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MANAGING PRODUCT DEVELOPMENT PROJECTS ACROSS FIRM BOUNDARIES

- EXPERIENCES FROM THE CONSTRUCTION INDUSTRY

by

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Abstract

In this paper, we discuss co-operative product development across firm boundaries. Firstly, we discuss reasons why innovation may beneficially be co-ordinated among firms, and we provide some empirical evidence for the existence and significance of the phenomenon. Secondly, we discuss the relevance of co-operative innovation for the construction industry which, at present, is characterised by low degrees of innovation *and* co-operation. We then present the results from a co-operative product development project within the construction industry. Lastly, we discuss managerial implications which may be drawn from the study in relation to co-operative product development in the construction industry.

Introduction

'Division of labour' and 'innovation', respectively, are generally argued to benefit individuals, firms, industries, and nations. Precisely due to the division of labour among firms, innovation may beneficially be co-ordinated across firm boundaries. The construction industry is an industrial setting in which the degree of innovation and inter-firm co-ordination is low. In several European countries, this is regarded as a problem, and national councils have instigated programmes aiming at increasing innovation *and* inter-firm co-operation. As firms within the industry are inexperienced with such efforts, how do they approach such endeavours, what are the results, and what may be learned from the difficulties they encounter?

The division of labour and knowledge

Smith (1776) proposes that the primary cause of wealth and improvement in the productive powers of labour is the *division of labour*. By dividing work among individuals, firms as well as nations, it is possible to increase the quantity of work which can be carried out by any given number of individuals, firms or nations. Smith (1776, p. 112-113) argues that there are three general circumstances underlying the rise and advantages of the division of labour. Although he primarily discusses these three circumstances in relation to individuals, they are also supposed to apply to firms and nations. Firstly, the division of labour enables an increase in the dexterity (skilfulness) of all workmen. As Smith (1776, p. 113) proposes *"The improvement of the dexterity of the workman necessarily increases the quantity of the work he can perform; and the division of labour, by reducing every man's business to one simple operation, and by making this operation the sole employment of his life, necessarily increases the dexterity of the workman"*. Secondly, by dividing work among individuals, it is possible to save the time commonly lost when passing from one type of work to another. As Smith (1776, p. 113) suggests *"a man commonly saunters a little in turning his hand from one sort of employment to another. When he first begins the new work he is seldom very keen and hearty; his mind, as they say, does not go for it, and for some time he rather trifles than applies to good purpose.* Thirdly, the division of labour has enabled the invention of machines which make it possible to increase the quantity of output which one individual can make. The inventing, in turn, is enabled by the division of labour partly as *"men are much more likely to discover easier and readier methods of attaining any object when the whole attention of their minds is directed towards that single object than when it is dissipated among a great variety of things"* (Smith 1776, p. 114). However, the invention of machines is also partly due to another type of division of labour which is not related to those who *use*

the particular machines when carrying out a particular productive activity but, on the contrary, to *"makers of the machines, when to make them became the business of a peculiar trade"* (Smith 1776, p. 115).

Specialisation, or skilfulness within a particular area, is assumed to be a *consequence* of the division of labour – not only a point of departure for dividing labour. As Smith (1776, p. 120) argues *"the difference of natural talents in different men is, in reality, much less than we are aware of; and the very different genius which appears to distinguish men of different professions, when grown up to maturity, is not upon many occasions so much the cause as the effect of the division of labour."* Following the same line of argument, Penrose (1959) argues that individuals as well as firms develop skills according to the activities they perform and the resources with which they work. Hence, dexterity, skilfulness, and competence arise in relation to the particular specialisms or foci which individuals, firms or nations pursue over a period of time. Somewhat similar arguments have been put forward by Loasby (1999, p. 50) arguing that *"the principal cause of the division of knowledge was the division of labour; for knowledge grows by division"*.

Exchange and co-ordination

A particular specialism is only meaningful to the extent that it is complementary to - useful for - other specialisms. As Smith (1776, p. 118) notes *"nobody ever saw a dog make a fair and deliberate exchange of one bone for another with another dog"*, but as opposed to other races of animals, human beings have a particular propensity – namely, "*the propensity to truck, barter and exchange one thing for another"* (Smith 1776, p. 117). Therefore, "*among men [..] the most dissimilar geniuses are of use to one another; the different produces of their respective talents, by the general disposition to truck, barter, and to exchange, being brought, as it were, into a common stock, where every man may purchase whatever part of the produce of the other men's talents he has occasion for"* (Smith 1776, p. 121). In other words, *exchange* is a prerequisite for the usefulness of the division of labour; if exchange was impossible, the division of labour would be equally so. Furthermore, the division of labour, which can be profitably pursued, is assumed to be 'limited by the extent of the market'. Smith (1776, p. 12) argues that *"as it is the power of exchanging that gives occasion to the division of labour, so the extent of this division must always be limited by the extent of that power, or, in other words, by the extent of the market."* Hence, the division of labour is assumed to arise in relation to the *quantity* of the demand for the specialised produce of individuals, firms or nations. On markets, the demand and supply of homogeneous products, i.e. the outputs of and inputs for specialised individuals and firms, are quantitatively adjusted to one another on the basis of price signals, as money is perfectly divisible. The need for money to be perfectly divisible was, as Smith (1776, p. 127) argues, the reason why metals were originally preferred as the instrument of commerce and circulation. Furthermore, it is generally assumed that markets which are characterised by *perfect competition* are advantageous for society in the sense that they rule out the existence of monopolies as well as collusion among small number of buyers or sellers, respectively. Perfect competition is defined as *"the existence of many buyers and sellers of each homogeneous commodity and by the absence of any artificial restraints upon their activities"* (Richardson 1960, p. 7). Hence, markets offer a particular type of *co-ordination* for the exchange among individuals or firms namely that of *spontaneous co-ordination* of homogeneous products, and neither buyers nor sellers accept any obligations with regard to their future conduct.

