VARIETY, STABILITY AND LEARNING IN TECHNOLOGICAL DEVELOPMENT PROCESSES ACROSS FIRM BOUNDARIES IN THE CONSTRUCTION INDUSTRY:
- Development of MSTF technology in the Danish building industry, 1994-2002

by

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INTRODUCTION AND PURPOSE

Due to the assumed importance of innovation for the survival and competitiveness of firms, networks, industries and nations alike, much research has focused on understanding how attempts at innovation may be encouraged and factors influencing the economic successfulness of such attempts. So far, most researchers seem to agree that innovation is important. However, there is much disagreement – or confusion – about which factors are important for bringing about innovation. Increasingly receiving attention is the idea that innovation comes about due to a combination of stability and variety in the context 'surrounding' the innovation.

Thus, in this paper, we discuss the conjecture that innovation is a function of stability and variety (innovation=f(stability,variety)). We review existing contributions on the issue and conclude that the suggested ideas are very abstract and not easy to transfer to a practical setting. Thereby it is somewhat difficult to get insight into what it means to create and cope with stability and variety in innovation processes. With this as the point of departure, the purpose of the paper is to understand (1) how a technology develops in relation to variety and stability in the context and (2) what creating and coping with variety and stability over time may imply for involved actors. We discuss and conceptualise these issues on the basis of an empirical study of the development of Multi-Storey Timber-Frame (MSTF) technology in Denmark during 1994-2002.

STABILITY, VARIETY AND INNOVATION IN THEORY: IMP AND BEYOND

Within the IMP Perspective

Within the IMP (Industrial Marketing and Purchasing) Perspective, substantial conceptual experimentation has been carried out towards understanding inter-firm relationships, see e.g. Håkansson (1982), Axelsson and Easton (1992), Håkansson and Snehota (1995), Ford et al. (1998), Gadde and Håkansson (2001), and Ford (2002). The basic assumption of the perspective is that firms are embedded in networks of relationships and other firms to which a single firms has substantial, continuous relationships which, furthermore, are connected to each other. Hence, a single firm must be viewed in lieu of its relationships to other firms in the network and the relationships between the other firms in the network. Thereby, the value of a firm's actions, investments etc. is dependent on what other firms do, which in turn is dependent on the structure of and processes in relationships between firms in the wider network. Within the IMP Perspective, 'relationships' and 'network', are seen as a particular *"form of organisation"* (Håkansson, 1997). In other words, there is 'joint organisational substance' between firms and not only exchange with each firm organising its separate part of the exchange. For a brief overview of the IMP Perspective, see Håkansson and Snehota (2000).

Within the IMP Perspective, technological innovation is assumed to be an integral part of relationships and networks. Thus, technological innovation is considered not to be the result of the efforts of a single firm or innovator but, on the contrary, the result of an interplay between a number of different firms, see e.g. Håkansson and Laage-Hellman (1984), Håkansson (1987), Ford and Saren (1996), and Ford et al. (1998). Consequently, the innovativity of a firm is assumed to be a function of the extent to which a firm engages in relationships comprising innovation in networks. Furthermore, the IMP Perspective stresses the importance of 'history' and embeddedness for understanding how innovation takes place within relationships and networks (Ford et al., 1998). Thus, due to the large amount of investments made along different dimensions, the existing structure of the network acts as a brake on both organisational and technological innovation (Håkansson and Ford, 2002).

Several attempts have been made within the IMP Perspective towards understanding more specifically what it is about 'relationships' and 'networks' that enables a firm to be innovative and develop new technologies, products and processes. Among the factors, which have been proposed as being of importance, are stability and variety. Two contributions can be said to explicitly discuss the relation between stability, variety and innovation, i.e. that innovation=f(stability,variety). In his discussion of networks as a mechanism (or governance form) for developing resources and increasing their value, Håkansson argues that *"inter-firm networks offer a mix of variety and stability that can foster learning and innovativeness [..] stability in relationships between involved companies can be seen as a necessary condition for efficient learning to take place"*(Håkansson, 1993, p.216). The same underlying understanding forms the basis for an article by Håkansson, Havila and Pedersen in which they suggest that: *"the ability to innovate is related to the relative stability and variety of (1) the relationships in which the firm is directly involved and (2) the relationships among the firms in the wider network"* (Håkansson, Havila and Pedersen, 1999). However, although networks and relationships offer an opportunity for combining and confronting resources and thereby possibly increasing their value, such effects are not created automatically but require that efforts are made towards combinative experimentation. Håkansson (1993, pp.220-221) formulates this in the following way: *"The network structure can be very efficient for collective learning, given that the features in the structure are used correctly. However, [..] there is no automatic mechanism which guarantees that relationships are used productively"*. For example, stability can exist without any development efforts taking place; variety can exist without it being utilised, i.e. it is suppressed or disregarded etc. (see e.g. Holmen, Pedersen and Torvatn, 2002).

Although not explicitly discussed under the labels of stability, variety and innovation, there are a number of contributions within the IMP Perspective which touch upon the relation. One of these is Waluszewski (1990) who uses the IMP Perspective as the theoretical point of departure for studying the development of a mechanical pulp technique over time. Although she does not conceptualise stability and variety in relation to the process of developing the new technique, it is possible to search for and find examples of how the technique develops over time as it becomes 'confronted' with various emergent contexts, but also to find examples of how some elements of the technique are preserved, to some extent, over time.

