Organizing International Technological Collaboration in Subcontractor Relationships An Investigation of the Knowledge-Stickyness Problem

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Abstract

Technological knowledge is often claimed to be context-bound and sticking to local surroundings. This paper investigates how technological knowledge can be exchanged in international subcontractor relationships, using relationship-oriented organizational practices. Five hypotheses concerning such practices are tested. It is shown that the use of relationship-oriented practices varies with exports and the active development of subcontractors in product and process development activities. Moreover, international development-oriented subcontractors are more likely to use interpersonal exchange, electronic data interchange and formalized contracts than other types of subcontractors. Research implications as well as managerial implications are derived.

Keywords

Subcontracting, knowledge, international division og labour,

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Contents

Introduction

Hand in hand with a growing vertical division of labour and an increasing internationalization of subcontracting markets, investigations confirm that the technology content of internationally sourced intermediate goods is growing (Wyckoff, 1992, Papaconstantinou et al., 1996, Helper & Sako, 1995).

The increasing trade in high-technology components relates to the increased international competition. To keep up with the escalating competitive pressure in the globalizing marketplace, firms specialize in core activities and turn to external sources for additional technology inputs (Gomes-Casseres, 1994). These inputs are to an increasing extent found outside their home markets (A.T. Kearney, 1993). Sometimes internationally sourced components are used to such an extent, that the distinction between "domestic" produced and "foreign" produced products are blurred. Hence, domestic produced products may very well have a higher content of foreign components than imported products (OECD, 1996). Reflecting this development, a large and probably growing number of subcontractors are engaged in exports (Andersen & Christensen, 1998) and the imports of subcontracted goods are on the rise (Wyckoff, 1992).

As international subcontracting becomes increasingly technology-driven, inter-firm interaction becomes more complex. Because of lacking supportive institutions in the international market place, relations between users and producers involving technological development has typically been seen as restricted to local surroundings (Porter, 1990)

This paper attempts to explore how subcontractors overcome the factors that are normally seen as confining inter-firm technological development to local areas. It is structured as follows: The first section outlines the qualitative and quantitative changes in international subcontracting. The second section provides an overview of the factors enforcing the localization of technological competences as requirements for engaging in international activity. This overview is based on the contributions from research on industrial districts and user-producer relationships. Section three proposes five hypotheses concerning the actions taken by subcontractors in order to compensate for the factors restraining geographic dispersion of technology-based subcontracting relationships. Section four provides a short description of the empirical background and methodology for investigating these hypotheses. Section five contains the statistical analysis and the empirical findings. Finally, section six discusses these findings and explores implications for research and management.

The growing importance of international technology-based subcontracting

Subcontracting is usually defined as the delivery of goods or services, which are specified by the contractor. The form and degree of specifications may vary considerably: from drawings, machinery and material, where subcontractors merely deliver production capacity to the specification of problems, where contractors have little knowledge concerning the potential solutions to their experienced needs and where the specialized skills of subcontractors play a decisive role in the design of components (Andersen & Christensen, op.cit.)

Traditionally, subcontracting has mainly been a local phenomenon (Wyckoff, 1992). The large service content of subcontracting, including intensive dialogue and adjustments to the contractors' needs, production planning, etc. has spurred an almost prohibitive market failure for contractors wanting to source supplies outside their logistic hinterland (Min, LaTour & Williams, 1994).

However, the importance of international subcontracting has increased during the past decades. Several observations document this trend (Kotabe & Omura, 1989; Wyckoff, 1992). In Denmark, four of every ten subcontractors are engaged in direct export activities (Andersen & Christensen, op. cit).

Global economic pressure have led to firm-specific changes in the organization of production and product development. Stronger emphasis on core competencies have expanded the demand for subcontracted goods. Following the general internationalization of the world economy, multinational companies (MNCs) are turning to sourcing policies as a lever for gaining competitive advantage (Arnold, 1989) Firms in diverse industries such as Benetton (fashion wear), Nike (Sport shoes), Ford & Toyota (motor vehicles) and John Deere (Agricultural machinery), are intensively pursuing global sourcing policies as a centre piece of their overall business strategy. Parallel to this development, world-class subcontractors are increasingly used as providers of new technology. A recent survey confirmed this picture. Technology-intensive subcontractors are more likely to permeate the internal markets of multinational corporations than other subcontractors (see figure 1).

