

The dynamic costs of coordination and specialization

Production activities and learning processes in the Danish
construction and furniture industries

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ABSTRACT

The paper deals with the relationships between specialization of production activities and coordination mechanisms, in firms as well on markets, aiming at explaining why patterns of specialization and coordination differ between industrial sectors; or between production systems or regional innovation systems. Based upon a theoretical discussion of the “activity-focused” model of coordination, and inspired by two empirical case studies, the paper builds a theoretical argument of the *dynamics* of coordination and specialization. It suggests that while there is a relationship between the activities undertaken by entrepreneurs (their specialization) and the mechanisms they apply to coordinate them within or across firm boundaries, entrepreneurs may experiment with changing their coordination mechanisms and/or their specialization, in order to minimize on production costs, transaction costs, and dynamic transaction costs. This dynamic process of *coordinating* by matching activities and coordination mechanisms is circumscribed by *dynamic coordination costs* and/or *dynamic specialization costs*. Some of these dynamic costs may be idiosyncratic to single firms, whereas some may be caused by the market context in which activities are carried out. Hence, the nature of dynamic costs within particular

sectors; production systems; or regional innovation systems may explain their different patterns of specialization and coordination.

I. Introduction

This paper is an early attempt of coupling insights from industrial economics; organizational economics; and organization theory, in order to further our understanding of *coordination mechanisms*, in firms as well as on markets. It deals with the relationships between coordination mechanisms, *specialization of production activities*, *information and knowledge*, and *learning processes*, and empirically supports its arguments with a comparison of two production systems, from within the Danish construction and furniture industries, respectively.

The paper views coordination as a transfer of information and/or provision of common knowledge amongst entrepreneurs, in order to align the interdependent industrial activities they undertake. The main argument of the paper is that while there is a relationship between the activities undertaken by entrepreneurs (their specialization) and the mechanisms they apply to coordinate them within or across firm boundaries, this relationship is *dynamic*, because entrepreneurs may experiment with changing their coordination mechanisms and/or their specialization, in order to minimize on production costs, transaction costs, and dynamic transaction costs. This dynamic process of *coordinating* by matching activities and coordination mechanisms, implies costs. We call the resource costs of identifying and applying coordination mechanisms *dynamic coordination costs*, and the costs of changing specialization *dynamic specialization costs*. Some dynamic costs may be idiosyncratic to single firms, whereas some may be circumscribed by the broader market context in which activities are carried out. Given large dynamic costs — for example, caused by frequent demand fluctuations or high levels of market opportunism —, some entrepreneurs may fail to match coordination mechanisms with activities. This may imply relatively high production, transaction, or dynamic transaction costs.

In section II of the paper, we review the existing theoretical approaches to coordination focusing upon information costs and interdependencies of activities. We argue that while this literature is useful in describing mechanisms of coordination in a much more detailed manner than merely distinguishing between “markets” and “hierarchies”, it fails to provide a full account for *when* and *why* various coordination mechanisms are applied.

Section III presents our propositions on dynamic coordination costs. Notably, it is proposed that processes of learning should be taken into account when investigating when and why particular coordination mechanisms are dominant. On markets with high resource costs to experimenting with and applying particular coordination mechanisms, such mechanisms are likely to be discarded, while in other contexts with low dynamic costs, coordination practices may be closer to the predictions of the theoretical models that focus on the nature of interdependent activities.

In section IV, we provide some empirical support for this argument by comparing two production systems that operate on different markets and with different dynamic costs: A case of roof production within the Danish construction industry; and a case of sofa production within the Danish furniture industry. The section accounts for the industrial activities undertaken within each of these two production systems; the interdependence of activities within each system; the applied coordination mechanisms; and their dynamic coordination costs.

Finally, section V provides some rumination on the implications of the paper on related research fields. In particular, the problem of *the boundaries of firms*, as well as the notions of *institutional environments* and *innovation systems* are touched upon.

II. Activities and coordination

Division of labor and coordination

As stated by Smith (1776), at the heart of economic prosperity lies organization — first and foremost, division of labor internally in organizations, as well as division of labor between organizations (what has since often been referred to as social division of labor, or *specialization*). Division of labor facilitates learning processes that upgrade skills (“dexterity”) at the level of single activities, as well as, with increasing market size, scale economies (Smith 1776). A division of labor also allows those who carry out each activity while trading with others to vary their product range, and to avoid lock-in to particular technologies (Storper 1992). Learning processes may also take place at the interface between specialized activities (Lundvall 1985; von Hippel 1988), as there is a division of knowledge between the activities (Hayek 1937; 1945).

Division of labor and knowledge however also implies *costs*, for example, in the guise of time costs; transaction costs; or dynamic transaction costs (loss of innovative capacity)(Langlois and Robertson 1995). Hence, the efficiency of a division of labor hinges upon *coordination* of activities. As Hayek (1937: 49) put it, there is a problem of “... how the spontaneous interaction of a number of people, each possessing only bits of knowledge, brings about a state of affairs in which prices correspond to costs, etc., and which could be brought about by deliberate direction only by somebody who possessed

the combined knowledge of all those individuals.”¹ Coordination can thus be defined as *an alignment of actions of agents who undertake different activities*, minimizing the costs of division of labor. Hayek’s contributions are clearly focused upon how “spontaneous” coordination arises in the market, and provide little insight into how entrepreneurs may deliberately design and apply coordination mechanisms, to coordinate activities within or between firms.

Hayek’s contemporary, Coase (1937), however founded a rapidly growing interest in the *institutional arrangement* of coordination, explaining the rise of firms as a such institution, functioning as an alternative to “costly” market coordination (notably, costly due to the functioning of the price mechanism, i.e. search and negotiation costs).² Coase was preoccupied with the problem of the boundaries of the firm, and simplified the question of coordination to a question of firms vs. markets.³ However, as noted already by Richardson (1972) and readily accepted by a range of very different scholars, a range of other institutional arrangements than firms may also facilitate coordination of activities — e.g. cooperative arrangements, alliances and “networks” between firms.

Taking a range of other costs — as well as institutional arrangements — into account, later contributions on coordination focus upon *the type of activities* that are coordinated. Coase’s most famous successor, Williamson (e.g., 1975; 1985) bases his contribution upon assumptions of incentive problems related to coordination, providing an elaborated typology on the way firms can coordinate activities through contractual arrangements.⁴

¹ Richardson (1960) rephrased this problem as “... how, in a competitive economy, a rational allocation of resources can result from the investment decisions of many independent entrepreneurs”.

² The costs of coordinating on the market are, according to Coase, dependent on the costs of (a) discovering the relevant prices and (b) negotiating and concluding a contract for each exchange transaction. Forming a long-term contract may reduce the costs of the latter and a firm is likely to emerge. The costs of using the firm are largely dependent on the number of transactions since (a) the costs of organising additional transaction within the firm may rise and (b) the entrepreneur may fail to arrange the factors of production in the best possible way.

³ In the words of Coase (1993 (1937):19): “Outside the firm, price movements direct production, which is co-ordinated through a series of exchange transactions on the market. Within a firm, these markets transactions are eliminated and in place of the complicated market structure with exchange transactions is substituted the entrepreneur co-ordinator, who directs production. It is clear that these are alternative methods of co-ordination production.”