Lundgren (1995) has the IMP Perspective as one theoretical point of departure for his description and conceptualisation of how digital image technology co-develops with an industrial network. Lundgren (1995) mentions the concepts of stability (also coined continuity) and variety (also labelled heterogeneity or variation). Furthermore, he argues that generation of variety is an important aspect of development but, equally, that 'history matters' in the form of path-dependence and claims, for example, that *"changes emerge from pre-existing structures and, if viable, they will eventually be re-integrated with the structures from which they originated"* (Lundgren, 1995, p.96).

Stability is also discussed by Ford et al. (1998, p.47) suggesting that *"fixed resources must be efficiently utilised"* and by Håkansson and Waluszewski stating that "*every investment has by definition to be used over a certain time period in order to recover its costs"* (1999, p.3). This aspect is also discussed in Holmen (2001) under the label 'resource fixity'; stressing that whether or not a resource is fixed depends upon choices made by actors related to the resource. The fact that fixity (or stability) is a matter of choices made by actors is also the point of departure for Löfmarck Vaghult (2002) who discusses what it means that a firm chooses to embark on 'a quest for stability' in relation to their customer relationships.

Araujo and Harrison (2002) discuss the relation between path-dependence, agency and technological evolution in relation to ICI's (re)actions related to the banning of CFCs and the decision to build plants for producing a CFC alternative. While stressing the importance and economic raison d'être of stability (mainly labelled path-dependence or reuse), they focus their attention on agency and thereby on choices made by actors in their efforts towards creating new paths. Thereby, they emphasise that even if development of technology is path-dependent, it is not path-determined, since resources are multifarious by nature, and the possibilities for developing connections between these are, in principle, inexhaustible. They stress the importance of considering the issue of 'time' and seem to discuss 'time' in three different ways. Firstly, they stress that a choice is made at a particular moment of time and place. That is, they claim that choices are critical junctures *"arising out of the confluence of a number of interrelated trajectories"* (Araujo and Harrison, 2002, p.14) at particular points in time. Secondly, they stress that actors make choices on the basis of the "*fusion of the past, present and future"* which form the actors' choice or decision frame (Araujo and Harrison, 2002, p.15). In that way, a choice is framed time-wise from an '(inter)subjective' time perspective, which is the fusion of a particular view of the past, present and future. Thirdly, they stress that it is important to consider the passage of time since circumstances, and how they are framed, change over time. On the basis of this understanding, they seem to propose that in order to understand how technologies develop, it is necessary to recognise that the path-dependent and –creating choices and actions of the actors, who create technologies, are based on these actors' frames in terms of time (past, present, future) and space (many different, substantive trajectories becoming connected) and how they become connected over time. Consequently, Araujo and Harrison (2002) claim that taking a processual perspective is important when studying and trying to understand technological development. As they propose, we need to make *"a close examination of the notion of temporality and patterns of connections between events [..] path dependence (should be understood) not simply from a retrospective perspective [..] (therefore, we need to focus) on how actors react to an uncertain future in real time"* (Araujo and Harrison, 2002, p.5). We shall return to the methodological implications of this claim later on; however, we may end this subsection with the observation that the relation between stability, variety and innovation has, so far, been discussed within the IMP Perspective – even though different 'labels' are often used. Furthermore, it seems reasonable to conclude that more attention is paid to the issue of stability than to the issue of variety within the IMP Perspective. This may not be overly surprising since the main idea behind the IMP Perspective is that stability of relationships is, at least in some cases, superior to 'market mechanistic' relations to changing counterparts.

Beyond the IMP Perspective

The relation between stability, variety and innovation has been proposed not only within the IMP Perspective but also within other streams of research. Among the most important contributions are those which belong to the traditions of Evolutionary Economics – coming e.g. from the Resource Based View, the Dynamic Capabilities View, the Dynamic Transaction Costs View – or the Path-Dependence Perspective.

In their 'Evolutionary Theory of Economic Change,' Nelson and Winter (1982) discuss the relation between routines and change/innovation. For example, they argue that *"an innovation may involve nothing more than the establishment of new patterns of information and material flows among existing subroutines. It may involve the replacement of an existing subroutine by a new and different one that performs, in relation to the rest, the same function that the old one did. Some parts of the innovative routine may rely on physical principles only recently discovered and now implemented through novel types of equipment and newly developed skills – but surrounding this novel core there may be many layers of complementary activity governed by the same routines that have prevailed for many years"* (Nelson and Winter, 1982, p.130-131). Thereby, they emphasise the importance of routine (stability) for innovation. They question "*the general notion of an opposition between routinization and innovation. Reliable routines of well-understood scope provide the best components for new combinations. In this sense, success at the innovative frontier may depend on the quality of the support from the 'civilized' regions of established routine"* (Nelson and Winter, 1982, p.131). In a somewhat similar but also complementary vein, Feldman (2000) draws attention to the concept of routines, which by some authors have been used as to indicate *"repeated patterns of behaviour that are bound by rules and customs and that do not change very much from one iteration to another"* (Feldman, 2000, p.611). Instead, she opts for seeing routines as a source of continuous change, which come about as people reflect on the outcomes of previous iterations of a routine. Thereby, she seems to stress both the importance of stability (she still uses the concept of routine) as well as variety (the suggestions that variation and reflection can lead to (a partial) change of routine).