However, other types of co-ordination are possible than co-ordination via markets. As Coase (1937) points out, some co-ordination takes place *within firms*, where the price mechanism is superseded by authority, or direction, due to the advantages offered in terms of lower transaction costs and flexibility. As Coase (1937) argues, in order for exchange to take place in markets, contracts regulating and specifying the exchange need to be devised. However, in cases where a particular factor of production is required repeatedly, it is possible to have only *one contract* with the supplier of that factor of production *within* a firm as opposed to the *series of contracts* which would be required if the exchange was to take place on markets. The types of contract used within a firm also have the advantage of reducing the need for precise forecasts and, as such, the need for knowing precisely which particular factors of production, in which particular quantities will be required at which particular points in time. Therefore, as Coase (1937, p. 392) proposes, *"a firm is likely therefore to emerge in those cases where a very short term contract would be unsatisfactory"*. Hence, Coase focuses on *two* types of co-ordination: direction and market exchange, and he views these two as *"islands of conscious power in this ocean of unconscious co-operation like lumps of butter coagulating in a pail of buttermilk"* (Coase 1937, p. 388). The propositions by Coase (1937), as well as the school-of-thought which has arisen around the concept of transaction-costs, may be criticised in several respects; however, since the main aim of this paper is not to discuss the nature of the firm, we shall instead proceed with a third type of co-ordination in which we are particularly interested given the purposes of the present paper.

Co-ordination across firm boundaries may take place via *co-operation*. Richardson (1972) was among the first who discerned between *three* types of co-ordination: market transactions, direction (i.e. hierarchy) or co-operation. As Richardson (1972, p. 885) argues, *"the habit of working with models which assume a fixed list of goods may have the unfortunate result of causing us to think of co-ordination merely in terms of the balancing of quantities of inputs and outputs and thus leave the need for qualitative co-ordination out of account"*. Hence, Richardson (1972) put emphasis on *co-operation,* or *qualitative and quantitative co-ordination, across firm boundaries* which may take place in *inter-firm relationships* and *networks*. Co-operation is assumed to be beneficial when the *activities* of one firm are *closely complementary* to the activities of another firm while the *capabilities* which form the basis of the activities in the two respective firms are *dissimilar* and, hence, unfavourable to manage and develop within the context of a single firm.

As mentioned earlier, market exchange assumes that the object of exchange is given and that there is a large number of buyers and sellers. However, if the object of exchange is not given, and the law of large numbers (Richardson 1972, p. 891) does not apply, co-ordination across specialisms involves the *matching* of *qualitative and quantitative* aspects. Hence, co-operation across firm boundaries is required. One particular case in relation to which qualitative and quantitative co-ordination is of relevance to consider is that of *product development* or *innovation* which, *per se,* involves (a) qualitative change and (b) exchange across firm boundaries. One particular aspect of innovation, which is stressed, for example by Dosi (1988), is its inherent *uncertainty* which regards technical as well as market aspects. Due to the existence of uncertainty, the need for communication, and the need for making investments, it has been argued, for example by Teece (1988), that *systemic* innovation may beneficially take place within firms. As opposed to *autonomous* innovations which can be introduced without modifying other components or items of equipment, *systemic* innovations require significant readjustment to other parts of the system (Teece 1988, p. 268). He proposes (1988, p. 263) that *"intra-organizational boundaries are typically more permeable than market boundaries – in part because secrecy is not jeopardized, and a common*

language can be employed", therefore *"integration facilitates systemic innovations by facilitating information flows, and the coordination of investments plans"* (Teece 1988, p. 269). Hence, following Teece (1988), innovation is assumed to take place within firms, and the innovations which cross firm boundaries in the form of products are assumed not to require 'significant' adjustments being carried out by the acquiring parties. In his early work, Richardson (1960, p. 117-118) touches upon the same issue when arguing that *"if the common policy demands different degrees of risk and sacrifice from the different firms, some more intimate form of association is likely to be required. The large multi-product firm, or the vertical integration of several stages of production, are themselves means by which, over a certain area, an appropriate assortment of intermediate and final output can be planned"*. However, the predictions which follow from these assumptions do not (always) concur with empirical evidence of co-operation among 'non-vertically integrated' firms which seems to comprise elements of innovation.