⁴ Williamson (1985) distinguishes between four different institutional arrangements for coordination: *Market governance*, *bilateral governance*, *trilateral governance* and *unified governance* (ownership). The frequency (“occasional” or “recurrent”) and specificity (“non-specific”, “mixed” or “idiosyncratic”) of the undertaken transactions determine the appropriateness of an institutional arrangement. Market governance is the main governance structure for both recurrent and occasional non-specific transactions. Trilateral governance is used for occasional and (medium and highly) specific transactions. Bilateral governance is used for transactions facing the same problems, caused by medium or high specificity, of relying on market governance as trilateral organised transactions. But the recurrence of transactions allows for more specialised governance structures, such as bilateral and unified governance, to arise. Unified governance is likely to be used for recurrent and highly specific transactions.

Coordination, information, and knowledge, I: Thompson

While Williamson makes sophisticated observations on how incentive problems may arise from the nature of specialized activities and thus enhance the need for coordination, he loses sight of the other coordination problems that relate to the nature of activities. As Foss (2000) notes, coordination is not only about getting incentives right, it is also about aligning *information*, and, in some cases, *knowledge*.⁵ Thompson (1967) early addressed these problems. Without taking as an outset the question of firm boundaries, his focus is upon the different activities represented by a division of labor, and how they may be coordinated through aligning of information and knowledge. Thompson assumes that coordination mechanisms are serving to provide common knowledge and/or transfer information from one part of an economic system to another (for instance, from one activity in a value chain to another), according to the way production activities are dependent on each other. Thompson's original statement identified three different ways activities may relate, as well as appropriate mechanisms of coordination:

- *Pooled interdependence*, referring to a situation where activities belong to the same system, while not interdependent in any direct way. It can be described as a situation where "...each part renders a discrete contribution to the whole and each is supported by the whole." (Thompson 1967: 54). Pooled interdependence should be coordinated through *standardization*, involving "the establishment of routines or rules which constrain action of each unit or position into paths consistent with those taken by the others in the interdependent relationship" (Thompson 1967: 56).
- *Sequential interdependence*, describing a direct, non-symmetrical, relation between activities; for instance, activity 1 has to be carried out before activity 2 can proceed. Here, coordination by *plan* — such as work schedules — is appropriate.
- *Reciprocal interdependence*, characterizing a direct and ongoing symmetrical relation between two activities: Activity 1 depends on activity 2 and visa versa. With reciprocal interdependence, *coordination by mutual adjustment* (or by *feedback*) is suitable, encompassing "new transmission of information during the process of action" (Thompson 1967: 56).

The three mechanisms serve to coordinate through different levels of information transfer. The two latter coordination mechanisms have higher demands to information alignment than standardization, which in turn demands shared knowledge (represented by the standards). In particular, mutual adjustment is information costly, but is also more flexible, allowing for coordination under higher market uncertainty.

Coordination, information, and knowledge, II: Grandori

⁵ Further, aligned information or knowledge is often a prerequisite for incentive alignment (Foss and Lorenzen forthcoming 2002).

A more recent contribution, focusing even more explicitly on information and knowledge, has been offered by Grandori (1997; 2000). She views economic systems as a range of activities that are often connected in various ways, and argues that different mechanisms of coordination are applied simultaneously in value chains, or within firms. Thus, in Grandori's view, a coordination mechanism does not equal an institutional arrangement like a firm.

She outlines eight different mechanisms of coordination, grouped in four pairs:

- *Price* and *vote* coordination. Since a market includes an array of coordination forms (e.g. negotiation), in stead of *market* coordination, Grandori (1997) refers to *price* coordination, based on unilateral decisions. Using common codified information (i.e., price), each agent makes up an independent decision based on his local knowledge of his own productive or consumption activity. Besides price, no information is transferred between agents. *Voting* resembles price coordination in the sense that it is based on local knowledge and local decision-making. Here, each agent maximizes by choosing between a number of well-defined alternatives.
- *Authority* and *agency* coordination. In the case of *authority*, according to centralized managerial knowledge and transfer of information, a central agent makes decisions on subordinates' behavior. Since this does not allow for local decision-making through individual maximizing, control rights should also be viewed as centralized. This coordination mechanism is based on the premise that the central agent has the capacity to handle the information required for directing the behavior of subordinates, most notably, that monitoring (of e.g. output) is feasible. If this condition does not obtain, *agency* can serve as an alternative, using a mixture of incentives (as in the cases of price and vote coordination) and of monitoring mechanisms (as in the case of authority). In the case of agency coordination, parts of the decision rights, as well as of risks, are transferred to the subordinates. Both authority and agency demands bilateral information transfers between principal and subordinates in what Grandori (2000) terms a *partially connected* network. The principal transmits information to subordinates in the guise of more specific (the case of authority) or less specific (the case of agency) instructions. Subsequently, monitoring provides the principal with information on the behavior of subordinates, and he then uses for providing incentives, designing new instructions, etc.
- Coordination in *teams* and by *negotiation*. In *team* coordination, all rights are equally shared among a group of agents with homogeneous preferences and differentiated knowledge. Information is transferred without any hierarchy, and decisions are made jointly and unanimously. Closely related is *negotiation*, which is also based on reciprocal information sharing, but where conflicting issues are paid more attention. Negotiation processes lead to joint, but not unanimous, decisions. In these coordination mechanisms, relations and information transfers are multilateral, representing *totally connected* networks.

- Coordination through *institutionalization of norms and rules*. Rather than pertaining to calculations of interests, norms and rules (routines) that are common knowledge within a given context (e.g., a firm, or a network of firms) facilitate what Foss and Lorenzen (forthcoming 2002) term *cognitive* coordination, allowing agents to coordinate their actions by first coordinating their beliefs (expectations, plans, strategies, etc.). Using such institutionalized “signposts”, decisions are made unilaterally. Hence, these coordination mechanisms do not primarily serve to coordinate the actions of agents with different interests. Rather, they align the very interests.

As can be seen, these mechanisms represent different types of information transfer and use of knowledge. They span from a limited transfer of information in the cases of price and voting; hierarchical dissemination of information in the cases of authority and agency; local sharing of information within teams and negotiations; and in the case of norms and routines, only a limited information transfer is necessary due to the prevalence of shared knowledge. Due to their different information aligning properties, each mechanism of coordination is suitable for particular relations between activities. For instance, coordination by teaming is well suited for coordination of activities including a limited number of people exchanging extensive and complex amounts of information, whereas coordination by pricing is appropriate in situations with many people, exchanging only the limited and non-complex information represented by prices.

III. The dynamics of coordination and specialization

Thomson (1967) and Grandori (1997; 2000) represent an *activity-focused* model of coordination mechanisms — suggesting that the relational characteristics of activities determine which coordination mechanisms are applied. This suggestion however cannot provide a satisfactory account for the cases where different entrepreneurs apply different coordination mechanisms, even if they coordinate similar activities. The activity-focused model of coordination also fails to explain why coordination mechanisms may change, while coordinated activities remain the same — or vice versa. To remedy these problems, in what follows, we shall try to introduce some dynamics into the model.