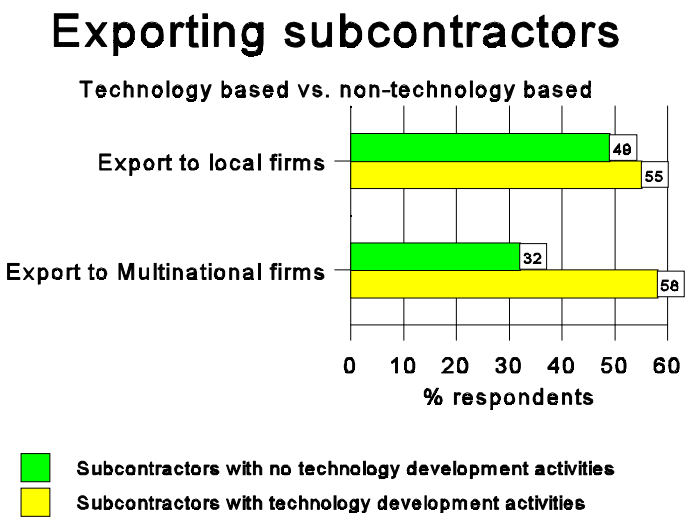

Figure 1: The permeability of international technology-based subcontractor outputs
Source: Andersen & Christensen, 1998

Traditional cost-driven motives for sourcing internationally are being supplemented with motives pertaining to economies of variety and speed demanding a continuous inflow of complementary competences (Storper & Salais, 1997). Several empirical studies confirm the importance of suppliers to the company's technical development (Kagono et al, 1985, Christensen & Kristensen, 1995). Studies have confirmed the positive relationship between competition and collaboration. As the competitive pressure increases so does the need for marshalling supportive partners through alliances and other forms of collaboration (Lundvall & Kristensen, 1997, Lundvall, 1997). In the knowledge-based economy, the ability to obtain new skills from internal as well as external sources becomes a *sine qua non* for the globally operating firm. Hence, the global firms' ability to integrate diverse streams of technology across organizational and national borders into serving customers needs more efficiently than competition becomes an asset in its own right, and some might say the most important differentiating factor in long-term competitive performance.

Global technology sourcing is seen as an indispensable element in the competitive ability of MNCs as it gives access to a larger pool of technological competencies, reduces the time-to-market for new product ideas as well as uncertainty through risk-sharing with supplier partners (Arnold, 1989, Armistead, 1989, Johnston, 1996, Cavusgil et al., 1997). Moreover, joining strategies with subcontractors providing complementary technologies reduces risk and investment requirements

for the single firm, as compared to going-alone (Quinn & Hilmer, 1994). Finally, new technologies require multiple sets of complementary technical developments which may pose insurmountable challenges for even the largest firms (DeBresson & Amese, 1991). Cross fertilization of complementary competencies may provide synergistic gains for both partners (Nonaka & Takeuchi, 1994).

From the perspective of the exporting subcontractor, this means that relationships with local customers, are increasingly being supplemented and occasionally even replaced by international relationships with foreign firms. Empirical investigations confirm that especially MNCs constitute an option for international development-oriented subcontracting (Andersen & Christensen, op. cit). Hence, the traditional local confinement of subcontractor relationships is changing. In the following section, the central factors for restraining subcontracting to local surroundings are identified.