Innovation across firm boundaries

Freeman (1991, p. 500) argues that a large number of empirical studies have suggested (or confirmed) *"the central importance of external collaboration with users and external sources of technical expertise"*. In addition to suggesting the importance of networks for innovative activity, Freeman (1991, p. 500) stresses the importance of *informal* networks, which seem to be more important than formal networks, the latter of which involve explicit agreement on legal aspects and the sharing of costs, profits etc. originating from the innovative activity which is circumscribed by uncertainty and, consequently, difficult to foresee and specify. Such suggestions are based, for example, on the often-mentioned studies by von Hippel (1988) showing that technological information and know-how are often exchanged informally among engineers from different firms. Furthermore, Freeman (1991) points out that although there seems to be an upsurge in the number of innovative activities which cross firm boundaries, it is not a new phenomenon, but only a phenomenon which has not be paid much explicit attention until the latest decades. As Freeman (1991, p. 510) concludes *"networking for innovation is in itself an old phenomenon and networks of suppliers are as old as industrialised economies."*

Among the earliest, and most famous, studies which pointed to the empirical 'fact' that innovation takes place across firm boundaries, we find the studies of von Hippel (e.g. 1988), who notices the dominant role of users in product innovation processes. Based on a number of empirical studies von Hippel (1988) proposes the 'customer active paradigm' (CAP) as opposed to the more traditional 'manufacturer active paradigm' (MAP). The MAP describes the more 'well-known' (at least in textbooks) situation where a manufacturer, by employing traditional market research methods, identifies user requirements which guide the development of new products. Conversely, CAP describes the situations in which (a) a user has an idea for a new product and approaches a manufacturer with the suggestion that the manufacturer can transform the idea into a new product and launch it on the market or (b) a user has developed a crude prototype of a new product, and possibly even tested it, and approaches a manufacturer with the suggestion that the manufacturer can further refine the ideas incorporated into the prototype into a new product and launch it on the market. In addition to these two most well-know types, he also suggests 'the supplier active paradigm', which describes the situation in which a supplier has an idea for how their products (which may be e.g. a new material or component) can be used for a new product (for a manufacturer) and approaches such a manufacturer with the suggestion that the manufacturer can transform the idea into a new

product and launch it on the market. In the 'wake' of the studies and propositions of von Hippel, (summarised in his 1988 book) other studies promptly followed, for example, Foxall and Tierney (1984), Voss (1985), Håkansson (1987), Foxall (1989), and Biemans (1991). These studies elaborated on the studies by von Hippel by looking at different 'phases' in which external parties were involved in innovation as well as looking at different types and numbers of counterparts involved in the innovation process. Over time, the involvement of external parties in technical development has been discussed and conceptualised by many researchers operating from many different theoretical perspectives and empirical angles. Some of the studies are more managerially oriented, such as Rothwell (1992) who proposes that contemporary generations of innovation processes encompass a high degree of co-operation with different types of counterparts; Tidd (1995) who suggests that firms' ability to develop and commercialise new products, among other things, depends on the firms' links with external organisations such as suppliers and customers; and Tidd, Bessant and Pavitt (1997) who discuss the general importance of external co-operation. Others studies are more explicitly theoretically grounded or related, such as Van de Ven et al. (1999) who discuss 'the importance of creating dynamic networks for the purpose of carrying out specific projects' on the basis of the socio-cognitively inspired processual studies and theorising originating from the Minnesota Innovation Studies; Dosi (1997) who, within the theorising of Evolutionary Economics, discusses how firms' innovative activities are based on learning from internally gained experience as well as from the experience gained from external sources such as e.g. customers, suppliers, universities, consultants, licensors and licensees etc.; and Lundvall (1988 and 1993) who stresses the importance of 'user-producer' interaction for product innovation both from a micro-economic perspective as well as from the perspective of national systems of innovation. Lundvall (1988) argues that relationships enable users and producers to exchange 'qualitative' aspects of demand rather than only 'quantitative' aspects of it (which is the only possibility in 'markets') – thereby relationships can enable single firms as well as national systems of innovation to become more innovative. Business relationships, and their function for innovation, have also been studied extensively by researchers within the Industrial Network Approach; see, for example, Håkansson (1987), Håkansson (1989), Waluszewski (1990), and Ford et al. (1998). All the studies within this stream of research corroborate the empirical 'fact' that innovation in industry often takes place informally among a number of firms, which have developed connected business relationships. Hence, such firms form part of 'business networks', and it is argued that such business networks, as opposed to 'markets', offer a mix of variation and continuity which is conducive to innovation in the aggregate structure of firms. Hence, business networks as a governance form may possess features which are superior to, but also complementary to, markets and hierarchies.

Two cross-sectional studies of innovation across firm boundaries

In order to asses the significance of innovation across firm boundaries, thereby assessing if the phenomenon is marginal or central to innovation in industry, let us take a brief look at two cross-sectional studies in which co-operative innovation or technical development has been investigated.

The first study is reported in Håkansson (1989 and 1990), and the data in this study originate from a cross-sectional study of 123 small and medium-sized Swedish firms. The types of technical co-operation, which were investigated in the study, comprise both product and process developments, and both formal and informal technological co-operation was

investigated. In general, the study centres on describing technological collaboration in business relationships. The second study is a Danish cross-sectional survey of 1022 small, medium-sized or large manufacturing firms, which is reported in Thøis Madsen (1999). The study centres on describing the extent of product development efforts within Danish industry in general, and on describing extent of co-operative product development across firm boundaries in particular. The study focuses on product development, only, and not on development of new processes. The type of co-operation, which is investigated in the study, is co-operation that involves two or more parties. Furthermore, both formal and informal co-operation is studied.