Dynamic coordination costs

First, rather than regarding interdependencies as stable interactions (Staudenmayer 1998), a coordination model should take into account that coordination mechanisms are the institutionalized results of *learning processes*. Whereas prices; standards; and norms are often institutionalized results of organic (bottom-up) learning, authority; agency; and negotiation are often more planned processes. The important point, however, is that the outcome of any of each of these processes is not given in advance, as it comes about through experimenting with and changing coordination mechanisms corresponding to given contingencies. Even if important, the nature of activities is only one such

contingency. At a given time, other considerations may lead entrepreneurs to apply particular coordination mechanisms.

Second, a dynamic view upon coordination mechanisms should acknowledge that experimentation and change — i.e., learning — has information costs itself.⁶ Ideally, entrepreneurs may learn the appropriate coordination mechanisms for the activities they undertake, homing in on the mechanism of coordination (or combinations hereof) that minimizes production costs (such as time and material costs), transaction costs (notably, costs emerging from incentive conflicts between agents carrying out different activities (Williamson 1975; 1985), and dynamic transaction costs (lack of mutual adaptation and loss of innovative potential in the interface between activities (Langlois and Robertson 1995), as predicted by the activity-focused model. However, this process of learning depends on certain conditions. For instance, interactions have to be repetitive in order to allow learning, which in turn requires stable relations between the entrepreneurs who carry out the different activities. When entrepreneurs experiment with coordination mechanisms, they are also often influenced by their broader institutional environment, for example, by social conventions, laws, or high levels of social trust that point towards particular, dominant, ways of interacting. Such collective institutions solve entrepreneurs' "higher-level" coordination problems when two or more entrepreneurs have to *agree* upon which coordination mechanisms to apply (Foss and Lorenzen forthcoming 2002). If interactions are short-lived, and/or institutional environments are "thin" (for example, in industries with high demand fluctuations; project-based subcontracting arrangements; high levels of competition; sparse social relations between entrepreneurs; and few industry collective associations), the costs of learning new coordination mechanisms — what we shall term *dynamic coordination costs* — may be high.

Dynamic specialization costs

With high dynamic coordination costs, in order to improve on coordination, entrepreneurs may choose to experiment with their *division of labor* — changing the composition of activities — instead of changing coordination mechanisms. Like the process of coordinating, this process of specializing also has learning costs, i.e. *dynamic specialization costs*.

In other words, specialization is not given while coordination mechanisms are subject to learning. *Both* division of labor and coordination may be changed through learning processes, and economic organization, in firms as well as on markets, is a question of *coordinating*, namely achieving a match between the division of labor and coordination mechanisms that is relatively efficient at a given time. If dynamic specialization costs are higher than dynamic coordination costs, some entrepreneurs may dedicate the bulk of

⁶ Even if explicitly focusing on information transfer, Thompson and Grandori pay little notice to the creation and transfer of information on the relative efficiencies of different coordination mechanisms in different situations.

their recourses to learning new coordination mechanisms, while others may bear the relatively high production, transaction, or dynamic transaction costs incurred by a low level of coordination. At any rate, this introduction of dynamics into the activity-focused model of coordination complicates the relationship between the nature of activities and coordination mechanisms.

IV. Empirical example

In the following, we shall illustrate the argument put forward in section III by means of two case studies of production systems. With the outset in Grandori's (1997; 2000) categories of coordination mechanisms, we describe and compare the interdependence of activities and the application of coordination mechanisms in two different production systems. The case studies are deliberately chosen on account of their differences in learning capacity.

The purpose of this work is to:

- Illustrate that there is not a perfect match between the nature of interdependent activities and coordination mechanisms as suggested by the activity-focused model in section II. We find that while it is empirically possible to identify coordination mechanisms as suggested by Grandori, they are not applied according to the activity-focused model.
- Illustrate dynamic coordination costs and dig into their nature and causes. Concerning this objective, it is demonstrated by one of the cases that demand fluctuations and project organization may constitute impediments for some firms to lowering time and transaction costs through changing their coordination mechanisms.
- Illustrate the dynamics of coordinating, i.e., the changes in specialization as well as in coordination mechanisms. This issue is illustrated by one of the cases, where a coordination mechanisms seem rather stable compared to the changes in activities.

Two production systems in the Danish construction and furniture industries

We have chosen to investigate one production system within the Danish construction industry; and one within the Danish furniture industry. These two cases are selected because they represent high and low learning costs, respectively. Construction projects are usually complex, which makes it difficult for entrepreneurs undertaking different activities to locate causalities and learn accordingly (Levinthal and March 1993), and further, the project organization and thus temporary nature of supplier relations (Eccles 1981) means a low degree of repetition, further limiting learning (Slaughter, 1993, Boyed and Robson 1996, Barlow and Jashapara 1998). This is characteristic for the studied production system, namely on-site production of a roof, with the participation of different contractors. Furniture production systems on the other hand, often enjoy repeated

interactions and long-term supplier relationships. This applies to the studied furniture producers — a producer of upholstered sofas and its suppliers. Further, they are all located in an environment that is institutionally “thick”, notably in the guise of shared social conventions and expectations to cooperation, and a high level of social trust — more specifically, the industrial district of Salling in West Jutland.

The case studies aim at mapping the activities within the two systems; identifying their interdependencies; locating the coordination mechanisms used; and identifying the dynamic costs to coordination. Data on the two production systems have been collected in the spring 2001 by a combination of observations and semi-structured interviews. The differences of the cases necessitated different research practices. In sofa production, each activity is ongoing, routinized, and known by the management. Consequently, it was possible to collect the required data in a two-day period, starting with key-informant interviews supplemented with short interviews with employees.⁷ In roof production, the craftsmen switch to and from roofing activities and other activities on the building site. Hence, there are very busy days on the roof, and days of little activity. Furthermore, the specific way to perform each activity varies from time to time. Consequently, only the workers know many aspects of the activities. Hence, we had to apply a more time consuming approach, as the craftsmen, and not the management, had to be interviewed intensively.⁸

The data presented below concentrates upon activities and their coordination, and, due to the limited scope purpose of the empirical exercise, may seem to pay relatively little attention to questions of firm boundaries and firm size. These questions are addressed for the case studies elsewhere (Thomassen and Lorenzen forthcoming 2001).

The nature of production activities

⁷ We relied on existing empirical data on the firms (from Lorenzen 1999), and further spent 20 hours on interviews and observation in two furniture firms in the Salling district. The interview/observation started out with a guided tour by the production manager or similar, showing the flow of activities and asking questions. This provides the general view which in turn allowed for very focussed interviews with individual employees.

⁸ In total we spent 120 hours – distributed over a four-week period — on observation and interviews with the carpenters, ventilation people, carcase makers, roofing-felt makes, and plumbers involved in making the roof on a 30 department social housing building located in the northern part of Copenhagen. In order to compensate for any deviations in planned and actual way of performing activities, we were present when all major activities on the roof took place. The point of departure was the work done by the carpenters (the trade spending most hours on producing the roof). The daily activities of the carpenters were followed, including being part of lunch breaks etc. Besides giving the information presented here, being part of the environment gave way for discussing a wider set of issues related to the coordination and organization of roof production. And importantly, it made it possible to study coordination by *teaming* between carpenters — a mechanism of coordination we expected to have some importance in construction due to the low degree of standardization and routinization.

