document-based vs Human-network-based

The contrasting knowledge structures and organisation 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 'externalised' and translated into procedures, guidelines or specifications for transmission to other members of the organisation. 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 organisation 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 behaviourial routines. It is coordinated and transmitted through intensive human interaction and extensive networking throughout the organisation. 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 per cent, I would say it's only about 50 or 60 % 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 organisations 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 ORGANISATION OF TECHNICAL WORK

The differences in the organisation 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 organisational models of knowledge structure has not only persistently generated tensions and conflicts in the joint work between the two firms but more seriously, it 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.

1. 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 organisation 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 the 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 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 organisation 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 'finalised' 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 behavioral 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.

2. '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 of 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, that is 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.

3. Asymmetry in Knowledge Transfer and Organisational Learning

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 characterised by its high degree of tacitness and is transmitted through an established network of human relationships. It is distributed, contextual, less articulable and is not immediately transparent to outsiders. The transmisson of this type of knowledge requires a great deal of prior investment in building up a shared context and common understanding between communication parties (Boisot 1995; Hall 1976). 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 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 describe 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 organisation 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 organisation. It enables learning to occur in a more coordinated and collective fashion. In contrast, 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). Individual learning is often constrained by a limited ability to interpret complex reality (Dodgson 1993: 384): Simon's (1957) bounded rationality problem . Further, the small number of gate keepers 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 organisational learning 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; Inkpen and Beamish 1997). 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, and thus reduce the capacity of the partner firms in joint knowledge creation.

CONCLUSIONS

Based on an empirical analysis of a close collaboration between a British and a Japanese high-technology firm, this study has illustrated how differences in the organisation of knowledge between firms in different societal settings can seriously inhibit collaborative work and impede effective knowledge sharing across national boundaries. The research has extended and applied Polanyi's philosophical concept of 'tacit knowledge' in a much wider societal context. It develops a conceptual framework for analyzing the main differences between the British 'professional' and the Japanese 'organisational' models of organisation of knowledge in high-level technical work. It shows how the dominant form of knowledge held in organisations, its degree of tacitness and the way in which it is structured, organised and utilised can vary considerably between firms in different societal settings. These differences are deeply embedded in the contrasting national systems of skills formation, labour markets and occupational structures.

The study demonstrates the strong presence of societal effects on the knowledge base of the firm and how this might impose a limit on knowledge sharing and organisational learning across national boundaries. It questions the argument presented in much of the management literature that globalisation of business and the acceleration of cross-border learning will lead to a worldwide diffusion of technologies and knowledge and weaken the 'societal effect' (Ohmae 1990; Adler 1990; Mueller 1994). There is no evidence in the present study that the two partner firms, despite their long years of close collaboration, have become more alike in their organisational forms or knowledge bases. On the contrary, the two firms appear to have become more divergent in their distinctive and complementary capabilities. Indeed, 'organisational learning' has made the partner firms become more aware of their fundamental differences. This has led the two firms to pursue an arm's length collaborative relationship and a strategy of partner specialisation in complementary activities within their collaborative ventures. In this respect, collaboration has become more a vehicle for gaining 'access' to, rather than 'absorption', of the partner firms' knowledge assets. Contrary to the 'globalisation' argument, cross-national collaboration can potentially lead to a strengthening of the societal specificity of the knowledge base of the firm, not weakening it.

Although the evidence presented in this paper is based on one case study and this inevitably limits its scope for generalization, a study of this kind can be particularly revealing. My previous research in the British and Japanese electronics industries highlights significant societal differences in the organisation of technical work between firms in the two countries, many of which are reflected in the two partner firms examined in this study. Collaboration between these two different systems has brought to the forefront the main 'points of friction' as perceived and experienced by the actors as they interact with each other. The approach adopted in this study allows a close analysis of the differences in the structure of knowledge embedded in the two systems and the problems it has generated for actors operating across the normative boundaries. 'Societal effect' is not only an academic theory in comparative social research, it creates real 'problems' for actors operating in the global economy.

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Danish Research Unit for Industrial Dynamics

The Research Programme

The DRUID-research programme is organised in 3 different research themes:
- The firm as a learning organisation

- Competence building and inter-firm dynamics

- The learning economy and the competitiveness of systems of innovation

In each of the three areas there is one strategic theoretical and one central empirical and policy oriented orientation.

Theme A: The firm as a learning organisation

The theoretical perspective confronts and combines the ressource-based view (Penrose, 1959) with recent approaches where the focus is on learning and the dynamic capabilities of the firm (Dosi, Teece and Winter, 1992). The aim of this theoretical work is to develop an analytical understanding of the firm as a learning organisation.

The empirical and policy issues relate to the nexus technology, productivity, organisational change and human ressources. More insight in the dynamic interplay between these factors at the level of the firm is crucial to understand international differences in performance at the macro level in terms of economic growth and employment.

Theme B: Competence building and inter-firm dynamics

The theoretical perspective relates to the dynamics of the inter-firm division of labour and the formation of network relationships between firms. An attempt will be made to develop evolutionary models with Schumpeterian innovations as the motor driving a Marshallian evolution of the division of labour.
The empirical and policy issues relate the formation of knowledge-intensive regional and sectoral networks of firms to competitiveness and structural change. Data on the structure of production will be combined with indicators of knowledge and learning. IO-matrixes which include flows of knowledge and new technologies will be developed and supplemented by data from case-studies and questionnaires.

Theme C: The learning economy and the competitiveness of systems of innovation.

The third theme aims at a stronger conceptual and theoretical base for new concepts such as 'systems of innovation' and 'the learning economy' and to link these concepts to the ecological dimension. The focus is on the interaction between institutional and technical change in a specified geographical space. An attempt will be made to synthesise theories of economic development emphasising the role of science based-sectors with those emphasising learning-by-producing and the growing knowledge-intensity of all economic activities.

The main empirical and policy issues are related to changes in the local dimensions of innovation and learning. What remains of the relative autonomy of national systems of innovation? Is there a tendency towards convergence or divergence in the specialisation in trade, production, innovation and in the knowledge base itself when we compare regions and nations?

The Ph.D.-programme

There are at present more than 10 Ph.D.-students working in close connection to the DRUID research programme. DRUID organises regularly specific Ph.D-activities such as workshops, seminars and courses, often in a co-operation with other Danish or international institutes. Also important is the role of DRUID as an environment which stimulates the Ph.D.-students to become creative and effective. This involves several elements:

- access to the international network in the form of visiting fellows and visits at the sister institutions
- participation in research projects
- access to supervision of theses
- access to databases

Each year DRUID welcomes a limited number of foreign Ph.D.-students who wants to work on subjects and project close to the core of the DRUID-research programme.

External projects

DRUID-members are involved in projects with external support. One major project which covers several of the elements of the research programme is DISKO; a comparative analysis of the Danish Innovation System; and there are several projects involving international co-operation within EU's 4th Framework Programme. DRUID is open to host other projects as far as they fall within its research profile. Special attention is given to the communication of research results from such projects to a wide set of social actors and policy makers.

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