Firstly, we may look at the extent to which technical development is carried out in co-operation with external parties vs. internally. As shown in table 1, the Swedish firms differ with regard to the extent to which their technological development is internal or external. Furthermore, the table shows that approx 50% of the firms' technological development is related to external parties.

Relative share of development work involving collaboration		Companies	
Low share	0-9%	7%	
	10-19%	12%	
	20-29%	16%	35%
Medium share	30-39%	8%	
	40-49%	6%	
	50-64%	18%	32%
High share	65-79%	18%	
	☐80%	15%	33%
Total			100%
Weighted average value	48.6%		

Table 1: Relative share of development work in co-operation with external units (Håkansson 1990, p. 374)

If we compare these results to the ones found in the study of Danish firms, the findings are relatively similar - the Danish firms differ widely with regard to the extent to which their technological development is internal or external. This is shown in table 2:

Usually develops new products without co-operating (<50% of the projects)	Co-operates in half the projects (50%)	Usually co-operates on product development (51-99%)	Co-operates always (100%)
27%	14%	15%	44%

Table 2: Number of new products developed in co-operation with external parties in relation to the number of new products developed within a period of three years (N=252) (Thøis Madsen 1999, p. 22)

In general, the results of the two studies show a relatively high degree of consistency – regardless of them concerning firms in two different countries and concerning two different points in time (late 1980ies vs. late 1990ies). A large amount of technical development, including product development, is carried out in co-operation with external counterparts. However, both studies also show that not all technical (product) development is carried out in collaboration. Furthermore, both studies conclude that firms have different co-operation

profiles regarding technical (product) development. In the study by Håkansson (1990), the following profiles were identified (table 3):

Collaboration profile	Percentage of companies
Isolated companies	24%
Focused companies	36%
- *Mainly customers*	*(22%)*
- *Mainly suppliers*	*(3%)*
- *Mainly horisontal units*	*(11%)*
Companies with a broad co-operation profile	17%
Companies with a very broad co-operation profile	23%

Table 3: Collaboration profiles (based on Håkansson 1989, p. 55-56 and Håkansson 1990, p. 376)

In the study by Thøis Madsen (1999), the following profiles were identified (table 4):

Co-operation profile	Percentage of companies
The seldomly co-operating	28%
The supplier co-operating	11%
The supplier-customer co-operating	45%
The frequently co-operating	17%

Table 4: Co-operation profiles among Danish small, medium-sized and large industrial firms (based on Thøis Madsen 1999, p. 7)

In the study by Thøis Madsen, the four types of profiles were investigated in relation to the number of new products developed per firm. As shown in table 5, the frequently co-operating firms develop by far the largest number of new products per firm.

	The seldomly Co-operating	The supplier co-operating	The supplier-customer co-operating	The frequently co-operating
Number of product developments per firm	9,9	13,1	9,0	32,0

Table 5: Average number of product developments per firm in each of the four groups (Thøis Madsen 1999, p. 89)

However, even if the findings by Thøis Madsen (1999) suggest that co-operative firms may be more innovative, it seems as if the two studies, in general, offer support for the conclusion that there is no 'one best way' to be technologically innovative – different avenues may be open to industrial firms regarding the extent to which they carry out development internally vs. externally, i.e. they may have different co-operation profiles. This is, in fact, also stressed by Håkansson (1989, p. 147-148) stating that *"there are obvious economic reasons for maintaining a certain amount of external collaboration, and there are equally good grounds for not having too much [..] we would expect (that) [..] the best solutions in terms of profit and growth occur when the company invests about half its development volume in external collaboration"*; however, due to the large variation in the results, Håkansson (1989) concludes that *"what constitutes an appropriate proportion of external co-operation thus varies in relation to the company's situation"*.

Co-operative co-ordination on innovation across firm boundaries

Having established, in the two preceding sections, the existence and significance of co-operation across firm boundaries on innovation, we may return to the issue of co-ordination discussed earlier.

To reiterate, Richardson (1972) argues that *qualitative and quantitative* co-ordination may take place as *co-operation* across firm boundaries. He proposes (1972, p. 891) that *"we rely on markets when there is no attempt to match complementary activities **ex ante** by deliberately co-ordinating the corresponding plans; salvation is then sought, not through reciprocal undertakings, but on the stability with which aggregates, by the law of large numbers, are providentially endowed"*. Conversely, co-operation is relied upon, when the law of large numbers is not expected to apply, i.e. when it is beneficial to *co-ordinate ex ante* with *specific counterparts*. Such co-operation may comprise co-ordination of *investment plans* before they are carried into effect, co-ordination of the features, provision and use of *new products* before they are put one the market, as well as co-ordination of *production plans* before they are carried out. One benefit which is assumed to arise from inter-firm co-ordination *ex ante* is related to the observation that *"investments which are socially desirable might not appear profitable, if they had to be undertaken successively, although they would appear profitable if they were each part of a simultaneous and uniform advance"* (Richardson 1960, p. 99). Richardson (1960, p. 115) further argues that *"It may be possible to achieve substantial economies by large-scale manufacture of standardized intermediate products; but unless appropriate modifications are made in the nature of the products or the processes of firms which might use them, the intermediate production will not find a market"*. In other words, *simultaneous co-ordination* (co-operation) across firm boundaries is superior to *successive co-ordination* (market transactions) in the sense that the former lowers the risk for single firms when carrying out investments plans and various types of activities which are (closely) complementary to other firms' investments plans and activities. And, by lowering risk, it is assumed that the investment, innovation, and production which will is carried into effect on the basis of co-operation will be to the benefit of single firms, industrial structures, as well as society at large.