Loasby explicitly discusses the relation between innovation, stability and variety within various types of 'institutions' such as e.g. firms, districts or industries. For all such institutions, he claims that *"although evolution is undoubtedly about the emergence of novelty through processes of variation and selection, it is also about stability - and necessarily so. If everything is changing, or even liable to change at any moment, then nothing can be relied upon - for making decisions, or constructing new knowledge"* (Loasby, 2001, p.405). In short, *"without variation, there is no experience to act as a basis for learning; without a stable framework there is no assurance that any valid connections can be made between actions and outcomes"*(Loasby, 2000, p.XX) and, as such, *"it is likely to be extremely difficult to interpret and guide the learning process when many interrelated* *procedures are being changed simultaneously"* (Loasby, 1998, p.148). Hence, Loasby suggests that both stability and variety (also labelled variation) are crucial for bringing about innovation. As an example, Loasby suggests that in the long run, specialisation within firms should be combined with specialised co-ordination between firms since innovation, and the learning on which it is based, is often best achieved through interactive shaping by members of different organisations with distinctive but closely complementary knowledge bases.

In addition to proposing this relation, Loasby draws attention to the importance of 'time'. He argues that time matters because time changes the knowledge which is available to agents (Loasby, 2001, p.395) and thereby the choices they make at particular points in time. His conclusion is that if one subscribes to the view that time is important in the aforementioned sense, then this has conceptual as well as methodological consequences. Hence, *"we need to modify our use of dates: they are now required [..] in order to identify the sequence in which things happen and in which knowledge and possibilities become available [..] what matters for dynamic analysis is that decisions must be dated – because knowledge must be dated"* (Loasby, 2001, p.395). Furthermore, this leads him on to stress the importance of studying and understanding processes: as he suggests *"any process of variation and selection is meaningless unless both the variants and the selection environment persist for a time"* (Loasby, 2001, p.405).

Teece, Pisano and Shuen (1997) focus on the institution known as a firm, but their argument is very much in line with part of Loasby's discussion of stability and variation. As they state: *"a firm's previous investments and its repertoire of routines (its 'history') constrain its future behaviour. This follows because learning tends to be local. That is opportunities for learning will be 'close in' to previous activities [..] this is because learning is often a process of trial, feedback, and evaluation. If too many parameters are changed simultaneously, the ability of firms to conduct meaningful natural quasi experiments is attenuated. [..] i.e. the ability to ascertain cause-effect relationships is confounded because cognitive structures will not be formed and rates of learning diminish as a result. One implication is that many investments are much longer term than is commonly thought"* (Teece, Pisano and Shuen (reprinted in Foss, 1997, p.275)).

A somewhat different view is presented by Langlois (1999). He discusses economies of scale and scope and basically argues that in most of the ways in which such economies are conceptualised, the benefits reaped are related to 'reuse of knowledge'. He claims that both types of economies are mainly related to the presence of nonconvexities or shared overheads. As he concludes *"the idea of knowledge reuse blurs the distinction between economies of scale and economies of scope. In the former case, a body of knowledge is shared over a large number of identical units. In the latter case, a body of knowledge is shared among several slightly different products [..] indeed, it is often a matter of the definition of the product that decides if it is economies of scale or economies of scope that are at work."* (Langlois, 1999, p.251). First and foremost, Langlois (1999) draws attention to the economic benefits of reusing investments in knowledge. However, he also touches upon reuse in terms of learning processes over time in the sense that knowledge, which can be reused, is not necessarily public and, thereby, transferable to other individuals and organisations, i.e. *"reusable template knowledge has low marginal costs of transmission to succeeding units of production, not low marginal costs of transmission to other individuals or organizations"* (Langlois, 1999, p.249). Langlois' arguments are closely related to those of Garud and Kumaraswamy (1993), which Langlois and Robertson (1995) also cite when discussing the issue of modularity which also is closely related to the possibility of combining stability and variety within a (technical or organisational) system. The former introduce the concept of 'economies of substitution' which *"exist when the cost of designing a higher performance system, through the partial retention of existing components, is lower than the cost of* *designing the system afresh"* (Garud and Kumaraswamy, 1993, p.362). In other words, they argue (1993, p.362) that *"technological progress can be accomplished by substituting only certain components of the multicomponents system while retaining others"* and that there are economic benefits from doing so.

The name David is closely related to the term 'path dependence'. Therefore, the father of 'path dependence' should be shortly mentioned in this paper. David (1985) uses the example of the QWERTY keyboard to assist our understanding in realising that temporally remote events can have a very real impact on the present (and future), that physical artefacts can persist even when one purpose, they once served, cease to exist – the explanation being that the relation between keyboard and the typist, who had become accustomed to the keyboard, and the relation between keyboard and the production of it, made it efficient to preserve the, from one point of view, inefficient keyboard. Over time, path dependence has been discussed by many researchers, and qwertynomics are said to arise due to positive feedback in the form of e.g. economies of scale in production, learning, technological interrelatedness, network externalities, and networks (see e.g. Lundgren, 1995, p.66). Such feedback mechanisms are argued to "counteract novelties to the same extent as they preserve the pre-existing structure" (Lundgren, 1995, p.67).

Synthesising the arguments

Having assembled a number of sources dealing with stability and/or variety in relation to innovation, time has come to connect these – synthesising the arguments and thereby hopefully assisting our understanding of them.

Firstly, why is 'some stability and some variation' important for innovation? There seems to be some consensus among the contributions reviewed that this is the case because innovation is conceptualised as a trial-and-error learning process, which benefit from stability, variety (systematic and possibly also unsystematic). If there is no stability – no familiar elements in trial-and-error innovation processes – then understanding becomes difficult. However, if nothing changes, if no new elements are introduced, if no new connections are made between elements, then there is, of course, no development. We may say that the idea that innovation=f(stability,variety) makes immediate sense at an abstract level when innovation is viewed as a trial-and-error driven learning process.