The activities involved in producing the roof and sofa, respectively, are outlined in figures 1 and 2. To simplify, we have focused our study on specialized *production* activities and how they feed into each other (in some interfaces, as specialized deliveries from one firm to another), excluding for example sales functions and deliveries of non-specialized inputs.

In roof-production, the activities performed on the building site, including deliveries, have been investigated. Seven firms have been involved directly in this process: producers of the carcass, haulage contractors, carpenters, the surveyor, ventilation contractors, plumbers (making the gutter), and roofing felt contractors. Usually one to two employees from each company have worked on the roof with the exception of the carpenter-company using four people during busy periods. Studying site-activities has also provided information about specialized inputs (i.e. rafters) and design activities – ranging from overall sketches to specific plans for single parts of the building - conducted by the architect. Sale-functions and the purchase of non-specialized inputs have not been studied.

Concerning sofa production, we have mapped the activities involved in making a sofa model named *Function*— a sofa for which a smaller firm A (15 employees in 2001, whereof three skilled) produces the hidden wooden frames, while a larger firm B (110 employees in 2001, whereof two skilled) does the upholstery (end production). The sofa case omits non-specialized inputs (e.g. raw wood, foam, fabrics), as well as (due to data constraints) a specialized supplier of visible wooden frames.

In the figures, each box represents an activity, that is, one continuous working process (resulting in tangible or intangible transformation of an input), as conducted by a single person using the same tool(s) or equipment (boxes with dotted lines may include more than one activity). Each color represents a firm. Boxes with a capital letter represents activities performed by the same person using the same tool for the same working procedure. For instance, the same person uses the same drilling machine for making holes for the joining of various part of the sofa (illustrated with an “A”).

Figure 1: Activities involved in producing a roof

-- INSERT FIGURE 1 HERE --

Figure 2: Activities involved in producing a sofa

-- INSERT FIGURE 2 HERE --

In the figures, it is evident that even though the number of man-hours spent on making a roof outweigh the number of man-hours spent on making a sofa, sofa production consists of at least as many activities. This of course has to do with the division of labor, and in turn the costs of coordination (we shall return to this issue shortly). Further, where sofa production is organized in sequences of activities located *within* two firms, roofing is

undertaken by a much higher number of firms, and implies a much higher need for *inter-firm* coordination.

Coordination mechanisms

In order to decompose the use of coordination mechanisms, we investigated different types of information exchanged. These different objects for coordination was identified as part of our empirical research (a test study of the installments of windows made this approach feasible) and includes information on: *Who* and *when* to do the activities; which *materials* to use and the *extent* of the work (how much to produce); the *finish* (look) of the output (if any further requirements than the one given by the materials and the extent of the work); and which *tools* to use and *how to do* the job. Finally, the coordination mechanisms also differ in terms of how they facilitate information transfer to undertake *quality control* and *resolution of doubts*. By juxtaposing the coordination objectives with the coordination typology offered by Grandori, a fine-grained matrix for describing coordination practices was created.

Roof production

The coordination of activities within roof production is much influenced by the fact that to a substantial degree, coordination is provided by external firms specialized in coordination and not done by the management of the producing firms. As we will touch upon in the concluding remarks, the externalization of coordination seriously limits the possibility of experimentation with coordination forms.

At the building site, the project management provides an overall timetable, specifying *when* (in which period) the activities have to be carried out (i.e., coordination by authority). Based on this, the foreman, clerk of works or similar superior within the company, also by authority, instructs a group of peers (i.e. people belonging to the same trade). Within this group, the exact division of labor is agreed upon by a process of teaming. Within very narrow limits teaming is also used for finding out when to do the activity.⁹ Coordination of *materials*, *extent of work*, and *finish*¹⁰ are predominantly ensured by the cross-firm authority exercised by the architects and engineers. Some simpler materials (screws, standard wooden beams etc.) are selected by the craftsmen themselves (based on their

⁹ The exact period, for which coordination by teaming is used, rarely exceeds the period of an activity. For instance, if the activity includes fixing wooden-plates to the rafters is expected to last three days, within this period, the carpenters are not told exactly when to do what. At the level of the foreman or clerk of works, besides by the overall time-schedule, specifications on progress in work is given on the weekly site meeting.

¹⁰ Not many instructions were given to the craftsmen on finish on the objects studied. For windows, the producers of windows took care of the major part of the finish. The majority of activities involved in the roof concerns hidden parts of the building in which finish for obvious reasons are not considered important. It is most likely that more instructions are used for visible parts of the building. Interviews with carpenters making the lowered ceilings in gypsum on the case-study site seems to support this.

routine) from the small on site inventory. The carpenters nearly always make decisions on *tools*. Without much reflection they take the appropriate (and multi-purpose) tool from the toolbox. *How to do the work* is also an area of coordination mainly left over to the judgement of the craftsmen. In the beginning of an activity there are elements of teaming inside the peer group, but mostly, work is done according to routines.

Quality control is to a large degree the responsibility of, first, the intra-firm clerk of works (or similar superior person internally in the company), and next, the inter-firm project management. However, peer group teaming is to some degree also used in the rare situations when a peer group (i.e. trade) performs subsequent activities: the quality of the previous activity is observed with how easy it is to perform the present ones.¹¹ Cross-functional teaming also takes place when one trade addresses another trade directly in order to make them improve their output. This is particularly predominant when the two trades are working on their respective activities at the same time. And finally *resolution of doubts* usually takes place by asking a peer (teaming) or superior closest to you (authority), that is, the foreman or the clerk of works. It is very rare that craftsmen take direct contact with more superior levels like project management or the architect.

Sofa production

In sofa production, activities are undertaken by fewer firms, whereof we have illustrated two in figure 2. A substantial part of the coordination is undertaken by structuring the work in a sequence of working stations within the two firms — the supplier of wooden frames (firm A), as well as the end producer of sofas (firm B). In both firms, each working station uses a specific machine and — depending on the batch — specific template. Allocating activities to specific working stations allows for coordination by routines, concerning *whom* to do the activity and obviously also which *tools* to use. In combination with the template made by the foreman or manager, the tool also structures *how* to do the job to a substantial degree. Which *materials* and how much to produce (*extent*) to use is very much given by the input from previous activities since the activities where new materials are added are few (see figure 2).

Structuring the work around a defined sequence of activities further provides some information on *when* to do the activity, since they workers simply process the input provided to them. Instructions from the management on which materials to use and when to initiate a batch triggers this process. Management also decides on which deliveries to make when. In this way, information on when to do the activities flows two ways. It flows forwards, since the output of one activity is the input of the next. And it flows backwards, since the foremen have the responsibility of making sure deadlines for outbound deliveries are met. In case the foreman in the assembly part (i.e. at the end of the value chain within the end producer of sofas) discovers delays, in agreement with foremen up stream, manpower is allocated to bottlenecks. The specific form of the reallocation varies, depending among other on the machinery. For machinery that demands personnel with

¹¹ For instance, if rafters are not in plump, fixing of wooden-plates becomes very difficult.

short training, most persons can be reallocated whereas only experienced personnel or skilled workers — very often the foremen — are used for more advanced machinery.