An addition matter of concern in relation to qualitative change and innovation is that of 'path-dependency'. For example, Richardson (1960, p. 114) argues that *"It is evident that, whatever the nature of the economy, the allocation of resources can never proceed on the basis of a **tabula rasa**; the existing pattern of production, and not merely current objectives and technical possibilities, will affect the composition of additional output."* Similarly, Teece, Pisano and Shuen (1997, p. 275) argue that *"a firm's previous investments and its repertoire of routines (its 'history') constrain its future behaviour. This follows because learning tends to be local. That is, opportunities for learning will be 'close in' to previous activities [..] this is because learning is often a process of trial, feedback, and evaluation. If too many parameters are changed simultaneously, the ability of firms to conduct meaningful natural quasi experiments is attenuated. If many aspects of a firm's learning environment change simultaneously, the ability to ascertain cause-effect relationships is confounded because cognitive structures will not be formed and rates of learning diminish as a result. One implication is that many investments are much longer term than is commonly thought"*. Somewhat similar arguments, from different theoretical perspectives, are proposed by Kogut and Zander (1992), Loasby (1999), Håkansson and Waluszewski (1999) and Holmen (2001). In other words, development of new products and adjustments related to their provision and use are required be related to the existing resources and patterns of production of the firms

involved. Furthermore, if firms are (regarded as being) different (i.e. heterogeneous), the qualitative and quantitative co-ordination implies taking into account the idiosyncratic resources, and the available capacity, of the particular counterparts, with whom co-operation is undertaken. In other words, even if it is possible to switch counterparts, switching is not (necessarily) unproblematic. Such aspects are, in particular, stressed by researchers working within the Industrial Network Approach. Within this approach, it is assumed that qualitative and quantitative co-ordination among firms is facilitated by the existence of on-going relationships involving knowledge and experience with the resources of specific counterparts, and the concept of resource ties and activity links (Håkansson and Snehota 1995).

In this section, we have stressed the importance of and possible benefits from co-operative co-ordination of innovation across firm boundaries. Furthermore, we have emphasised the need for taking into account the existing idiosyncratic resources of the involved firms as well as the benefits which may arise if the interaction takes place within the context of on-going relationships. On the basis of the arguments put forward, we may expect benefits to arise if the co-operation among firms involves boundary-crossing *interaction* aimed at *jointly* defining and revising, *throughout* the innovation process, the nature of the (focal) new product and other (closely complementary) resources which are to support the provision and use of the new product. In addition, we would expect that the possible existence of on-going relationships would *facilitate* the above-mentioned type of interaction. Furthermore, we would expect that if interaction of the type mentioned above takes place among firms involved in co-operative innovation, it would be *reflected* in the outcome of the interaction process in the sense that the involved firms' different possibilities and restrictions would have been taken into account when creating the (focal) new product and its supporting provision and use structure.

The construction industry

The construction industry is characterised by a tender system which leads to a focus on standardisation of products and sub-contracting work, the ability to compare prices and choose the lowest price per product and sub-contract, competition between 'identical' and independent suppliers, and the use of different suppliers in each construction project. Furthermore, most work within the construction industry is organised as projects. The tender system as well as the 'project-organisation' of most work within the industry leads to a structure of firms with 'market-like' relationships - even if the firms encounter the same set of counterparts in various construction projects over time. It has been suggested that this structure with its lack of continuous, dense relationships between firms is the main reason for the lack of increase in efficiency and innovation in the construction industry (Cox and Furlong 1997). Lundvall (1993) argues that industrial structures characterised by arms-length relationships among firms are expected to impede development and introduction of new products. This accords with the observation by Dubois and Gadde (2000, p. 17) that *"strong reliance on standardised products and standardised interfaces between firms clearly does not foster technical development. [..] Therefore, it is not surprising that the only traces of product development found in this study were related to the input side of the material producers"*. The lack of innovativeness within the construction industry comes as no surprise if one considers the previously discussed importance of qualitative co-ordination across firm boundaries in order to make firms invest and change their resources, activities and products in a simultaneous rather than successive manner. We may expect firms within the construction industry to have little experience with innovative co-operative co-ordination across firm boundaries. As discussed earlier, skilfulness is a consequence of the division of labour; hence, firms which have not practised co-operation across firm boundaries can be expected to be relatively unskilful at it.