Secondly, that economic benefits can be reaped from reusing investments (and couplings between investments) of various types (technical-physical-social-cognitive etc.) in more or less new ways (combinations) also makes immediate sense (at least to economists who recognise that resources are heterogeneous). These two lines of reasoning seem to underlie most of the contributions reviewed in this paper. However, there are also differences, which lead to our third observation.

Thirdly, the different contributions seem to discuss the idea that innovation=f(stability,variety) in relation to different 'boundaries'. That is, we can identify some differences as to what the concepts and their relations are supposed to explain. In table 1, we have tried to identify the main units of analysis discussed in the respective contributions. For example, in Håkansson (1993) the idea that innovation=f(stability,variety) is discussed in the following ways: (a) that stability and variety in a firm's relationships influence the innovativity of the firm and (b) that stability and variety in a network influences the innovativity of the network. As another example, Loasby discusses the idea that innovation=f(stability,variety) in relation to (a) individuals, that is, that the innovativity of an individual depends on the stability and variety in his or her context and (b) that the innovativity of an industry (or network or district) depends on the stability and variety of the firms within the industry (or network or district), and the relationships between the firms. A third example is Waluszewski (1990) who discusses the development of a technique over time in relation to its network context comprising both by stability and variety.

	Håkansson	Håkansson et al.	Waluszewski	Lundgren	Ford et al.	Håkansson and Waluszewski	Holmen	Löfmarck Vaghult	Araujo and Harrison	Nelson and Winter	Feldman	Loasby	Teece et al.	Langlois	Garud and Kumaraswamy	David
Units of analysis																
Individual		X							X		X	X				X
Firm or business unit	X	X		X			X	X	X	X	X	X	X	X	X	
Relationship	X	X			X		X	X	X		X	X				
Network or district	X	X	X	X	X	X	X	X				X				
Industry									X			X			X	
Technology			X	X	X	X			X						X	X
Routine							X			X	X		X	X		X
Resource unit (physical facility, material etc.)							X		X					X	X	X

Table 1: Units of analysis discussed in the different contributions

Hence, as (hopefully) appears from table 1, a large number of units of analysis (boundaries) are discussed in relation to the idea that innovation=f(stability,variety). In addition, the question 'how individuals, firms, or networks can go about handling issues of stability and variety' is, to a large extent, left up to the reader to imagine. That is, the conjecture *that* a combination of stability and variety enables innovation is left on an abstract (general) level; and although it (at least to us) seems to make sense on this abstract level, it requires quite some additional imagining, puzzle-solving, and connecting of the conjecture to the reader's own knowledge of practice, to be able to transfer the abstract idea that innovation=f(stability,variety) to a practical setting. In other words, we may pose the following question: '*how* do and may individuals, firms, networks or (whichever unit of analysis which may be treated as an actor) go about with creating and coping with stability and variety in order to enable innovation?' In short, we aim to contribute to turning the conjectured 'knowledge that' innovation=f(stability,variety) a bit more into 'knowledge how' innovation=f(stability,variety), cf. Ryle (1949). Thereby we opt for the view explicitly stressed in some of the studies that actors and their frames, ideas and choices are important to take into account. After all, nothing is fixed *per se* – keeping something fixed is a matter of choice (often by several involved actors) whether done on the basis of explicit consideration, routine, rule, chance, imitation etc. (cf. Snehota, 1990, p.72)

We believe that the above-mentioned question may usefully be addressed on the basis of empirical studies. Furthermore, we believe that such studies – due to the complexity of reality and the number of different units of analysis possible (cf. Table 1) – should take a narrow focus since the number of variables would else become too large.

STABILITY, VARIETY AND INNOVATION IN POLICY: THE PPB PROGRAMME

Most scholars agree that the construction industry is characterised by a low degree of innovation. What this means is that the main sources of innovation in the construction industry are suppliers of materials and machinery (Pries and Janszen, 1995; Dubois and

Gadde, 2000; Miozzo and Dewick, 2002) and not architects, consulting engineers, main contractors, subcontractors etc. In trying to explain why this is the case, several inquiries have been made into the idiosyncratic characteristics of the construction industry. The construction industry is characterised by a *tender system* which leads to a focus on *standardisation of products and sub-contracting work*, the ability to compare prices and choose the *lowest price* per product and sub-contract, competition between 'identical' and independent suppliers, and the use of *different suppliers in each construction project*. In addition, the parties to a large extent rely on standardised types of contracts (accompanied by standard contract forms) (Cox and Thompson, 1997) which identify (limit) the respective responsibilities of the parties. These characteristics are seen as impediments to innovation, for example, *"in several countries [..] it appears that the practice of awarding contracts through lowest cost tender may act as a constraint to innovation and R&D spending among contractors"* (Miozzo and Dewick, 2002, p.990). In a similar vein, Dubois and Gadde (2000, p.17) suggest that *"strong reliance on standardised products and standardised interfaces between firms clearly does not foster technical development. [..] Therefore, it is not surprising that the only traces of product development found in this study were related to the input side of the material producers"*.