Factors restraining international technology transfer in subcontracting relationships: The Knowledge-Stickyness Problem

International technology-based subcontracting challenges some of the contemporary views on interorganizational technological collaboration. Due to the mutual adaptation and the novelty of technological knowledge, routinized modes of transaction are inadequate. Complex patterns of knowledge tend to "stick to" the surroundings in which they are developed, used and refined (Von Hippel, 1994). Therefore, this form of knowledge is difficult to obtain, transfer and set up in a novel business context. The stickyness of technological knowledge can be illustrated by the difficulties of transferring knowledge, even within a boundary of an organization (Nonaka & Takeuchi, 1994) The problem of knowledge transfer in diversified MNCs to obtain economies of learning is at top of many research and business agendas (Douglas & Craig, 1989, Bartlett et al, 1989) Moreover, even in intra organizational inter-group collaboration, organizations must implement mechanisms to overcome knowledge-stickyness. Technology as a driver of organizational complexity has long been acknowledged (Thompson, 1967; Perrow, 1972). Aligning diverse sets of technologies involves a considerable degree of problem-solving and mutual adaptation of resources and activities (Håkansson, 1994, Thompson, 1967). Thus, it can be stipulated that the more exchange activities move away from standardized exchange, the more exchange and communication are called for (Asanuma, 1989).

Thus, given the complexity and impactedness of knowledge as a good, exchange of technological

supplies therefore usually involves market failure, as decision makers have great difficulties in assessing their market value (Arrow, 1974). This is also valid for subcontracted technology supplies, which involves considerable knowledge exchange between subcontractors and contractors in order to coordinate and align activities (Asanuma, op. cit, Spekman, 1986). Investigations of purchasing behaviour in industrial markets have shown that uncertainty increases with the geographical distance between buyers and sellers (Håkansson & Wootz, 1975; Min et al; 1994)
The information used in technical problem solving is often costly to acquire, transfer and use in new settings. Hence, this process is regarded as confined within local surroundings (Malmberg et al, 1996). The mechanisms confining interorganizational development activities in local surroundings may be discussed under the following four headlines:

- The uncertainty of development activity outcome
- The need for interaction and iteration in technological development processes
- The absence of information codes for the exchange of complex knowledge
- The cost of complex information exchange over large physical distances

First, processes of technology development are basically uncertain in terms of economic outcome (Freeman, 1982). High failure rates combined with numerous possibilities for exposure to opportunistic behaviour add to decision-makers' uncertainty (Foxall, 1988, Scarborough, 1995). Local surroundings offer at least two risk reducing services in this respect: Local reputation systems, where the credibility of potential collaborative partners can be accessed (Rao, 1994) and the accumulation of specialized and sophisticated users, with interest and knowledge in the particular technology area (Porter, 1990).
Second, reports on inter-firm technology collaboration usually underline the interactive and iterative features of development processes (Lundvall, 1985; Imai et al., 1985; Kristensen, 1992a &b; Håkansson, 1994). Trial-and-error processes are a well known feature of both intra- and interorganizational technological collaboration. Physical proximity greatly favours this form of interaction: Meetings can be arranged on short notice, informal visits can be paid, and the likelihood of professional communities, where ideas are discussed on an informal basis are much larger in local contexts as constant interaction and geographic proximity sustain shared experiences and joint skill-building the best (Lundvall, 1985). Moreover, interaction in interorganizational local

networks is re-inforced by personal, cultural and symbolic networks (DeBresson & Amese, 1991). As the effectiveness of knowledge exchange grows through the development of shared information codes in the local environment, alternative codes become less attractive (Lundvall, op. cit).

Third, a central characteristic inter-firm technology development is the employment of informal mechanisms for information exchange. Not all information can be transmitted by transcription, since no prescription for it exists. Parts of complex technological knowledge are private to the beholder and are only transferrable through human interaction, as physical interaction provides richer learning environments (Weick, 1987). The alignment of cross-organizational collaborative teams calls for face-to-face contacts, especially concerning the exchange of tacit knowledge (Nonaka, 1991, Nonaka & Takeuchi, 1994), and some types of knowledge may only be transferred by example through various forms of meister-apprentice systems (Nonaka, 1991). Finally, costs of communication are expected to increase with physical distance, especially where discontinuous and complex information are involved (Lundvall, op. cit). Inter-firm technological collaboration requires the mutual exchange of knowledge across organizational borders. Costs of information transfer over physical distances may be quite considerable (Pavitt, 1988). Especially up-stream activities in the value-added chain as compared to downstream activities call for proximity as technology information loses more meaning by being divorced from its network than marketing information (Kristensen, 1992a & 1992b). Complex information exchange over large geographical distances may therefore be ridden with prohibitive costs. Together these factors suggest that at least some elements of inter-firm knowledge development are sticky, and neither rapidly codified nor diffused across regional and national business environments.