The lack of innovation within the construction industry is generally perceived as a problem. In several European countries there is on-going discussion, on the level of firms as well as on the level of the

industry, on how the rate of innovation may be enlarged; and, it is assumed that inter-firm co-operation is a requirement for increased innovation. Experience with co-operation across firm boundaries is often found within manufacturing industries where production takes place within controlled factory environments and where the supply of goods is merely a repeat process off a production line. Such experience may not be immediately transferred to the construction industry (Cox and Thompson 1997, p. 128). Cox and Thompson (1997, p. 128) argue that the type of co-operation on innovation in manufacturing has "*very little application to an industry such as construction where repetition is rare and works are procured typically on a one-off project-by-project basis"*.

It may be that it is possible to conceive of and design a construction industry which, more closely, would resemble manufacturing industries; this, in turn, might make it easier to rely on experience from the latter industries on co-operative co-ordination. However, the existing structure of the construction industry need be taken into account when attempting to increase the degree of inter-firm co-operation and expected increased rate of innovation. It is not possible to start with a *tabula rasa*, the new forms of co-ordination must be based on the existing structure. Therefore, it is important to study attempts at co-operative innovation across firm boundaries which, for the moment, are attempted within the construction industry. Because, by studying such attempts, it may be possible to learn and, on the basis of that, revise subsequent initiatives and endeavours into co-operative co-ordination within the construction industry .

Methodology and empirical basis

The method adopted in the paper is case research which implies investigating a contemporary social phenomenon within its real-life context (Yin 1989). The material gathered for the case study is both retrospective and real-time, and multiple sources of empirical evidence are used e.g. industry conference papers, company documents and in-dept interviews. Due to the limited number of cases studied, i.e. one, the type of generalisation aimed at is *analytical generalisation* (Yin 1989).

The empirical basis of the paper has been gathered in connection with the Nordic research project coined '**I**nterorganisational **P**rojects in **I**ndustrial **N**etworks' (IPIN). This project is carried out in collaboration between researchers at Swedish School of Economics and Business Administration in Finland, University of Southern Denmark, Uppsala University in Sweden, and Norwegian University of Science and Technology. More specifically, the empirical basis of the paper consists of a product development and construction project carried out among a number of firms in the Danish construction industry. Due to the lack of innovativeness in the construction industry, the Danish Industry Council has set up a programme explicitly aiming at changing the organisation form used in the industry. Among other things, the programme aims to encourage and enable firms within the industry to try out co-operative forms of organising-for-innovation. The Council formed the programme 'Process and Product Development in the Construction Industry' (PPC) for the years 1994-2001. The overall purpose of the programme was to 'stimulate renewal, development, and sharing of experience within the Danish construction industry in order to improve the quality of construction projects and secure their future'. The specific goals of the programme were to increase: (1) co-operation and vertical integration among firms within the construction industry; (2) competitiveness through product and process development and innovation in the construction industry; and (3) export and employment within the construction industry through improvement of the competitiveness, with special focus on increasing the productivity in construction projects.

The programme got underway in 1994, when the Danish Industry Council invited tenders for the competition for participating in the programme. Single firms were not allowed to participate in the competition – only consortia could hand in tenders. A consortium should

consist of a number of firms within the construction industry, e.g. contractors, architects, consulting engineers, and producers of construction materials. Each consortium was to hand in a proposal for a project in line with the goals of the PPC programme. In the proposal, specific development activities should be outlined. Furthermore, these development activities should be related to a number of specific construction projects in which the results from the development activities could be put into practice. Such projects containing both **D**evelopment projects and **C**onstruction projects, we shall hereafter refer to as DC-projects. In total, 29 different consortia handed in proposals for projects within the PPC programme, and four 'winners' were selected. One of the winners was a consortium whose main idea was to develop and build multi-storey timber-framed buildings. Such houses had not been erected in Denmark since the 1900th century. Furthermore, the firms were to *co-operate* on the development of such houses. Hence, the project was regarded as being highly innovative – aiming both at product and organisational innovation. The consortium consisted of a contractor, a consulting engineer firm, and an architect firm. In addition to these three firms, a sawmill, a producer of wood elements, a producer of insulation material, and a producer of gypsum were involved as associated partners. Furthermore, a research institute was involved in the project. Due to space limitations, we cannot describe the project at length in this paper; instead we focus, in the following section, on presenting examples of relevance to the focus of the paper.

Analysis

In this section, a number of examples relating to the *presence* as well as *absence* of *interaction* among the firms involved in the DC-project are presented. When structuring the examples, we have taken the new product –the multi-storey timber-frame system– as the point of departure. Therefore, we primarily focus on the presence as well as absence of interaction, across firm boundaries, related to the development, production and assembly of the wooden wall elements, the floor divisions and the joints which constitute the main parts of the multi-storey timber-frame system.

Example one: One of the reasons why the idea for the consortium came up was that one of the architects at that point in time read an article on multi-storey timber-framed houses erected abroad. The two main architects at the architect firm had always been interested in using wood for house construction; and, several decades ago, their joint graduate project from the Danish School of Architecture had actually focused on wood-based rowhouses. In addition to this, the consulting engineer firm had recently worked on a number of sports centre construction projects. These sports centres had been made with wooden tie beams. In the 'brainstorming phase', the workload was divided between the three firms in the consortium with approximately 40% on the consulting engineer firm, 40% on the architect firm and only 20% on the contractor, as the contractor had less knowledge regarding wood-in-construction. In this phase, the three firms interacted relatively intensively, and they developed material containing descriptions of the basic idea, drawings of a trial building, descriptions of development projects connected to the trial building, and a description of the organisation of the project and the co-operation between parties in the consortium.