Furthermore, most work within the construction industry is organised as (construction) *projects*, which are always *unique* in some respects also implying that it is not feasible to make and test full-scale prototypes (Gann and Salter, 2000). Firstly, few clients are able to provide demand for a series of (relatively similar) projects; therefore, such *"projects are intermittent and dependent on highly unpredictable and heterogeneous demand"* of different clients (Easton and Araujo, 1997, p.88). The discontinuous and temporary nature of projects presents a problem for the accumulation of knowledge in the construction industry (Miozzo and Dewick, 2002, p.991) since *"a new learning curve is climbed by the supplier each time"* (Cox and Thompson, 1997, p.128). Secondly, individuals from different firms who work together within one project only infrequently meet each other again in other projects (Welling and Kamann, 2002), and even within a single project substitutions of individuals frequently takes place. Thirdly, within a single project, the design process and the construction (implementation) process are often separated which implies that possible feedback from the construction process is not taken into account in the design process – within a single project, the design remains fixed. Thereby, contractors often have very little autonomy *"to alter design specifications and introduce product and process innovations"* (Miozzo and Dewick, 2002, p.990).

The lack of innovation within the construction industry is generally perceived as a problem. In several European countries there is ongoing discussion, on the level of firms as well as on the level of the industry, on how the rate of innovation may be enlarged. It has been suggested that the lack of continuous, dense relationships between firms may be a main reason for the lack of innovation in the construction industry (Cox and Furlong, 1997). Hence, it is increasingly assumed that inter-firm co-operation is a requirement for increased innovation. Due to the lack of innovation in the Danish construction industry, the Danish Industry Council set up a programme explicitly aiming at changing the organisation form used in the industry. Among other things, the programme aimed to encourage and enable firms within the industry to try out co-operative forms of organising for innovation. The programme 'Process and Product Development in the Construction Industry' (PPB in Danish) took place in 1994-2001. The overall purpose of the programme was to *"stimulate renewal, development, and sharing of experience within the Danish construction industry in order to improve the quality of construction projects and secure their future"*. The specific goals of the programme were to increase:

(1) co-operation and vertical integration among firms in the construction industry;
(2) competitiveness through product and process development and innovation in the construction industry; and
(3) export and employment within the construction industry through improvement of the competitiveness, with a special focus on increasing the productivity in construction projects.

Thereby, the PPB programme seems to be based on an underlying conjecture of innovation=f(stability,variety). The conjecture seems partly to have been inspired by theory, partly by practice – mainly in other industries. The aim of the programme was to test out the conjecture in the Danish construction industry. Therefore, in 1994, the Danish Industry Council invited tenders for a competition for participating in the PPB programme. In order to enter into the competition, a consortium should be made. The consortium should consist of firms within the construction industry, e.g. contractors, architect firms, consulting engineers, and producers of construction materials. It was a specific requirement that a firm could only participate in one consortium. Each consortium should hand in a proposal for a project in line with the goals of the PPB programme. In the proposal, specific development activities should be outlined. These development activities should be related to a number of specific construction projects in which the results from the development activities could be tried out in practice. The main type of construction projects, which the PPB programme focused on, was social housing construction projects. Each consortium would be granted a number of flats to be divided among the construction projects. Furthermore, the projects were granted exemption from the European tender directives.

In total, 29 different consortia handed in proposals for projects within the PPB programme. A committee then selected eight of these consortia for the pre-qualification phase. Each of these consortia received DKK 250.000 for developing their initial proposals into more concrete project descriptions, which were evaluated by a committee. Four winners were selected, and of the four winners, 'The Living Wood' project from the Casa Nova consortium was considered to be the 'real winner' since it addressed both product and process innovation.

The basic idea of the Casa Nova consortium was to co-operate on developing and erecting multi-storey timber-framed (MSTF) houses in Denmark. Such houses had not been erected in Denmark since the 1900th century. The Casa Nova consortium consisted of: (1) a consulting engineers firm – Cowi, (2) a contractor - Skanska and (3) an architect firm - Nova 5. In addition to these three firms, a number of associated firms were involved in the consortium: (1) a producer of wood elements - Palsgaard Træ, (2) a producer of glulam - Moelven LNJ Limtræ, and (3) a producer of insulation material - Rockwool.

STABILITY, VARIETY AND INNOVATION IN METHODOLOGY: MSTF TECHNOLOGY

As Hayek (1948, p.60) argues *"no superior knowledge the observer may possess about the object, but which is not possessed by the acting person, can help us in understanding the motives of their actions"*. This means, for one, that even if the observer (researcher) has knowledge about a larger part of e.g. a network than the acting person, this knowledge cannot be used for explaining the actions under scrutiny. We may also stretch this logic to apply also to the same acting person at different points in time; knowledge which an acting person has acquired later cannot be used for reasonably explaining the motives of his or her actions at an earlier point in time. This issue has also been addressed by Snehota (1990, p.85) claiming (and building on Weick, and Singer and Benassi) that "*all knowing and meaning arise from reflection, from a backward glance [..] and even then [..] rationality tends to be retrofitted by cognitive elaboration of both means and ends after the fact"*. In line with these suggestions, we believe that addressing the aim of the paper requires taking a processual perspective to the empirical basis. We have tried to take a real-time, processual approach for gathering our empirical basis – although some of the information gathered is obviously retrospective, i.e. when informants talk about the past. It may be stated, however, that we did not start out with taking such a perspective, but increasingly we came to recognise that it was necessary for understanding the development of MSTF technology in Denmark.

We have made several ‘rounds’ of interviews with people involved in developing the MSTF technology in Denmark. The interviews were made during 1998-2002. The interview notes, tapes, and transcripts are our primary sources. Furthermore, since the Casa Nova consortium is part of the PPB Programme, there is ample documentation publicly available on the process. We have gathered approx 750 pages of secondary sources describing the PPB programme – including the Casa Nova consortium’s efforts over the years 1994-2001. This documentation consists of reports which describes workshops, interviews etc. at many different points in time during the whole period which means, that it is possible to trace opinions, actions – and how they change – etc. over time. In addition, we have searched the Internet for homepages etc. on which aspects related to Casa Nova efforts may be described.