Doubts are almost completely solved ex ante to production, as the templates and the given sequences of working stations render few contingencies unforeseen. *Quality control* on the other hand, is required which to a high degree can be explained by deviance in inputs; in particular, the quality and color of leather products can vary. Quality control is not done by management or third parties, but follows from the set up of activities in a sequence: In most cases, defaults will be identified immediately by those who carry out the next activity.

The role of information transfer shifts. When a new batch is launched, management spend large efforts manufacturing the information needed to produce templates and instruct workers on exactly how to do the job.¹² In the development phase teaming and negotiation is used at the management level and authority at the level of the employees. Later, when production of a series is well tested and becomes routinized, management only contributes to the internal process of coordination by giving notice on when to produce which batches and providing deadlines, that is, deciding which customers to satisfy first. Employees work predominantly by standards and routines, that is, processes where little information transfer is needed. In this part of the process, the only instances where information transfer is again upgraded is when management step in, changing the sequences of work, in order to accommodate specific, urgent needs by customers. This was particularly relevant for the activities undertaken by firm A, the smaller supplier of wooden frames, having a range of different customers.¹³ In order to cope with urgent deliveries, management shuffles around orders which in turn makes it necessary for the foremen to adjust which activities they work on in the different part of the value chain. Consequently, the foremen — especially in busy periods — use some time on discussing which of the many ongoing production activities to put on the top of the agenda.

An interesting feature of coordination in ongoing sofa production is its reliance upon shared knowledge and knowledge embedded in machinery. This is made feasible by the recurrent nature of activities, and their integration into only two firms. Within these firms, little information is transferred directly between persons — not only because standards and routines govern actions, but also because information is embedded in how the

¹² In firm A, this work is conducted entirely by the manager-owner of the firm. In firm B, the process is the following. When an idea is accepted, an prototype is sketched out. Based on this, the management split the prototype up into different working operations which allows a first test batch to be produced. The head of each of the three departments in which production is divided, closely follow this process, writing down problems or potential improvements. After the test batch, a meeting is held with the head of departments and one representative from sale and purchase respectively, in order to revise working procedures. If revisions are made, a new test batch is produced, and if everything works out, the series is put into production. Usually two or three test batches are produced. This is in agreement with the experience in firm A: It usually takes two or three tests before everything runs smoothly.

¹³ Firm B mainly produces according to the sequence in which orders are given. Where the foremen in firm A ensure deadlines, a computerized system keeps track of progress in firm B. Each employee types a four-digit code for each operation completed.

products move along the value chain (in firm B, the information on how to carry out the activities in the sequence is printed on a production note that is stapled to each product). In daily operations, the role of management for coordination seems limited. But as described, it is management that “hardwire” coordination into machines, prescribing working procedures (i.e. activities), and fixing relations between working procedures. Hence, the role of indirect management is large.

In construction, the opposite is the case. Because of the nature of activities and their disintegration into a large number of firms, routinization and hardwiring of coordination cannot take place to a degree similar to the sofa production case. Relying on the skills and routines of single entrepreneurs,¹⁴ but not encompassing routinization of coordination or indirect management of the kind found in the sofa case, roof production relies on authority provided by direct management.

Interdependencies and dynamic coordination costs

High dynamic coordination costs in roof production

In the roof production case, the interdependencies among the main activities have been mapped out in figure 3.

-- INSERT FIGURE 3 AROUND HERE --

The strengths of interdependencies vary. The strongest interdependencies we find between (a) the design of roof including design of roof houses performed by the architect and the construction of the roof houses performed by the carpenters; (b) internally among the carpenters doing the roof houses and the erection of rafters; and (c) between these two activities and the installation of the ventilation plant by the ventilation contractors.

According to the activity-focused model as exemplified by Thompson (1967) and Grandori (1997; 2000), strong interdependencies should lead to application of particular coordination mechanisms. Exactly *how* strong interdependencies should be in order to provoke the application of a particular coordination mechanism, is not made explicit in the activity-focused model. But let us consider the most important interdependencies in the roof production case, examining if they lead to particular coordination mechanisms.

The relations between the carpenters making the roof, the ventilation people installing the ventilation plant, the carpenters subsequently making the rafters and the ventilation people laying out the ventilation tubes, is an obvious choice. Not only are these interdependencies among the highest observed, they are also of a reciprocal nature: the carpenters provide a input to the ventilation people who in turn provide an input to the

¹⁴ This corresponds well with the observation that in the roofing-case only skilled workers are used, whereas most workers in the sofa-case are unskilled.

carpenters, who again provide an input to the ventilation people. Hence, according to Thompson (1967), we would expect to see a relatively high degree of coordination by *mutual adjustment* in this relation. Grandori' (1997; 2000) contributions suggest that *teaming* is an appropriate response in such highly interdependent — and consequently information-demanding — relations with few agents involved.¹⁵

Yet, the carpenters do not report that these relations are coordinated in any particular manner. Rather, the coordination pattern follows the typical patterns as above described. This observation is supported in an interview with the architect, who reports that the degree to which he specifies how the carpenters should make their work and the degree to which the craftsmen have been involved in the planning process do *not* differ for the roof-house and rafter activities, when compared with other activities on the roof. Hence, there is no difference in the extent to which degree coordination by *authority* is used, meaning that teaming (and presumably reciprocal coordination) is not prevalent. In short, the roof case suggests that particular interdependencies between activities do not necessarily result in particular coordination mechanisms as predicted by the activity-based model. In particular, it seems striking how little *teaming* is used.¹⁶ Agent involved in roof production seem to apply “average” coordination mechanisms that coordinate on “average” expected coordination problems, rather than tailoring *different* coordination mechanisms to meet different coordination problems. This rigidity must partly be ascribed to the high learning costs within the construction industry, due to short-lived relations and demand fluctuations.

Low dynamic costs in sofa production

If we turn to sofa production, the level of learning is higher. For example, when new products are introduced, the management of firms A or B devote its resources to find out how to produce and coordinate sofa parts, or sofa, respectively. In turn, these consideration are transformed into standards and routines, where information is inherent in the product flow and the given structure of workstations.

However, learning pertains to the division of labor more than to coordination mechanisms. In fact, coordination mechanisms seem rather stable. Rather than developing more and more fine-tuned coordination mechanisms, these producers reduce the complexity of the coordination tasks, by simplifying activities. Hence, they reduce the amount of information that it is necessary to transfer. In this way even activities that in the outset are different can come into agreement with a simple coordination scheme —

¹⁵ Grandori (and Soda 2000: 5-7) does not consider *teaming* to be identical with *reciprocal interdependence*, since the former is used for an even “more intensive type of complementarity and interdependence” than the one triggering reciprocal interdependence.