The organization of international technological collaboration in subcontractor relationship: Five hypotheses

The stickyness of technological knowledge is backed up in a number of studies (Storper, 1993, Dalum & Villumsen, 1996). It has repeatedly been shown that localized technology districts play an important role in global trade (Storper, 1993, Maskell, 1996). Still, the growing use of technological sourcing testifies that the stickyness of knowledge transfer may be suppressed or neutralized. Complex inter-firm exchange calls for the development of organizational practices in order to overcome the distances created by diversities in mind-sets, organizational and national cultures (Hallén & Sandström, 1989).

Therefore, the general tenant in the following propositions is that international subcontractor relationships involving exchange of complex information are likely to compensate for the lack of proximity by applying relationship-oriented practices. We will test this assumption through five hypotheses: Two of a more general nature and three which specifically address development-oriented subcontractors. The former group of hypotheses suggest, that the use of relationship-oriented practices will vary with a) exporting and b) the technological content of subcontracting. On a more specific level it is proposed that c) exporting subcontractors may compensate for the lack of proximity to contractors through developing formal contracts in order to reduce risk perceptions to a larger extent than is the case for domestic subcontractors; d) to a larger extent than domestic subcontractors, exporting subcontractors use an electronic data interface in order to facilitate iteration and interaction and finally; e) exporting subcontractors swap personnel in order to favour informal exchange of knowledge and learning-by-example to a larger extent than domestic subcontractors, in order to compensate for the lack of physical proximity. Table one provides an overview of the more general propositions and how they relate to transfer of sticky knowledge in subcontracting relationships. Cells marked with a question mark indicate that no relationship is stipulated between this segment of knowledge exchange and the hypothesized organizational practices.

Table 1: An overview of relationship-oriented practices for reducing knowledge Stickyness

	Interpersonal exchange	Electronic Data Interchange	Formal contracting
Knowledge Extraction	?	Enabling contacts	Reducing risk perception
Knowledge Transfer	Facilitating communication	Facilitating communication	?
Knowledge Implementation	Enabling “learning-by-doing”		?

As displayed in table 1, these relationship oriented practices may be seen in relation to three generic and consecutive activities comprising the knowledge transfer process: Knowledge extraction, knowledge transfer and knowledge implementation (Von Hippel, 1994). Knowledge extraction,

pertains to the process of attaining knowledge from a specification. Technological knowledge is often difficult to articulate and extraction calls for ongoing interaction between sender and recipient (Nonaka, 1991, Von Hippel, 1994). Knowledge transfer, relates to processes of moving knowledge from one site to another, and the organizational procedures to enhance this transfer (Rosenberg, 1982). These processes depend of course to a great degree on the type of knowledge to be transferred. Finally, implementation processes concern the ability to absorb new knowledge regarding the activities needed to implant the knowledge in the receiving organization (Cohen & Levinthal, 1990). The propositions outlined are explored and fully explained in the following part of the text:

Hypothesis$_{1:}$ *Exporting subcontractors are more likely to use relationship-oriented practices for knowledge transfer than domestic-oriented subcontractors*

It follows directly from the discussion earlier that subcontracting exports are ridden with barriers that need to be overcome through the use of relationship-oriented practices. Although some forms of market exchange on subcontractor markets may be supported by market institutions, the general nature of subcontracting - producing goods from the specifications of other firms - beget some form of information exchange.

