

Standards as a co-ordination mechanism in construction

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Abstract

The use of standard materials in the construction industry allows producers to benefit from economies of scale while users benefit from flexibility in that contractors may work with different sub-contractors in different projects (Dubois and Gadde 2002). Thompson (1967) suggests that standards are one of three co-ordination mechanisms for handling interdependencies. The construction industry is characterised by different types of interdependencies and many actors are involved, requiring co-ordination. Dubois and Gadde (2002) identify four dimensions of co-ordination in construction, including co-ordination in the supply chain of building materials and co-ordination within projects. However, co-ordination is also required between the supply chain and the project. For example, Vrijhoef and Koskela (2000) focus on the interfaces between the supply of materials and components and the construction site when discussing different roles of Supply Chain Management in construction.

The aim of this paper is to inquire into the use of standard materials in the construction industry as a co-ordination mechanism in the interface between the supply chain (upstream of the standard materials) on the one hand, and the project/ site (use of the standard material downstream), on the other. Using some empirical examples of improvement efforts in the construction industry, we examine the implications of these changes for the standards themselves, the supply chain of the standard products, the projects using the standard and the interface between the supply chain and the project.

Keywords: Construction project, standards, co-ordination, interdependencies, supply chain

Introduction – use of standards in construction

In 1959, Stinchcombe claimed that whereas mass production depends on standardised *tasks*, construction is characterised by use of standardised *parts*. Research into standards in construction has since been concerned both with parts (e.g. Gibb 2001, Dubois and Gadde 2002) and tasks (e.g. Kadefors 1995, Landin 2000, Moatazed-Keivani et al 1999, Henry 2000, Blyth et al 2004, Gidado 2004, Yates and Anifotis 1998), but still the use of standards is 'poorly understood by many involved in the construction process' (Gibb 2001: 307).

The literature suggests numerous categorisations of standards in general (e.g. Brunsson and Jacobsson 2000, David 1987, Tassej 2000, David and Greenstein 1990). Tassej (2000) bases his categorization on the different economic functions of standards: standards can be developed to specify acceptable product or service performance (quality/reliability), to help provide scientific evaluation (information standards), to specify properties that a product must have for it to function with complementary products (compatibility/interoperability) or to limit a product to a certain range of characteristics (variety reduction). Hence, standards create a common language between the adopters and reduce the transaction costs. Moreover, Gibb (2001) defines standardisation to be 'the extensive use of components, methods or processes in which there is regularity, repetition and a background of successful practice and predictability, claiming that it is not the standard (component) itself, but the interface that is interesting' (308).

In construction, standards are used for numerous purposes in line with these economic functions, for example due to the uncertainty related to lack of complete specification, lack of uniformity and an unpredictable environment at the site (Gidado 1996). In addition to the uncertainty, Gidado suggests interdependence as the other main category of complexity in construction because of (1) the number of technologies and the interdependence among them, (2) the rigidity of sequence between the various main operations and (3) the overlap of stages or elements of construction. The nature of these interdependencies seems to call for local, rather than centralised adjustments, based on extensive use of standardised parts, even if the site-specific solution is customised (Dubois and Gadde 2002). Specific products are seldom developed for particular construction projects or a specific primary contractor (Dubois and Gadde 2000: 210). In contrast, 'collective adaptations' are applied, meaning that standardised products and systems have been developed over time, partly through interaction among the actors in the construction industry, partly as a result of norms and rules laid down by government authorities (p 211). This leads to strong interdependences among activities within projects partly because of substantial adjustments on site and that the bulk of products delivered being standardised. In line with this, Groák (1992) in Gibb (2001) states that 'standard components can be used to great effect to produce customized solutions' (: 312) because 'for each project a unique pattern of linkages with material suppliers and components manufacturers has to be established for all the flows.' (: 311).