¹⁶ In order to check for the general validity of this observation, the carpenters involved in the roof-case were asked if they ever experienced higher degree of teaming in building projects. The answers given indicate that the activity-based model can not be entirely written of. Teaming is more prevalent in refurbishment and in activities concerning installation shafts – works that is considered to have a higher degree of interdependence than the one general found in roof-activities.

reducing not only the information need when coordinating production activities, but also eliminating the need for further experimentation with new coordination mechanisms. Efficiency of learning — within as well as across firm boundaries — leads to a change of division of labor while maintaining a rather narrow spectrum of coordination mechanisms, and not to many fine-tune mechanisms adjusted to particular interdependencies. However, it is notable that a high level of learning has a positive impact on efficiency. Through such learning, even activities that first may require substantial transfer of information can later be coordinated by information-cheap means such as standards and firm-routines, as provided by the flow of product and a given structure of working stations. Hence, the sofa case challenges the activity-focused model by showing that activities may have a very high degree of interdependence while requiring little interpersonal communication.

V. Concluding remarks

In the above, we have investigated into the relationships between the nature of industrial activities, coordination mechanisms, and what we have dubbed dynamic coordination costs, by means of theoretical speculation as well as empirical evidence. Our effort has been tentative indeed, but we have come up with some novel suggestions. Most notably, we have pointed towards the limitations of a non-dynamic activity-focused model of coordination. Hence, we have suggested that even if coordination mechanisms ideally should serve to align activities, there may be learning costs prohibiting firms to apply particular coordination mechanisms, meaning that robust coordination practices may prevail even with different and shifting activities. Further, we have claimed that with low learning costs, some firms may experiment with changing activities (e.g., reducing their complexity and yet make them very interdependent) rather than coordination mechanisms. Thus, both case studies – representing different levels of dynamic coordination costs – suggest a much less clear cut between interdependence of activities and coordination modes than proposed by the activity-focused model of coordination mechanisms.

Our suggestions clearly need to be sophisticated, and supported by further empirical work. Nevertheless, in the present section, we will speculate on some possible implications and perspectives, if our suggestions are accepted.

First, our focus on coordination rather than institutional arrangement facilitates, like Thompson's and Grandori's activity-focused model, a better understanding of *firm boundaries*. Our case studies substantiate the claim that an important function of the firm is to act as a coordinator (Casson 1997). However, the case studies also suggest that the specific ways in which this happens vary. In the sofa case, the firms handled the coordination created by change in markets (coordination between value chains) and change in production systems (coordination within the value chain). In the roof case only the former aspect of coordination is the domain of construction firms since firms specialized in coordination handles the matching of activities along the value chain. The

extreme disintegration of production activities and the externalization of coordination – ultimately caused by fluctuations in overall demand – in the roof-case makes it more difficult to experiment with coordination since the application of new coordination modes and / or redefinition of activities is beyond the realm of a single firm’s management and interest: any experimentation with specialization would change firm boundaries. Conversely, in contexts where learning costs are low, firms are able to experiment to higher degrees with coordination mechanisms and divisions of labor, and this may also shift firm boundaries. For example, our sofa case illustrated that a critical function of a firm operating in environments with efficient learning is to structure and routinize activities, thereby lowering the internal need for information transfer. This in turn frees managerial resources, focusing the sofa producing firm upon finding new external suppliers, pushing processes of joint product development (see Thomassen and Lorenzen forthcoming 2001). Consequently — and in contrast with the classical coasian and the newer team-theoretic notions on the firm — the sofa case suggest that often information transfer and processing is more intense *between* firms than *inside* firms. This finding also suggest, at least for some production systems, that even though firm boundaries do not correspond perfectly with coordination mechanisms, there are some correlation.

Second, we have suggested that dynamic coordination costs, i.e. the learning costs of coordination, are dependent on the external (market) context of entrepreneurs and firms. This suggestion is interesting when we want to explain why firms are organized differently in different market contexts. Social institutions are center stage here. The suggestions made in this paper could be refined to provide more substance to “*innovation system*”-perspectives. Adding to the insight that innovation often takes place at the interface between activities (and hence firms), a focus upon dynamic coordination costs can provide insight into when innovation takes place at the interface between firms, and when it takes place within firm boundaries. Could it be that high dynamic coordination costs also are impeding for user-producer innovation? If firms — due to high dynamic coordination costs — are not able to improve the match between coordination mechanisms and activities, the scope for user-producer innovation may be limited (i.e., there is a trade-off between coordination and innovation here). Further, the scope for joint action and institutional change at the collective industry level may be severely limited (firms spend all their resources trying to coordinate everyday tasks, leaving little room for joint strategic action, or for forming industry-level social institutions, building social trust, etc.). And conversely, when do the cases where firms are able to coordinate their interactions so effortlessly that there is scope for user-producer innovations, and a general upgrading of their collective social environment through joint action and institutional learning, amount to “systems” that further minimizes dynamic coordination costs (i.e., the emergence of innovation systems at the sector or regional level — industrial *clusters* or industrial *districts*)?

The latter speculations seem relevant for what appears to be an empirical paradox: *How come that the Danish furniture and construction industries, in spite of many similarities, perform so differently?* Denmark has through the last 25 years been relatively specialized within these mature and low-tech industries, partly due to a high national level of design and wood production skills. Even if the two industries are subject to similar political

regulation and both experience high market fluctuations, the furniture industry is, contrary to the construction industry, experiencing a prolonged boom (causing a number of construction firms to move their activities into the furniture industry). The furniture boom rests upon a high innovation rate, jointly building institutions (trust); and jointly boosting skill levels within local labor markets. Within the construction industry, the innovation rate is persistently at a lower level, and attempts to build industry-level institutions to improve on the efficiency and learning levels of (the frequent) inter-firm relations have so far been little successful. Taking differences in dynamic coordination costs into account could help to explain these other differences between the industries: The construction industry may suffer from its high dynamic coordination costs, in that its agents focus much upon minimizing time costs and transaction costs through particular, rigid, coordination mechanisms that do not allow for high levels of product innovation given the present configuration of firms, nor shifts of firm boundaries that would boost the innovation rate.