Hypothesis$_2$: *Development-oriented subcontractors are more likely to develop interorganizational practices for knowledge transfer than other types of subcontractors*

It has been implied earlier, that the orthodox definition of subcontractors needs to be further expanded in order to capture new subcontracting functions, such as technological development. Hence, several subcontractor and supplier typologies have been suggested (Asanuma, 1989, - Blenker & Christensen, 1996, Andersen, Blenker & Christensen, 1997). In general the models agree with the concept developed by Thompson (1967) that organizing complexity and technological complexity are directly interrelated. In the following, we will operate with a compound model, suggesting three categories of subcontractors. Standard subcontractors, traditional subcontractors and development-oriented subcontractors.

Standard subcontractors conduct simple operations for their customers, based on the contractors

drawings and specifications. These are parallel to the Japanese *Taiyozu* subcontractor type, where manufactured parts are made according to plans supplied by the contracting firm (Asanuma, 1989). *Development-oriented subcontractors*, partake actively in customers product and process development activities, and often take responsibility for developing a sub-component or routine, which subsequently are approved by the contractor. This form parallels the Japanese *Shoninzu*-type of subcontractors, where subcontractors develop component designs themselves which are approved by contractors (Asanuma, op. Cit., Nishiguchi, 1994).

Finally, as an intermediate group, *traditional subcontractors* occasionally exchange product and process knowledge with contractors, however on an ad hoc basis. They distinguish themselves from the standard subcontractor type, by occasionally being engaged in process development activities, and from development-oriented contractors, by not being engaged in product development activities. Appendix 1 elaborates on the criteria on which the taxonomy is based.

Hypothesis$_3$: *Exporting subcontractors swap personnel in order to favour informal exchange of knowledge and learning-by-example to a larger extent than domestic subcontractors.*

Regular face-to-face information exchange is seriously affected by geographical distance. As this form of interaction supports the transfer of non-prescriptive knowledge, subcontractors and contractors must find ways to compensate for this form of social proximity over long distances. One practice for overcoming problems of exchanging knowledge of tacit or private nature is by swapping personnel for shorter or longer periods (Nonaka & Takeuchi, 1994; Carlisle & Parker, 1995). Hence, it is expected that exporting subcontractors exchange personnel with their customers to a larger extent than domestic subcontractors.

Hypothesis$_4$: *Exporting subcontractors use Internet and platforms for electronic data interchange in order to facilitate iteration and interaction to a larger extent than domestic subcontractors*

Several academics believe that electronic interaction and virtual reality to a large extent will complement and even replace physical interaction in business (Hale, 1997, Greiner, 1995). Indeed, in the international business world video conferences and virtual meetings are seen as a potential substitute for resource-demanding business travels (Magid, 1995; Sharples, 1995). As international

technological subcontracting calls for iteration and interaction over large physical space, one way of compensating for physical proximity may be by means of virtual proximity. The number of subscribers to the Internet is growing at an incredible speed and more than 500 million active Internet-users are expected by the end of the millennium. The Internet is expected to change international marketing fundamentally (Hamill & Gregory, 1997). This development will most likely also affect subcontracting relationships. One of the future Internet functions is to support or improve interactive communications in marketing relationships regardelss of physical distance (Hamill & Gregory, op. cit.). In a survey including the 1,000 largest European manufacturers, 46 % mentioned electronic data interchange as an important criteria for selecting suppliers (A.T. Kearney, 1993) Already, several firms such as Nippon Electronic Calculator (NEC), Sony and Hewlett-Packard are using the "web" for informing subcontractors world wide on their purchase and auditing practices.