The benefits from using standards are reinforced by enabling economies of scale in the manufacturing of building materials (Dubois and Gadde 2002: 622). Whereas Stinchcombe (1959: 437) claims that 'managers must trade off the need to achieve economies of scale in the product on standardised factory parts with economies of scope in various stages of assembly', Dubois and Gadde (2000: 211) argue that 'performance is enhanced when activities are moved from the site backward in the supply chain'. Vordijk et al (2000) discuss the use of standards in different types of construction supply chains, referred to as 'subsystems of the supply chain of the building industry'. They claim that similar to mass production, the core competence of supplier-dominated supply chain systems is in the efficient manufacturing and supply of *standardised components*, components that are part of closed systems and difficult to combine with other methods. In contractor-dominated supply chain systems, similar to batch production, the contractors work at different projects with the same technologies and a small number of contractors who know the design and methods used, thus specialising in *standard products* such as small houses, factories and warehouses.

To summarise, the literature seems to focus on efficiency and productivity in the production of standardised materials and on co-ordination within construction projects. Supply chains are seen as feeding into the project at the site, making substantial co-ordination necessary due to many and strong interdependencies and uncertainties.

Aim, scope and structure of paper

Following Stinchcombe (1959), the focus in this paper is the use of standardised parts. The aim of the paper is to inquire into the consequences of the use of standardised building materials in the construction industry. Viewing standards (in accordance with Brunsson and Jacobsson 2000 among others) as a co-ordination mechanism we look at them from two sides: (1) upstream, i.e. into the supply chains producing the standard and, (2) downstream, i.e. into their role in construction projects. We suggest that the standard constitute an interface between these two sides. Using some empirical examples of improvement efforts in the construction industry, we examine the implications of these changes for both the standard product, the chain producing the standard, the project using the standard and the interface between the chain and the project.

In the next section we present our analytical framework. Section three discusses four examples of improvement efforts in construction in relation to the framework, whereas section four presents a concluding discussion.

Analytical framework

The analytical framework relies on a combination of: (1) the three forms of interdependence identified by Thompson 1967, (2) the co-ordination dimensions in construction discussed by Dubois and Gadde (2000), and (3) the four roles of supply chain management identified by Vrijhof and Koskela (2000).

Interdependencies in construction

Thompson's interdependence concepts have been mentioned in prior construction research, albeit in a fragmented way (see for example, Winch 1989 and Shirazi et al 1996). According to Thompson (1967), there are three types of interdependencies in an organization, which require some means of co-ordination, hence to provide more understanding of *intra*-organizational structures. The framework, however, has since been used for analysis of *inter*-organisational issues, e.g. Stabell and Fjeldstad (1998) and Håkansson and Persson (2004) focusing on value creation logics, and Dubois et al (2004) suggesting that the framework can be used to understand interdependence within and among supply chains. This paper continues within the stream of inter-organizational applications of Thompson.

Coordinating based on pooled interdependencies

Pooled interdependencies are characterized by a situation where 'each part renders a discrete contribution to the whole and each is supported by the whole' (Thompson 1967: 54). An example in construction, provided by Winch (1989), is the project group, which shares little else than overheads with its colleagues. Another example is the way two specialists share a crane or other major equipment (Shirazi et al 1996).

According to Thompson it is mainly for pooled interdependence that standards provide a co-ordination mechanism. He argues that the use of standardization requires relatively stable and repetitive situations involving few decision makers. The rules or routines, constituting the standard, constrain 'action of each unit or position into paths consistent with those taken by others in the interdependent relationship'. Furthermore, he claims that standardization requires less frequent decisions and a smaller volume of communication during a specific period of operations than does planning, and planning calls for less decision and communication activity than mutual adjustment.

Coordinating based on sequential interdependencies

Interdependence may also take a serial form in that 'the order of interdependence can be specified'. The output from one activity is the input to the next, i.e. there is direct serial interdependence. However, as they all depend on each other, indirect interdependence exists too and makes pooled aspects present (Thompson 1967: 54). Sequential interdependence in construction is typical in the traditional production process of material and components (Winch 1989). This is exemplified by Shirazi et al (1996) by the steel bender who bends bars that are then fixed into a form provided by the carpenter; and the bricklayer who makes the brick-wall (output), which serves as that input for the plasterer. According to Thompson, sequential interdependencies require co-ordination by plan. They do not require the same degree of stability and routinization that is required for co-ordination by standardization and is therefore more appropriate for dynamic situations.