Epistemologically, we subscribe to ‘systematic combining’ or ‘abduction’ in the form proposed by Dubois and Gadde (2002). In that sense, we recognise that understanding emerges over time as theoretical and empirical insights are cross-fertilised – sometimes standing on the inductive foot looking for a place to place the deductive foot, sometimes standing on the deductive foot looking for a place to place the inductive foot. Given that we, as mentioned earlier, have chosen to contribute to the understanding of the idea that innovation=f(stability,variety) by means of an empirical study, the main issue facing us is: ‘how can a detailed empirical understanding be transformed into conceptual understanding of stability and variety in technology development processes?’

STABILITY, VARIETY AND INNOVATION IN PRACTICE: MSTF TECHNOLOGY

“It is always hard to say where data gathering stops and data analysis begins” (Feldman, 2000, p.615). It is equally hard to say when description stops and analysis begins. In table 2, we have tried to make an overview of the nine construction projects, we have been able to identify, as well as the pre-qualification and the concept development phases. Given that the aim of the paper is to address stability and variety in relation to an actual technology development process, we have tried to present, in table 2 (over two pages), some of the variety and stability in the process of developing MSTF technology in Denmark. The representation is, at best, extremely limited – but it may give the reader an idea about how we ‘think about our data’. We have divided our data into a number of dimensions in which we have been able to identify variety and/or stability. Furthermore, we have arranged these in two tables – one primarily dealing with the organisations involved, and one primarily dealing with technological issues. Both are assumed to comprise economic logic. Since we have limited space, we shall discuss only five of the dimensions in table 2 here.

(1) Stability and variety in the dimension: contractors

The involvement of Skanska in the Casa Nova consortium does not seem to have been motivated by any particular experience or competence with wooden buildings. However, the fact that Skanska was one of the large Danish contractors seems to have influenced the fact that the other two consortium partners contacted Skanska.

Throughout the development process, only Skanska has been involved as a main contractor. This continuity was imagined from the instigation of the Casa Nova consortium. However, different Skanska units have been involved – depending on where the maiden buildings were going to be erected. Thereby this variety in the involved units has been driven by location considerations that emerged over time. Furthermore, a number of different people have been involved. The staffing has been influenced by availability concerns which, in turn, was influenced by the other building projects Skanska was involved in at the points in time when MSTF building projects were to be carried out. Quite a number of individuals have been involved, however, when possible the same individuals have been involved in several building projects. Furthermore, some activities and procedures have aimed at enabling transfer of experiences from project to project and from individual to individual. For example, workshops have been arranged, building manuals have been written etc. Furthermore, those individuals who repeatedly have been involved in the MSTF development and construction have become experts (internal consultants) within the Danish Skanska organisation.

(2) Stability and variety in the dimension: wood suppliers

In the pre-qualification phase, two wood suppliers were imagined to become associated with the consortium, i.e. Palsgaard Træ and Moelven LNJ Limtræ. Palsgaard Træ had experience with producing various types of wood elements. Even though the MSTF wood elements were expected to differ from their usual 'products', they were expected to have a reasonable degree of continuity with Palsgaard Træ's competences. Other suppliers of wood were possible, and the particular reason why Palsgaard Træ was chosen seems primarily to be *"that they did not form part of any other consortium in the PPC programme"*; and since the PPB programme required that a company could only be involved in *one* PPB consortium, there were some limits as to which suppliers could be involved. Similar reasons seem to have motivated the imagined involvement of Moelven LNJ Limtræ. In the concept development phase, when the development of the MSTF building system really took off, Palsgaard Træ actually was involved and delivered the wood elements which were used for the mock-up made at Teknologisk Institut's premises. However, in this phase, through discussions with the those responsible for making those changes in building legislation, which were required for erection of MSTF buildings in Denmark being possible, it seemed to be unlikely that MSTF buildings with more than 4 storeys would become included in the new legislation. Consequently, the imagined involvement of Moelven LNJ Limtræ was taken off the agenda. That is, *"a producer of glulam components has formally been involved in the consortium's development activities. The role of [this has] been very limited – both regarding development efforts and the test building projects [since] the involvement of the producer of glulam to a high extent was related to the possibility for building 5-storey buildings which, so far, has not become an actuality"*.

It seems that the original idea was that one wood supplier was going to partake in the development in wood elements and the subsequent supply of these for actual building projects. However, the imagined stability in this dimension ran into problems already in the first building project, Marieparken. Initially, it had been the hope that the building projects would follow as 'pearls on a string'. However, it proved difficult to get clients interested in actual building projects and the expected planning logic broke down. Thereby, the supply of wood elements for Marieparken and Thrigesvej needed to take place partially in parallel in stead of sequentially. As Palsgaard Træ did not have sufficient capacity to supply to both projects and it became necessary to involve a second supplier. Palsgaard Træ suggested Tåsinge Træ since they were both members of the same group of companies: Palsgaard Gruppen. Due to geographical considerations, Tåsinge Træ supplied to Marieparken and Palsgaard Træ to Thrigesvej. It seems that the involvement of Tåsinge Træ was imagined as an exception to the rule of Palsgaard Træ being involved. That is, Tåsinge Træ was not expected to be involved in any subsequent Casa Nova building projects. Thereby it seems as if continuity, once again, was expected in the wood supplier dimension. However, for the third building project, Tåsinge Træ was the supplier and, in fact, Tåsinge Træ has delivered wood elements to three Casa Nova building projects (although we are unsure which project is the third they have delivered to). Palsgaard Træ has been the supplier for, at least but probably more than, one MSTF building projects and the wood elements for the mock-up. *"Palsgaard Træ has - as an element producer – been involved from the consortium's start and has participated in the development of the concepts, jointing details etc. and, at their own factory, they have produced the series of elements for a mock-up and for one of the, so far built, test building projects (Herning)."*