Example two: The DC-project comprised 21 development projects, the results of which were to support specific construction projects. These development projects focused on issues such as IT, process development, logistics, organisation development, and technical issues related to e.g. fire resistance and noise insulation. The responsibility for these projects was divided

among the members of the consortium. The consulting engineer firm was responsible for the general technical construction system and specifications for the wooden elements, the contractor was responsible for co-ordination and logistics, and the architect was responsible for projects related to the outside facing of the houses, staircases, and wet- and bathrooms. The division of responsibility for and actual work in the development projects did not take place without problems. The consulting engineer firm wanted development projects partitioned according to a parts-of-building logic, i.e. floor, roof, wall etc. However, this conflicted with the logic of the architect firm who was not used to drawing floors, walls, and joints separately. The architect firm wanted to start with drawing 'an entirety', after having done that they wanted to 'go into the details'. However, the logic which eventually was pursued was the parts-of-building logic, and the respective parties carried 'their' development projects out relatively independently.

Example three: The sawmill which was selected, primarily by the consulting engineer firm, as an associated partner for the consortium, was a producer of wooden elements for prefabricated roof, rafter and façade elements. In the DC-project this sawmill was to produce floor divisions and internal walls for the multi-storey timber-frames. However, until the sawmill became involved in the DC-project, they had produced neither floor divisions nor wall elements. The sawmill was given drawings of the different wooden elements which were designed by the consulting engineer firm. Following this, the sawmill made some adaptations due to production technical aspects and they also made the detailed drawings of the joints. This was done relatively sequentially without a great deal of interaction; the consulting engineer firm first made the drawings, and then the sawmill made their own adjustments and designed the joints.

Example four: The sawmill had some discussions with the architect firm regarding how the main wooden elements were to be divided up in sections; these discussion centred on those elements which would be visible after the building had been erected. Furthermore, the two firms also did part of the detailed design activities together. The firms had not been involved in joint construction projects prior to this DC-project, but they collaborated without any problems.

Example five: The sawmill and the contractor had very little interaction during the DC-project, and the two firms had not worked together before. Since the sawmill had no experience with designing and producing internal walls and floor divisions for multi-storey timber-frames, and the sawmill's production facilities were regarded as somewhat old-fashioned with a low degree of automation, the contractor was rather sceptical as to the sawmill's ability to make the wooden elements according to the specifications.

Example six: Due to difficulties, among other things, with finding an interested building-owner, the DC-project was delayed for approximately half-a-year. This implied that the period during which the wooden elements for the DC-project were to be produced shifted from the winter half to the summer half of the year. This period is the busiest period for the sawmill due to seasonal fluctuations in their production. Hence, the sawmill did not have sufficient capacity to produce the wooden elements for the DC-project. Therefore, it was necessary to find an additional producer with sufficient competence and capacity to produce and deliver wooden elements during the summer half of the year. Since the sawmill is part of a group which comprises a number of wood element producers and wholesalers, the sawmill chose a wood element producer which had recently joined the group. The sawmill had some knowledge of the wood element producer and in their opinion the wood element producer had

the necessary competence for producing wooden elements and joints for the DC-project. Furthermore, the wood element producer had sufficient capacity available for producing the elements in the period during which they were required for the trial construction project. The further interaction between the wood element producer and the sawmill during the project was, however, very limited.

Example seven: After taking over the responsibility for supplying the wooden elements for the trial construction project, the producer of wooden elements had some interaction with the consulting engineer firm regarding the construction of the elements – especially regarding problems and possibilities regarding how they could be produced. However, the wood element producer felt that the design of the wooden elements did not benefit from their experience and ideas. Furthermore, there was no room for re-designs within a single construction project – the implementation of which the consulting engineer firm would have been in charge of. In general, production related considerations had not been incorporated to any considerable extent into the design of the wooden elements, and the wood element producer did not consider the elements to be 'production friendly'; hence, rational production was difficult to achieve.

Example eight: The contractor and the consulting engineer firm had a lot of discussions regarding the design, production and assembly of the wooden wall elements. Two aspects were regarded as very critical. Firstly, the contractor was of the opinion that the construction of the joints was too complicated - the consequence of this being that the contractor would have to spend a lot of time at the construction site finding ways of fitting different wall elements together with different types of joints. This was both a time and cost consuming activity and, in the view of the contractor, this could have been avoided by further developing and industrialising the multi-storey timber-frame concept. Secondly, the contractor was somewhat concerned about the wall elements being completely encapsulated by gypsum on both sides (in order to avoid the risk of fire). This encapsulation, in turn, increases the risk of moisture in the wall elements due to rain at the construction site during the assembly process. However, since the consulting engineer firm was responsible for the technical construction system and the specifications for the wooden elements, the contractor felt they had little influence on the final specifications.