Coordinating based on reciprocal interdependencies

Where reciprocal interdependence is concerned 'the outputs of each become inputs for the others', i.e. each unit poses contingency for the other, but there is also pooled and sequential aspects to this kind of interdependence (Thompson 1967: 54). Under conditions of reciprocal interdependence, each unit involved is affected by the other. Shirazi et al (1996) exemplify reciprocal interdependence in construction as the way heating, ventilation and electricity all depend on, and have to be adjusted to, each other. Thompson concludes that reciprocal interdependence calls for mutual adjustments

Interdependencies and technologies

Based on these three types of interdependencies, Thompson (1967) suggests three basic models for handling different combinations: (1) long-linked technology is based on both pooled and sequential interdependencies, (2) mediating technology is based on pooled and reciprocal interdependencies, whereas (3) intensive technology is based on all three. He uses construction as an example to illustrate intensive technology: 'In the construction industry, the nature of the crafts required and the order in which they can be applied, depend on the nature of the object to be constructed and its setting; including for example terrain, climate, weather.' (Thompson 1967: 17). Accordingly, our starting point is that all interdependencies exist in construction and different co-ordination mechanisms, including standards, are required for handling these interdependencies. The question, however, is: In which dimensions of co-ordination do standards seem more appropriate than others, and how can we identify these dimensions?

Dimensions of co-ordination in construction

Dubois and Gadde (2000) propose a framework for how to understand co-ordination in construction. They identify four main co-ordination dimensions. The first dimension refers to co-ordination in individual construction projects (I). The second concerns co-ordination between projects from the perspectives of the individual contractors and sub-contractors (II). The third dimension deals with co-ordination beyond individual projects among firms that occasionally meet in projects (III). Lastly, the fourth concerns co-ordination in the supply chains resulting in deliveries of building materials to the construction sites (IV).

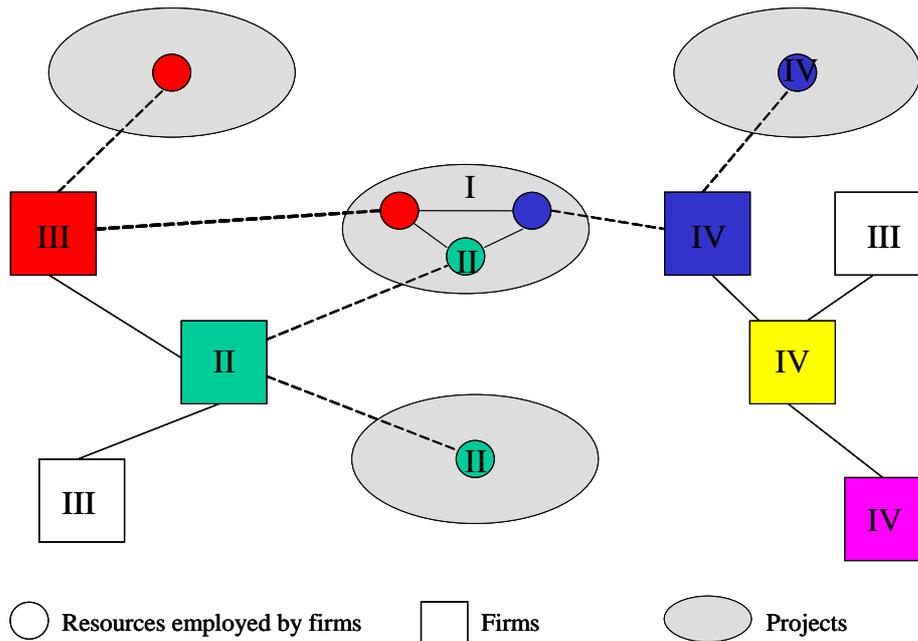


Figure 1. Four dimensions of co-ordination in the construction industry (Modified from Dubois and Gadde 2000: 212).

In any construction project, substantial adjustments have to be undertaken at the site while the bulk of products delivered are standardised. Therefore, 'the participating actors need to interact and compromise extensively to be able to make the necessary adjustments' (ibid: 212). As the resources of one particular firm are activated simultaneously in a number of projects, this creates potential problems of priorities if there is lack of capacity.