However, the variety of wood suppliers used for Casa Nova building projects did not only comprise Palsgaard Træ and Tåsinge Træ. For the fourth building project, a Lithuanian supplier was used. One explanation given for this is the following: *"the Casa Nova consortium has continuously considered the possibilities for buying elements from foreign suppliers."* Similarly, *"it is no secret that Casa nova has had difficulties with reducing the price of the raw-house to the level where it needs to be if MSTF technology is to be able to compete with concrete building technology. The Danish produced wooden elements have, in the opinion of the consortium, been much too expensive, and therefore Casa Nova has looked around in the neighbouring countries for alternative suppliers. Such an alternative has now been found in Lithuania where a factory with Danish management supplies the elements for the on-going maiden project Tøjhushaven in Randers. Before this was started up, Casa Nova had made large efforts at making sure that that the production in Lithuania in every possible way complies with Casa Nova's requirements regarding quality and delivery management. All elements are subjected to meticulous measuring and quality control before being shipped off to Denmark. The elements have now arrived at Randers, where the on-going assembly so far has gone without any problems. The fragile elements have during transport been carefully packaged and protected against weather and bumps, and Skanska does not operate with a larger 'reserve stock' even if the elements come from further away. If a gypsum plate* *should become damaged, it is easy to replace, and it is also not a big problem to build a new element on site if that, for some reason or another, should prove necessary. How much cheaper Skanska can get the elements from Lithuania, the project manager will not say, but he describes the price difference 'considerable'. If this will become a success I am sure that the factory in Lithuania will soon get additional orders here in Denmark, says the project manager."*

The variety of wood suppliers also came to comprise a fourth supplier – once again a Danish one – which supplied the wood elements for the fifth and the seventh MSTF building projects. This supplier is B.M. Byggeindustri Hobro. This supplier was preferred because it offered a low price and, in any case, the Lithuanian supplier had gone bankrupt. Hence, it seems as if the initially imagined logic of stability, which was assumed to enable learning and reduce production costs (by the possibility of achieving economies of scale) for the wood elements over time, changed over time. Lack of idle capacity, which also is due to the encountered difficulties with knowing when (and which) building projects would be carried out, seems to have been one important factor contributing to the change of the logic. Price seems to have been another deciding factor. Furthermore, it seems as if the emergent, only partial stability, in the wood supplier dimension, has been enabled by the facts that (1) no standard wood elements have been (possible to) develop(ed), (2) detailed technical specifications have, to a large though decreasing extent, been provided by Cowi, (3) large investments in wood element production equipment have been considered appropriate to avoid due to uncertainty regarding the extent of the market for MSTF buildings. Thereby, *"by far, the main part of the development work, among others the formulation of aims for the development, has however been carried out by the consortium's consulting engineer, Cowi, whereas it has only been a matter of making small adjustments in Palsgaard Træ's components and internal production processes. Palsgaard Træ's involvement has comprised participation in development and project planning meetings; supplying information about wooden components and their prices, the elements' construction and characteristics; as well as giving comments on the solutions developed by the consulting engineer."* Similarly, *"Tåsinge Træ's role was limited to only the production of wooden elements on the basis of the consultants' drawings and calculations. On their own initiative, Tåsinge Træ gathered and processed experiences from the Hørsholm building project and sent them to the consortium - and to Palsgaard Træ. In an ongoing Casa Nova building project in Odense, Tåsinge Træ has, once again, become involved, but this time in a much more active and integrated role."*

All this seems pretty much in line with the usual conditions in the construction industry where suppliers of building components usually have no guarantees for future work and are treated as sub-contractors which deliver customised components produced-to-order for single, unique building projects. Thereby, as in many construction projects, interaction may been reasonably intensive within single projects, and some (joint or individual company) learning may be re-used in later projects – if the same supplier happens to be used, which it should not base too much of its planning on - it is quite unpredictable.

(3) Stability and variety in the dimension: clients

The PPB programme was, in fact, based on the idea that a single or a few clients should be connected to each consortium on a more or less permanent basis. Therefore, a client, 3B Fællesadministrationen, was initially connected to the Casa Nova consortium. Even though the fifth Casa Nova building project was carried out for Fagforeningens boligforening v/3B Fællesadministrationen, the consortium has mainly worked for different clients in each building project. The only exception to this rule is the second and fourth building projects which were both carried out for Lejerbo – although in different municipalities. It seems as if there was some co-ordination between the two different building projects for Lejerbo in the sense that Lejerbo's positive experiences with Thrigesvej formed an important point of departure for Tøjhushaven. Besides this, there seems to have been a small amount of co-ordination between two clients in the sense that the Marina Park construction project was actually carried out for two clients, who have some kind of on-going collaboration.

In general, the Casa Nova consortium experienced difficulties with getting clients interested in MSTF building projects – at least in the beginning of the PPB programme. As reflected in the following citation, *"it is true that we experience an increasing interest from municipalities and clients all over the country now. This is in sharp contrast to the scepticism which we encountered in the beginning [..] this is probably related to the documentation which we have produced in relation to fire, statics and construction [..since we have experienced] an unwilllingness of clients to enter into contracts for non-proven technical solutions".* As such, the imagined stability in the client dimension (at least imagined by the PPB programme) – and thereby possibly in e.g. the type and/or rhythm of maiden building projects – proved impossible to achieve.