Hypothesis$_5$: *Subcontractors exporting technology goods use formal contracting to a larger extent than domestic oriented subcontractors.*

Repeatedly, research has shown that formal contracting is insufficient and only used occasionally in technological inter-firm collaboration (Håkansson, 1994). Technological development projects are difficult to stipulate in advance, and their outcome is highly liable. Moreover, technological developments may emerge gradually, with no ex ante formal agreement (Scarborough, 1995). Direct contacts and attempts to reach a truce in cases of disagreements is the normal modus operandi on industrial markets (Macaulay 1963). A subcontractor's engagement in international development activities is perceived as a considerably higher risk than if the subcontractor had entered into a local or national technological collaboration with contractors. Legal, economical, technical and socio-cultural contexts are different from local surroundings, increasing the decision makers uncertainty. Moreover physical distance limits the possibilities of solving minor disagreements in face-to-face dialogue. As there are fewer developed channels for informal market communication and reputation-building between countries than within countries, the propensity to use more formalized patterns of exchange are stronger (Håkansson & Johanson, 1988). Thus, one way of reducing uncertainty concerning foreign legal environments may be by stipulating legal contracts, determining the ground rules for the collaboration and how this can be terminated if necessary (Macneil, 1978). Rather than stipulating the form and content of the exchange, these

contracts may provide participants with an escape hatch, which can reduce decision makers perception of risk. In this sense formal contracts are seen as complementing the development of relationship norms and expectations rather than replacing them (Macaulay, 1963).

Questionnaire design and data collection

Data for testing the attributes of exporting and domestic subcontractors on the hypothesized relationship were obtained from an ongoing research of the industrial relations of Danish producers (Andersen & Christensen, op. cit.). This ongoing research program on inter-firm relationships is carried out by The Danish Statistical Bureau and Eurostat. The research program is supervised by Professor Peter Maskell, Copenhagen Business School.

The data material used in this article was collected during 1995. The survey questionnaire has been mailed to all Danish firms a) belonging to the NACE Industrial classification range 10-36 and b) with more than 10 employees in 1994. Questionnaires were sent to 4072 companies of which 1278 responded, amounting to a response rate of 39,4 %. The response analysis shows, that the results are fairly representative for the NACE segment of the Danish industry.[1] 541 firms, amounting to 42,8 % of the respondents have characterized themselves as subcontractors. 96 of the respondents marking themselves as subcontractors have been discarded because of inadequate answers, leaving a research sample comprising 445 subcontractors.

The firms were asked to answer 19 questions concerning their (in terms of profit) four most important customers. According to the response analysis, subcontractors answer to: “Who is your most important customer” are fairly consistent with their answers on the subsequent customers. In other words, subcontractors seek to economize on relationship building by applying similar business practices over a broad range of relationships rather than developing unique ones for each single relationships (Storbacka, 1994)

Nominal scaling was used. The respondents were asked a series of questions, based on dichotomous answering. Two groups: exporting (186 respondents) and non-exporting subcontractors (259 respondents) have been derived.

Using empirical material designed for more general and descriptive purposes in a hypothesis testing context does have some limitations. However, these limitations are largely off-set by the size and

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[1] The sub-branches printing, stone, clay & glass and transportation (NACE 22, 26 & 35) are under-represented, compared to their total proportion of Danish industry

representativity of the sample and the novelty of investigations into this problem area. More dedicated questionnaires would probably have given a richer material, but also have included fewer respondents.

The empirical material consists of both product/process development-oriented subcontractors and more traditionally-oriented subcontractors. Using the typology developed earlier subcontractors were divided into the three groups developed. The sample is distributed on these categories in table 2, below. (Please refer to appendix 1 for further information on how the typology is operationalized in the present context.)A residual group of 25 subcontractors cannot be classified based on the present subcontractor typology. These are discarded in the present analysis.

Table 2: Sample distributed on subcontractor categories

	Standard	Traditional	Development oriented
Number of respondents	92	183	145

Operationalization

On the basis of the questionnaire it has been possible to highlight relevant aspects of the hypotheses. Three questions were used for testing the above stated hypotheses. The research questions have been operationalized in the following way (table 3):