Dubois and Gadde conclude that most focus has been given to the project and the firm level, whereas the relationship level, i.e. among firms that meet in projects and in the supply chains of building materials, has not attracted as much interest as in other industries (2000: 213). In this paper we are concerned with the relationships in the supply chains in addition to the individual construction projects as well as the co-ordination between site, i.e. project, and chains feeding into it. Vrijhoef and Koskela (2000), discuss this particular interface as they identify four roles of supply chain management in construction (Figure 2). These roles represent different foci when management of the supply chain in relation to the construction site are concerned.

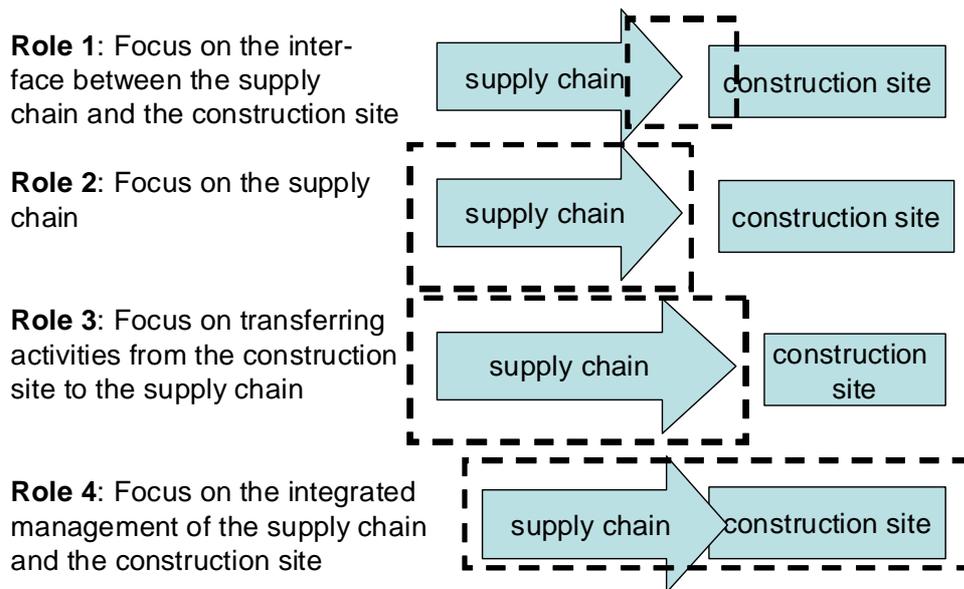


Figure 2: The four roles of supply chain management in construction (Modified from Vrijhoef and Koskela 2000)

The four roles of supply chain management represent a categorisation of different ways to focus regarding the supply chain, the construction site or both. In the first role the focus is set on the supply chain's interface with the site activities. Herein, the goal is to reduce costs and the duration of the site activities. Consequently, the primary consideration is to ensure dependable material (and labour flows) to the site in order to avoid disruption of the workflow. Hence, the main co-ordination is managed within the relationship between the 'direct' or closest suppliers and the buyer(s) of the building material i.e. the contractor or the sub-contractors. The second role focuses on the supply chain itself. As in other traditional supply chain management approaches the goal is to reduce costs in logistics, lead-time and inventories. In contrast to the two previous roles, the third one has to do with transferring activities from the site to the supply chain, i.e. prefabrication. Herein, the actual products resulting from the supply chains are altered. The main purpose of this focus is, according to Vrijhoef and Koskela, again to reduce total cost and duration by enabling concurrency. The fourth role focuses on integrating the supply chain with site production. Vrijhoef and Koskela exemplify such efforts by open building and sequential procedures. Open building entails postponement of decisions of users regarding the interior of the building by separating the infill from the structure of the building. Here the goal is to replace the usual temporary chains in construction with more permanent (traditional) supply chains.

Since our focus is set on the production and use of standard products we may categorise the four roles in two: The two first where the standard defines the interface between the supply chain and the construction project, and the two last where the standard, as well as the supply chain itself, is subject to adjustments.