Example nine: In the process of developing the wooden elements, the consulting engineer firm had both formal and informal interaction with a technological research institute in Denmark. This was not the first time the consulting engineer firm and the research institute had worked together. Their close co-operation had lasted for many years and dates back to the time when the main consulting engineer was employed as a researcher at the Technical University of Denmark. In order to test some of the technical details of the new building system, the research institute made a mock-up. In the mock-up, different aspects of the system were tested e.g. jointing details and noise reverberation. Originally, two different types of floor divisions were made on the mock-up. The mock-up was divided into four rooms – two below and two above. A sound-producing device was placed in one of the rooms, and the noise levels in the other three rooms were measured. This was done for all four rooms. Thereby, it was possible to compare the two different types of floor divisions. On the basis of these tests, it was concluded that none of the types of floor divisions made on the mock-up were 'optimal'. Therefore, some changes were made on the floor divisions, and new tests were made. Hence, in total three types of floor divisions were tested on the mock-up. In the process of making the mock-up, the research institute primarily interacted with the consulting engineer firm. The research institute had hoped that there would have been more

dialogue between them and the architect and contractor during the test phase. The contractor delivered the materials for the mock-up and got the results from the different tests, but their interaction did not work 'as intended'.

Discussion and conclusions

As discussed earlier, exchange between firms is a prerequisite for the usefulness of the division of labour. Looking at the Danish construction industry and, in particular, the focal DC-project, we can discern different ways of co-ordinating exchange between the firms. In the 'brainstorming phase', the consortium partners interacted heavily – they co-ordinated in a co-operative manner. One reason for this may be that developing ideas for new products is a relatively rare occurrence within the construction industry. Thereby, the involved firms had little experience with co-ordinating this type of activities, and it may have been easier to try out new ways of co-operative interaction in this phase. However, when the DC-project started and the consortium partners were to divide responsibility for various development projects, the firms applied their 'usual' way of co-ordinating. The firms did not interact across firm boundaries on technical issues to any considerable extent, and each firm made relatively independent decisions on technical solutions. Furthermore, the arms-length way of co-ordinating was not only used within the consortium, it was also to a large extend applied in relation to the associated partners, e.g. the sawmill which originally was to produce the wall elements and floor divisions. Both the contractor and the architect firm had very little interaction with the sawmill which was supposed to deliver the most important parts for the new product. The consulting engineer firm had some interaction with the sawmill, but not in a co-operative manner, which could have lead to joint development of specifications for the timber-frames. Hence, the DC-project was co-ordinated in an arms-length, market transactional way.

When the DC-project started none of the participating firms were specialists in constructing and erecting multi-storey timber-frame buildings, as this was considered 'totally new' in Denmark. However, the architect firm had some previous experience with designing wood-based rowhouses, the consulting engineer firm had been involved in a number of sports centre construction projects with wooden tie beams, and the wood element producer had some experiences with producing wood elements for one and two storey houses. As argued in the theoretical part of the paper, product innovation across firm boundaries require both interaction between the parties as well as knowledge of and experience with the resources of the counterparts. As the examples show, the different firms (a) did not have sufficient knowledge about the other firms' resources and skills when the project started and (b) did not interact intensively enough to develop this knowledge during the DC-project - thereby missing out on the opportunity to use the skills which the different actors actually had. Furthermore, the firms did not act as if they looked upon the DC-project as a starting point for developing new skills and resources which could be utilised in subsequent projects. If this was the case, according to theory, the outcome of the interaction process would reflect that the involved firms' different possibilities and restrictions had been taken into account when developing the new product and its support structure; and, in general, this was not the case.

The DC-project's amount of the involved firms' total business is insignificant. Furthermore, uncertainty exists as to the extent to which co-operative co-ordination within the DC-project may be valuable in relation to, or become integrated with, the parties' existing business. The DC-project is carried out within the PPC programme, and thereby special attention is paid

both to *innovation* as well as *co-operation* as a form of co-ordination. Following the PPC programme, the firms are to pursue these aims themselves; and it remains a question if the lessons learned will facilitate this.

Managerial implications

Firms involved in managing co-operative product development across firm boundaries may benefit from starting the process by looking at different ways of collaborating with specific counterparts, and thereby develop their co-operation profile from isolated or seldomly co-operating firms to more frequently co-operating firms or firms with broader co-operative profile. The reason for this is that co-operation is a specific co-ordination mechanism, which has to be learnt and tried out in different projects to gain familiarity with it. Especially in the construction industry, firms are very familiar with the market form of co-ordination which has been used for many years. Thus, we argue that managers need to learn how to co-ordinate in an interactive and co-operative manner. When firms within the construction industry have become familiar with co-operating across firm boundaries, the next step may be to try out co-operative *product development* in relationships with specific counterparts. We argue that on-going relationships may provide a facilitative context for development of co-operative innovations circumscribed by uncertainty by providing continuity as well as knowledge of and experience with the skills and resources of counterparts. However, even if relationships may facilitate innovation, they need to be *connected* in order to be useful for the firms involved in them – if not, the relationships may become isolated quasi-organisations. However, the ability to create *connected relationships* may require comprehensive change in the structure of the construction industry and the legal frameworks regulating exchange among firms. However, single firms are unlikely to bring about comprehensive change and, therefore, connected relationships among firms may need to be created with the purpose of effecting such changes.

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