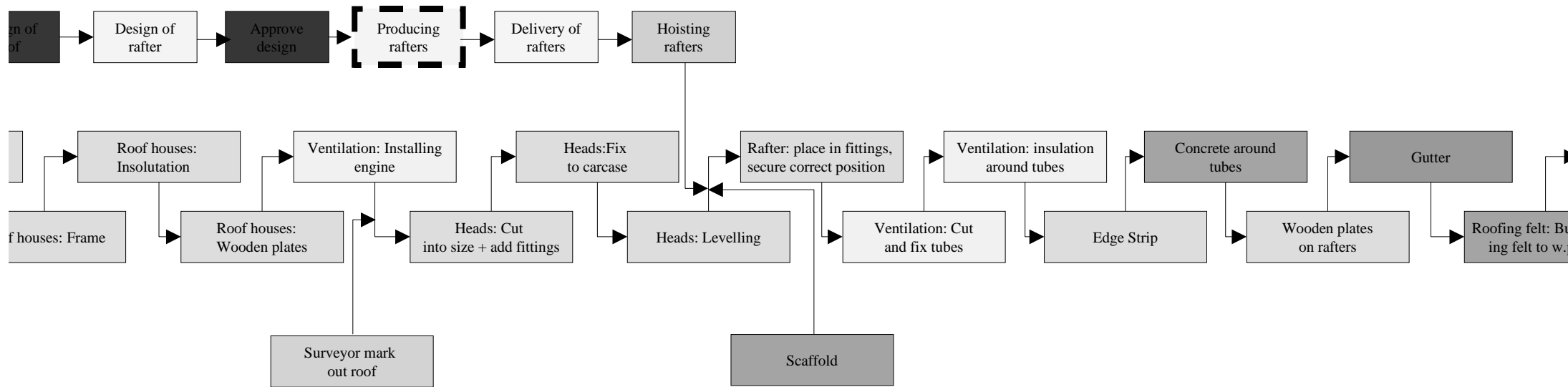
References

- Alchian, A A and H Demsetz (1972): Production, information costs and economic organization, in *Economic Forces at Work*, A A Achian (ed), Indianapolis: Liberty Press.
- Barlow, J. and Jashpara, A. (1998): Organisational learning and inter-firm “partnering” in the UK construction industry, *The Learning Organization*, vol. 5, no2, p.p. 86-98.
- Boyed, D, and Robson, A. (1994): Enhancing Learning in Construction Projects, *The Organization and Management of Construction: Shaping theory and practice* (vol one), eds. by Langford, D.A. *et al.*, E & FN Spon.
- Braczyk, H-J et al (Eds.)(1998): *Regional innovation systems*, London: UCL Press.
- Casson, M. (1997): *Information and Organisation*, Clarendon Press, Oxford.
- Coase, Ronald (1937): The nature of the firm, *Economica*, 4, November, p.p. 386-405.
- Edquist, C (Ed.)(1997): *Systems of innovation: Technologies, institutions, and organizations*, London: Pinter.
- Foray, D and B A Lundvall (1996): The knowledge-based economy: From the economics of knowledge to the learning economy, in *Employment and growth in the knowledge-based economy*, Foray and Lundvall (eds.), Paris: OECD.
- Foss, N.J.(2000): The Theory of the Firm – An introduction to themes and contributions, in *The Theory of the Firm, - Critical perspectives on business and management*, eds. N. J. Foss, Routledge, UK
- Foss, N J and M Lorenzen (forthcoming 2002): Foss, Nicolai J. and Mark Lorenzen (forthcoming 2002): Analogy and the emergence of focal points: Some suggestions for bringing cognitive coordination into the theory of economic organization, in Nielsen (ed.): *Uncertainty in Economic Decision-Making: Ambiguity, Mental Models and Institutions*, Cheltenham: Edward Elgar.
- Grandori, A. (1997): Governance Structure, Coordination Mechanisms and Cognitive Models, *The Journal of Management and Governance*, 1, p.p. 29-47
- Grandori, A, (2000): *Organization and economic behaviour*, London Routledge,
- Grandori, A. and Soda, G. (2000): A relational approach to organizational design, paper presented at LINK-conference, Copenhagen, October 2000.
- Granovetter, M (1985): Economic action and social structure: The problem of embeddedness, *American Journal of Sociology* 91: 491-510.
- Grant, R M and J C Spender (eds.)(1996): Knowledge and the firms, Special issue of *Strategic Management Journal*, 17.
- Grossman, S and O Hart (1986): The costs and benefits of ownership: A theory of vertical and lateral integration, *Journal of Political Economy* 94: 691-719.

- Hayek, Friedrich A. von. (1937): "Economics and Knowledge," in idem. 1948. *Individualism and Economic Order*. Chicago: University of Chicago Press.
- Hayek, Friedrich A. von, (1945): The use of knowledge in society, in idem. 1948, *Individualism and Economic Order*, Chicago, University of Chicago Press.
- Eccles (1981): The Quasifirm in the Construction Industry, *Journal of Economic Behaviour and Organization*, 2, p.p. 335-357.
- Langlois, R.N. & Robertson, P.L. (1995): *Firms, Markets, and Economic Change: A Dynamic Theory of Business Institutions*. London: Routledge.
- Levinthal and March (1993) The myopia of learning, *Strategic Management Journal*, p.p. 95-112.
- Lorenzen, Mark. (1999): *Localised Learning and Community Capabilities*. Copenhagen: Samfundslitteratur.
- Lundvall, B.-Å. (1985). *Product Innovation and User-producer Interaction*. Aalborg: Aalborg University Press.
- Lundvall, B A (1992): *National systems of innovation*, London: Pinter.
- Nelson, R R (Ed.)(1993): *National innovation systems: A comparative analysis*, Oxford: Oxford University Press.
- Penrose, E (1959): *The theory of the growth of the firm*, Oxford: Oxford University Press.
- Pralahad, C K and G Hamel (1990): The core competence of the corporation, *Harvard Business Review* 66: 79-91.
- Slaughter, S. (1993): Innovation and learning during implementation: a comparison of user and manufacturer innovations, *Research Policy* 22, p.p. 81-95.
- Smith, A. (1776). *An Inquiry into the Nature and Causes of the Wealth of Nations*, (Reprinted in part as Penguin Classics, Harmondsworth in 1979), London: W. Strahan and T. Cadell.
- Steinmueller, W E (2000): Knowledge and learning in the information age, paper presented to the DRUID sommer conference, Aalborg, June 2000.
- Storper, Michael. 1992. "The limits to globalization: Technology districts and international trade", *Economic Geography*, 1: 60-93.
- Thomassen, M A and M Lorenzen (forthcoming 2001). *Innovation vs. coordination?* LOK working paper. Copenhagen: Copenhagen Business School.
- Thompson, J.D. 1967: *Organizations in action*, Mc gGaw-hill book company, New York.
- von Hippel, Eric. 1988. *The Sources of Innovation*. New York: Oxford University Press.
- von Hippel, E (1990): The impact of "sticky" information on innovation and problem-solving, WP 3147-90-BPS.
- Williamson, O E (1975): *Markets and hierarchies*, New York: the Free Press.

Williamson, O E (1985): The economic institutions of capitalism, New York: The Free Press.