Standards as a co-ordination mechanism for handling interdependencies – towards a framework

Returning to the focus of our paper, i.e. to analyse the consequences of both the use and production sides of the standardised products, we focus on (1) the supply chains behind the standardised building materials and, (2) their role in building projects. While the production side corresponds with the supply chain dimension of co-ordination, the latter focuses on the use of standardised building materials in the projects. It is the consequence of the use of the standard building material for production and project and the interface between them that is of interest here, as standards may be seen as constituting this interface. Hence, for our purposes it is the interface between the first co-ordination dimension (i.e. within project) and the fourth co-ordination dimension (i.e. in the supply chain) of Dubois and Gadde's (2002) framework that is interesting. Accordingly, we are interested in

the standard as a mechanism for coupling (i.e. coordinating) between the supply chain and the project. While the supply chain is mainly characterised by sequential interdependencies, reciprocal interdependence characterise the activities in projects. These different forms of interdependence are thus confronted at the interface between the supply chains and the project. Therefore it is of interest to scrutinise how changes in the standard itself, in the supply chain producing the standard, or in the project using the standard, impact on the co-ordination needs (due to changes in interdependencies) and means (i.e. co-ordination mechanisms). The roles identified by Vrijhoef and Koskela (2000) provide us with a tool for describing the changes.

Improving the efficiency in construction

There are numerous examples of recent efforts by individual companies to improve the efficiency in construction. Here we have selected a few that may capture and illustrate different approaches, and that may suit our purpose of exploring the consequences of the use of standard products in construction. Hence, we have tried to capture a variety of initiatives based on what kind of actors that are taking the initiatives and how the changes may impact on the supply chain and the construction project respectively.

Examples of improvement efforts

Example 1. Contractors purchasing building materials from low cost countries

The larger main contractors in Scandinavia have started looking for sourcing opportunities in low cost countries. For building materials such as floors, kitchens, stairs, etc., the main opportunities seem to be found in countries such as Poland and the Baltic states owing to transportation costs and lead time requirements. Experiences show that the prices can be reduced by around 20 to 30%. The same kind of project based tendering processes practiced with domestic suppliers is applied and the logistics set-ups are organised on a case-to-case basis in cooperation between the supplier and the construction project.

Example 2. Manufacturers developing input materials for production of standard products

For producers of standardised building materials the development of the upstream activities is restricted in that the features of the standardised product when it is used cannot be subject to changes. An example of rather substantial changes of this kind is the input materials used for plaster-boards. From having previously only used plaster stone from Spain, the producers have added two other sources of plaster to the production of plaster-boards. One of these sources is plaster resulting as a rest product from oil energy production. Since oil energy production facilities are mostly run in situations where other energy facilities are utilised to their maximum capacity, the use of this source cannot be planned to the same extent as with other sources. Hence, the access to plaster from this process is uncertain since it depends on e.g. cold winters. The other alternative source is recycled plaster resulting from plaster-board scrap from construction sites. Using this source requires a process wherein the plaster is separated from paper etc.

Example 3. Contractors industrialising the building process

There are several examples of contractors that have set up construction factories wherein they produce parts of houses, or modules, according to efficient manufacturing principles rather than the traditional construction project logic. The use of prefabricated products represents such efforts. For example in building of sport stadiums, prefabricated tribunes have been used. Another example is one company that is simultaneously a contractor and a producer of prefabricated concrete elements. It aims at using more standardised moulds and input materials in the elements. This provides economies of scale and hence cost reductions. It is important to this company to "get into" the project as early as possible, so that the final product can be adjusted to these standard concrete elements.

The company has also established an overall operation department, responsible for both production and assembly. This enables more efficient co-ordination between the site and production plans and of the planning of transport from factory to site. As such some of the earlier site activities, i.e. assembly is moved to the supply chain, i.e. production.

Example 4. Manufacturers or distributors delivering ‘tailor made’ building materials

Manufacturers of e.g. plaster boards and insulation have tried to add value by adjusting their standardised products to specific buildings in order to move activities away from the building site. By doing this, the items supplied to the site are all specifically adjusted to fit in certain locations in the building, which put demands on detailed planning and internal logistics at the site. If some specific item becomes subject to damage it needs replacement by ordering new tailored items or by adjusting standard materials on site. Generally, the actors trying to sell these solutions have experienced difficulties in persuading the buyers of the benefits in relation to the higher price for these adjusted parts.