Table 3: An Overview of propositions and their operationalization

Proposition	Operationalization (Research question)
Exporting subcontractors are more likely to use relationship-oriented practices for knowledge transfer than domestic-oriented	Please state the nationality of your four most important contractors
The use of relationship oriented practices vary with subcontractor categories	See appendix 1 for details on subcontractor categories
Subcontractors exporting technology goods use formal contracting to a larger extent than domestic oriented subcontractors.	Do contracts exist which extend over more than one transaction with your customers (Yes/No)
Exporting subcontractors use electronic data interchange to a larger extent than domestic subcontractors	Do you exchange EDI with your customers (Yes/No)
Exporting subcontractors swap personnel to a larger extent than domestic subcontractors.	Do you conduct exchange programmes with your customers (Yes/No)

Data Analysis

Data have been computed and analysed, using the SAS for Windows software package for statistical analysis. To test the independent variables on the probability of international knowledge exchange in subcontractor relationships, categorical data analysis was used. In cases where dichotomous variable sets and categorial variable sets are paired, the LOGIT procedure is useful (Agresti, 1996). In a LOGIT model, the value of the dependent variables (exports, relation-specific practices) is based upon the log odds. It is the variation of this measure which is to be explained by the independent variable (subcontractor type) Thus, the computation and data analysis opens up the possibility of testing to what extent subcontractor type may predict the use of relationship practices in international subcontractor relations.

Results

The analysis results generally support the view that export and subcontractor type have an impact on the propensity to use relationship-oriented practices. Hence, hypothesis 1 & 2 are largely confirmed. The results of the statistical analysis are shown in table 4, using the three features of relationship practices as dependent variables. As shown in the table, the use of relationship-oriented

practices has significant p-values at least at a 5 percent level in the majority of cases. In the case of subcontractor type as an explanation of formal contracting, significance is at a 0.1 percent level.

Table 4: General results from the analysis

	Exchange of personnel	Electronic Data Interchange	Use of formal contracting
Subcontractor type	0.09	0.04*	0.0007***
Export	0.04*	0.91	0.01*

* Significant at 0.05-level ** Significant at 0.01-level *** Significant at 0.001-level

The exchange of personnel is not significantly linked to subcontractor type, although the probability is close to the 0.05 level of significance. Exports, however increases the likelihood of using this practice in subcontractor relationships, confirming the importance of this exchange practice in distant relations.

Testing hypothesis three, a difference between different type of subcontractors concerning their use of personnel swap arrangements is found. The results depicted in table 5 below show, that subcontractor types differ with respect to exchange of personnel, albeit not below 0.05 level of significance. In accordance with expectations, development oriented subcontractors are more likely to use practices of personnel swap than other groups. Surprisingly, however, the estimate shows, that standard subcontractors are more likely to answer “yes” to the question concerning personnel swaps, than traditional subcontractors. One possible explanation is that standard subcontractors are more internationally oriented than traditional subcontractors, measured in export intensity.

Table 5: Exchange of personnel as a function of subcontractor type

	Estimate	Standard Error	Probability
Standard subcontractors	0.04	0.2197	0.83
Traditional subcontractors	-0.35	0.1871	0.06
Development-oriented subcontractors	0.31	0.1814	0.08

* Significant at 0.05-level ** Significant at 0.01-level *** Significant at 0.001-level

Testing hypothesis four, table 5 shows, that exports does not predict the use of Electronic Data Interchange (EDI). The number of subcontractors using EDI on domestic markets strongly outnumbers exporters. The leading position of Denmark when it comes to implementation of EDI may play a role here, and catch-up effects may be found in future investigations.

However, the analysis shows that usage of EDI depends on subcontractor type. In table six, the impact of subcontractor type on the use of EDI is further assessed. The research results support the idea that development-oriented subcontractors are more likely to use EDI with customers. However, in order to access the nature and role of this exchange, further empirical exploration is necessary.

Table 6: Impact of subcontractor type on the use of EDI

	Estimate	Standard Error	Probability
Standard subcontractors	-0.1904	0.2929	0.51
Traditional subcontractors	-0.346	0.2511	0.16
Development-oriented subcontractors	0.5364	0.2287	0.01 **

* Significant at 0.05-level ** Significant at 0.01-level *** Significant at 0.001-level

Finally, the use of formal contracting, strongly depends on export activities and subcontractor type. Table 7 provides the findings on the impact of subcontractor type on the propensity to use formal contracting in relationships with customers. The sign in front of the estimate shows, that on an overall level development-oriented subcontractors are more likely to use contracts than the average. In the case of traditional and standard-oriented subcontractors the situation is reversed. This probably underlines the idea, that contracts are more likely to be used when both partners face outcome uncertainty concerning the exchange.