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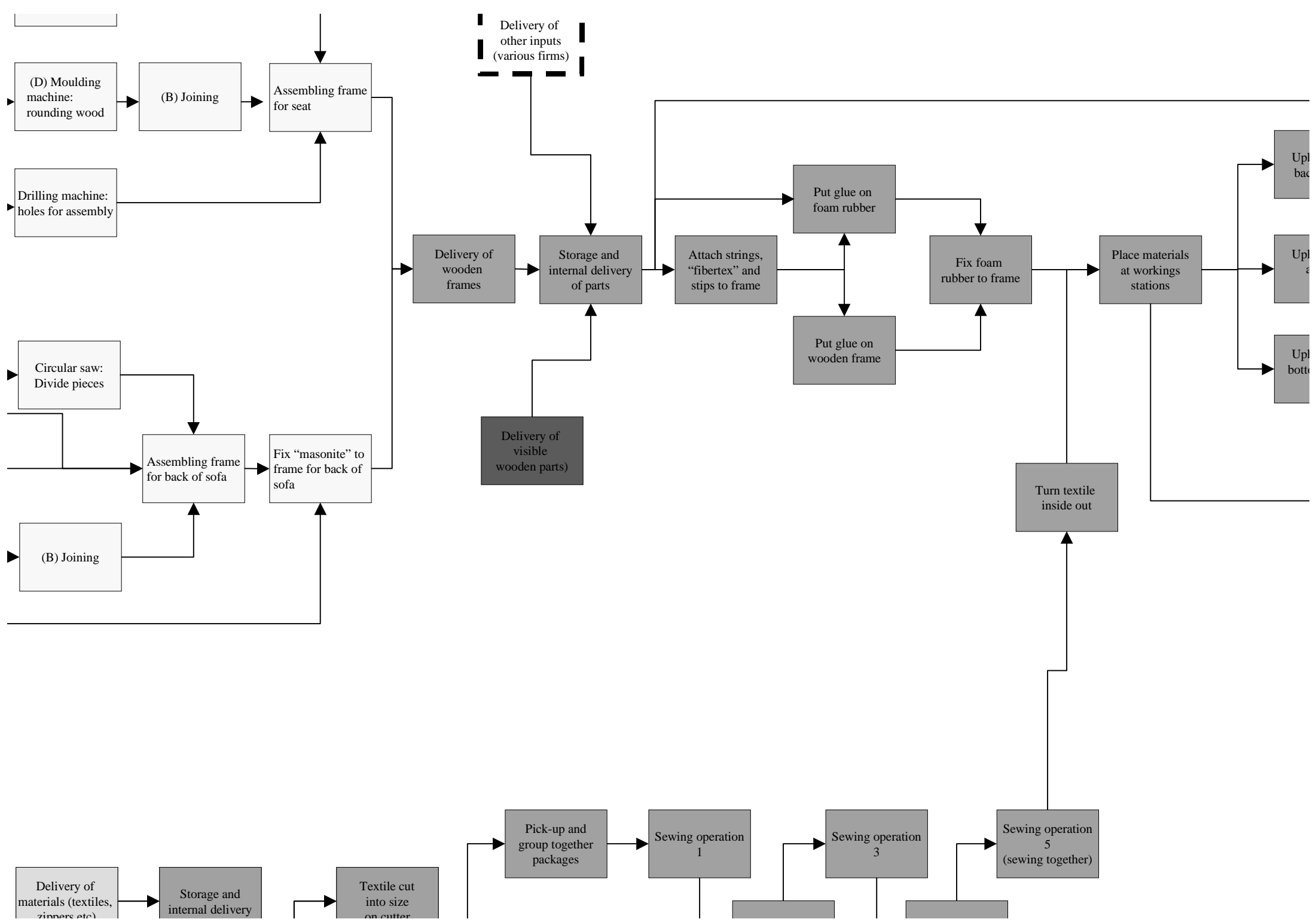
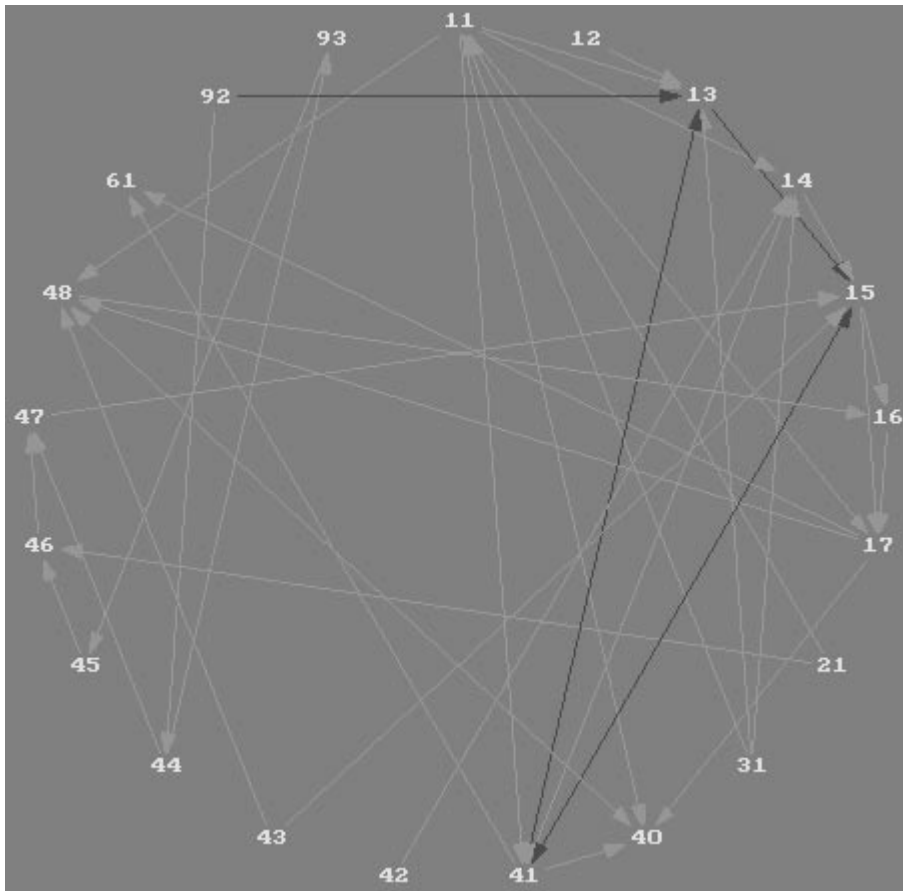


Figure 3: Interdependencies of activities in roof-production



Explanation: The numbers represents the major activities involved in the roof-production.¹ Based on the test study of instalments of windows, the concept of “interdependence” has been decomposed into six different sub-categories² and then measured on a five point likert-scale. Green arrows represent interdependencies summing up to five or less. Red colours represent situations where the sum of the six different interdependencies adds up to six or more (and hence represents at least two kinds of interdependencies)

¹ 11=: delivery and hoisting of building materials, 12= instalment of safety railing, 13= construction of roof houses, 14= making heads, 15= erection of rafters, 16= installing edge strip, 17= covering rafters with wooden plates, 21= making site accessible, 31= construction of concrete carcass, 40= making the roofing felt, 41= installing ventilating plant on roof, 42= surveyor mark out roof, 43= putting up scaffold, 44= design of rafters, 45=producing rafters, 46= delivery of rafters, 47=hoisting of rafters, 48= installing the gutter, 61= doing the concrete around ventilation tubes and soil pipes at top of carcass. 92=Overall design of roof by architect, and 93= approval of design of rafters (by architect).

² *Time-dependence* (the degree to which other tasks has to be completed before this task can be commenced), *Material-dependence* (the degree to which other tasks affects which materials to use for this task), *Tool-dependence* (the degree to which other tasks affects which tools and equipment to use for making this task), *Method-dependence* (the degree to which other tasks affects which methods / working procedures to use for this task), *Access-dependence* (the degree to which other tasks physically obstruct the physical accessibility needed for carrying out this task), and *Damage-dependence* (the degree to which other tasks affects the quality of the result of this task, for instance by damaging or making the outcome dirty)