Analysis of the efficiency improvement efforts

The examples and the consequences of the initiatives for the activities undertaken in the supply chains and in the projects respectively are illustrated in figure 3. The coloured parts illustrate the parts that become affected by the changes, while the other parts remain unchanged.

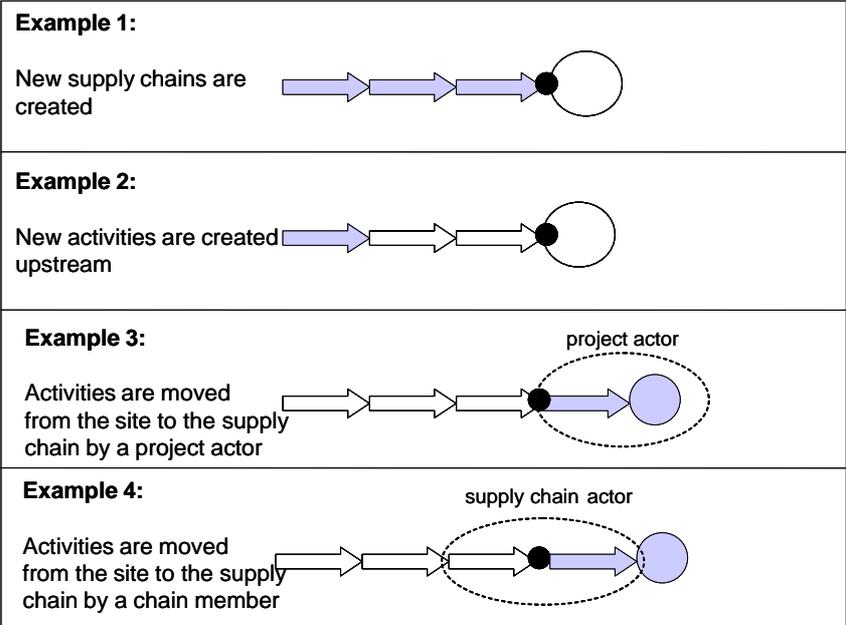


Figure 3: The four roles exemplified

The first two examples illustrate situations where the product itself is not subject to any changes, i.e. the standard itself remains unaffected. In the first example, a new supply chain replaces the previous one. By sourcing from low cost countries, instead of buying products produced in e.g. Norway and Sweden, prices can be reduced owing mainly to lower labour costs. However, major efforts to make the logistics and distribution solutions work may be required for the supply chains to become more cost efficient as a whole. Assuming that the quality and supply of these products are unaffected by the change there are no apparent effects on the co-ordination within the individual project. However, since this way of sourcing also entails a change of the purchasing cost structure this may require a certain purchase volume and so the larger contractors are possibly the ones that might gain the most from such efforts. Hence, pooled interdependence among users of the ‘old’ supply chains may suffer and thus smaller buyers may become negatively affected. Consequently, this kind of change may result in consolidation and concentration in the network as a whole. In addition, in order to benefit from the

supply chain and/or purchasing investments that may be required for these solutions to work efficiently they may also entail a need to improve the second dimension of co-ordination i.e. in between projects wherein the contractor is engaged. In this regard the new solution may thus become less flexible compared to the previous situation.

The other example focusing on changes that may be undertaken without affecting the standard product is technical development or changes upstream the supply chains. In order to create these new solutions mutual adjustments between the different project actors may be needed for instance as in the plaster example, by adjusting the handling of waste in construction projects to the need and processing of input material in the production of plaster boards. However, in these cases fewer adjustments are needed since the most part of the supply chain is unaffected, i.e. the manufacturer and the supply chain, including e.g. distributors, remains the same.

The third example concerns efforts to move previous on-site activities to permanent 'construction factories'. Hereby, it also becomes possible to develop more 'permanent' supply chains and to adjust activities and resources upstream to the activities and resources at the factory. Apparently, this also changes the products delivered to the construction site and possibly also the extent of standard products delivered to the site. Hereby, also the co-ordination in the supply chain in relation to the co-ordination at the site becomes more critical. In addition, the need to utilise the resources in the factory efficiently stresses the need to co-ordinate in between projects. Furthermore, the 'permanent' nature of the supply chain implies that reciprocal interdependencies can be explored by mutual adjustments among different parties in the supply chain and the construction factory in terms of logistical solutions etc, while still exploiting on pooled interdependencies in the supply chains in relation to other buyers of the standardised products. To enable efficient handling of reciprocal interdependencies remaining at the site, the need to adjust the work among project actor constellations may grow stronger.