Table 7: Impact of subcontractor type on the use of formal contracting

	Estimate	Standard Error	Probability
Standard subcontractors	-0.3008	0.1624	0.05 *
Traditional subcontractors	-0.2403	0.1356	0.07
Development-oriented subcontractors	0.5492	0.145	0.0002 **

* Significant at 0.05-level ** Significant at 0.01-level *** Significant at 0.001-level

Discussion & Implications for management and research

In order to overcome the knowledge-stickyness problems in international technology collaborations, subcontractors and contractors must develop new organizational practices which cross organizational as well as business environment boundaries. Practices that compensate for the lack of proximity in subcontractor development relationships involving development are already implemented and can be witnessed through the divergence of business activities between exporters and non-exporting development-oriented subcontractors. Moreover, knowledge-oriented subcontractors with international activities are more likely to take on such practices than other types of subcontractors. These conclusions correspond to the results from research on international business relationships in general also when it comes to encompassing technological-based exchange relationships between contractors and sub-contractors (Hallén & Johanson, 1988). Moreover, they extend our knowledge on interorganizational practices in international business relationships.

Research implications

The development of border-crossing organizational procedures is a field which increasingly deserves attention. The measures and practices used to overcome technology stickyness increasingly tops the agenda in MNCs, as economies of synergy, including learning, speed and variety become a central part of the international competitive environment (Douglas & Craig, 1989). At the same time, structuring efficient technological relationships with contractors has a high priority among proactive subcontractors looking for market opportunities beyond their domestic market scope.

The associations found in this investigation however, indicate that on central attributes, international subcontracting practices differ more in degree than in type from domestic subcontractor relationships. More conceptual and theoretical work is necessary to pursue this

further. Also, in order to identify the central aspects of how international technology-based subcontractor relationships are organized more research is necessary. Especially the development of the use of Internet and in technologically-based subcontracting is an area which deserves more attention from organization and marketing researchers.

Managerial Implications

The investigation has confirmed that it is possible to overcome the knowledge-stickyness problem in international subcontractor relationships, even over large distances. Proximity may be substituted by means of formalization through contracting and by interpersonal exchange. The tacit nature of technical knowledge makes obtainment, transfer and implementation of knowledge difficult and perceived as risky. However, some of these problems can be obviated by strengthening interpersonal relations. Moreover, the use of formalization mechanisms such as contracts may reduce decision-makers risk perception and pave the way for collaboration and hence the development of mutual norms and other forms of exit barriers.

However, these means are just two of the numerous practices than can be taken into use by subcontractors and contractors. One can imagine several practices directed at conquering the problems of physical distance in such information and interaction-demanding situations. As the development of information and communication technology commences, the groundwork is laid for novel forms of technology-based collaboration in international subcontractor relationships. Hence, although physical proximity undoubtedly will continue to be a competitive strength for subcontractors, new forms of interorganizational practices will certainly strength as substitutes and even rival forms of organizing technology-based subcontractor relationships.

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Appendix 1: Respondents distributed on subcontractor type based on responses on customer relationship attributes

	Stan-dard	*Traditi-onal*	*Development-oriented*
Does the contractor provide materials and/or components for your firm to further process	Yes	-	No
Do your firm actively participate in contractor product develop-ment activities	No	No	Yes
Do contractor partake in your product development activities	No	Yes	No
Are products usually developed from contractors specifications	Yes	-	No
Do contractors exchange product development ideas with you	No	No	Yes
Do you develop products and processes together with contractor	No	No	Yes

-: Both answers are applicable in this subcontractor category cell 1&4

Danish **R**esearch **U**nit for **I**ndustrial **D**ynamics

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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