The last example concerns building material manufacturers' efforts to deliver tailor made products to the site. This also implies a stronger focus on co-ordinating the activities and resources in the supply chain with the activities on site. Hence, both sequential and reciprocal interdependencies are increasing as an effect from this change.

The two last examples both stress an increasing need for co-ordination between the activities and resources in the supply chains with the activities and resources at the construction site. Hence, for these solutions to work efficiently at the site the potentials in developing more 'permanent' relationships with other project actors such as architects, consultants and sub-contractors may be greater than when using more standard material at the site in order to benefit from specialisation and routines that may replace the project specific mutual adjustments needed to deal with 'local' reciprocal interdependencies with joint adjustments that may be used across a number of projects.

Concluding discussion

The use of standards in construction has been dealt with in various ways in the literature. Following Stinchcombe's (1959) distinction between standardised tasks and standardised parts, we have in this paper chosen to focus on the latter, i.e. the use of standardised building materials in the construction industry. Many authors argue that the use of standardised parts increases efficiency through making it easier to coordinate within each construction project and each supply chain feeding into the project.

We started out this paper with the aim of inquiring into the consequences of the use of standardised parts for both the production (i.e. the supply chain behind the product) and the use of such products (i.e. the project in which the product is used). By using four empirical examples of different efficiency improvement efforts, we examined how the use of standardised parts affected and were affected by changes in the interface between the supply chain behind the product and the project in which the product was used.

In this section we will elaborate further on some issues emerging from the preceding analysis, which we consider as important in relation to the use of standard parts in construction. One interesting issue is the pre-requisites for when standard parts actually provide efficiency.

Seen from the point of view of the supply chains for standardised building materials the pooled interdependencies provide opportunities to gain from *economies of scale*. Also, the standardised way

of dealing with the sequential interdependencies enables exploitation of pooled interdependence to some degree, i.e. by using the same delivery conditions, routines and distribution facilities. From the users' perspectives the standards provides *flexibility* that (1) makes anyone able to buy any of the standardised products for any project, and (2) makes it possible to handle the complexities at the site where a lot of adjustments are needed and thus reciprocal interdependencies make themselves felt.

Taken together the standard products produced in construction supply chains and used in construction projects have important functions regarding how the main interdependencies can be managed (see figure 3). However, the combination of what the two sides of the standard product gain from the use of standard products can also make it difficult to make any significant changes on any side of the standard product, or indeed of the standard itself. The standard products used function as de-coupling points where production and use are concerned, so that the strong interdependencies in construction projects can be separated from the supply chains wherein strong reciprocal interdependencies needs attention.

The main value configurations represented by supply chains and construction projects can be described by the logic of 'value chains' and 'value shops' respectively (Stabell and Fjeldstad 1998), in the way they are different when the major interdependencies are concerned. Production and use of standard products provide opportunities to keep these interdependencies apart. However, the structural consequences of this way of organising interdependencies may be hampering development in supply chains as well of within projects. Difficulties arise when trying to change on one side while not affecting the other.

However, economies of scale and scope are exploited by standardisation, similarity and specialisation where pooled interdependencies are captured by different firms using the same or similar features of a particular supply chain. Hence, since many firms buy the same, or similar, building materials resulting from the same supply chains, economies of scale can be captured in the activities performed by the firms in the supply chains.

Use of standardised building materials means that anyone can buy them, i.e. the client, the main contractor or a sub-contractor without creating any particular adjustments on site. Therefore, standardised products resulting from supply chains that anyone in the industry can access (although their purchasing conditions may differ) provides a high degree of flexibility in that no firm specific adjustments or long term co-operation is needed between the producers and the buyers of these materials. However, this may also hamper long-term efficiency improvements in that most change initiatives are associated with increasing interdependencies that are difficult to manage in the structure as a whole.

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