(4) Stability and variety in relation to the dimension: facing

In the concept development phase, it seems that it was already considered that MSTF buildings should be possible to cover with different types of facings. For example, in co-operation with Teknologisk Institut, a mock-up was made and on this, the following types of facings were tried out: western red cedar (both horizontally and vertically), larch, spruce, bricks, rockwool plates, and dressed masonry. All these types of facings were immediately available 'on the market' - the basic idea was that only existing products should be used. Some uncertainty, however, existed as to how suitable these facings would be for MSTF buildings. Initially, the involved firms were interested in covering the MSTF buildings with wood; i.e. it should be possible to see that the buildings were 'wooden buildings'. However, various factors made this difficult.

On the first building project, Marieparken, the local requirements for Hørsholm required that areas covered with wood were restricted to those areas which were not immediately observable from the (public) street. Furthermore, the local requirements directly prescribed which facings were allowed. This led to the following three facings being tried out on Marieparken: yellow brick, dressed masonry, and western red cedar (vertical). On Thrigesvej in Herning, western red cedar and zinc plates were tried out. Following intense interaction with the fire brigade in Herning, the involved companies were allowed to cover large amount of the facing with wood. Zinc plates had not been tested on the mock-up. However, zinc was considered useful in order to fulfil the fire regulations. On the Rugårdsvej project in Odense, unplaned Norwegian spruce was used. As such, the buildings were more or less completely covered with wood. Fire pressure impregnated spruce facings had been tried out on the mock-up. The use of Norwegian spruce was primarily motivated by price and transport considerations. In addition, the possibility for using a type of wood, which could effectively be fire impregnated, was considered to be an advantage. In general, it was also considered an opportunity to try out this type of facing in an actual building project. On the Tøjhushaven project in Randers, dressed masonry was used for the lower parts of the building, and the remains of the building was covered in zinc plates. Thereby, the building did not appear as a wooden building at all. However, Tøjhushaven represented an opportunity to try out a combination of two facings which had been tried out, in other combinations, on earlier Casa Nova building projects. Unfortunately, we do not have information about the facings used for the Grønhøj project. On the Snerlehaven project, western red cedar was, once again, tried out this time with details in mahogany. On the Marina Park project, Siberian larch was used for the first time. Larch had, as mentioned earlier, also been tested on the mock-up. On the project in Silkeborg, a combination of larch and galvanised steel was used. Whereas larch had been tried out on the mock-up as well as the Marina Park project, galvanised steel was new as a facing for Casa Nova MTSF buildings. On the Hald Ege project in Viborg, we do not have information about the materials used for the facing.

In general, a variety of facings have been tried out. Some had been imagined from the start, others had not. The type of facing is mainly related to the facings allowed in the local plans for the different municipalities – and the degrees of freedom which could be acquired. It seems as if it has been important for the Casa Nova consortium to actually try out different types of facings, i.e. *"the erected buildings are references which the consortium consider important in terms of facings"*. In fact, over time as different facings were tried out on actual buildings, the brochures describing the MSTF technology got to include information that now "*this type of facing can also be made"*. Variety in terms of facings has emerged as an important issue. However, many of the types of facings are traditional Danish facings – therefore, they were considered important to have within the span of solutions offered for MSTF buildings since it proved impossible to only use wood facings for the MSTF buildings. As it is stated in a report written by the end of the PPB programme, *"aesthetically, buildings constructed according to the [..] Casa Nova building system can be "made with many different architectural expressions, since there are no bindings on the use of facings, e.g. wood, zinc, brick, dressed masonry can all be used."*

(5) Stability and variety in relation to the dimension: elements/production method used on site

The imagined solution in the pre-qualification and concept development phases was to apply *"industrialisation principles from prefabricated construction to wooden buildings"*. The involved companies were aware that this was not the only possible alternative. For example, it was well known that in the US, the in-situ platform-frame principle was used. This latter production method supposedly has the advantage that only simple tools are required, and the building is easy to create on site. However, as the Casa Nova consortium stated, they would take another route – that of industrialisation/prefab. However, at the same time, the consortium would not reject that in situ solutions might be interesting to use for small building projects. The first choice of solution, i.e. prefab, was used for the first two building projects: Marieparken and Thrigesvej. However, in the third building project, Rugårdsvej in Odense, some on site production of wood elements was carried out. This project was, in part, an infill project which implies that one of the buildings had walls which were immediately adjacent with existing buildings. Consequently, special end-walls had to be made since there were interfaces between the MSTF building and the existing, non-MSTF buildings. The in situ creation of wood elements concerned the end-walls, only. On the fourth building project, Tøjhushaven in Randers, prefabricated wood elements were, once again, used. However, on the fifth building project, Grønhøj in Ballerup, considerable use of the platform-frame principle was made. As written in one of the PPB reports: *"paradoxically, the consortium considers not using prefabricated elements and instead try out an in situ construction solution on the planned Ballerup buildings. Even if Casa Nova specifically bet on a prefab system and still is working on achieving an* *increasingly higher degree of finish, the consortium has all the time been keen on the American platform-frame principle, where buildings are erected on site – without or by use of prefabricated elements.[..] On Swedish buildings, the Casa Nova contractor Skanska's Swedish sister unit has successfully used such principles and, in particular, reports claiming economic advantages have attracted Casa Nova."* However, not only supposed economic benefits are given as the reason why the platform-frame principle is explored. As stated by the engineer from Cowi: *"In Ballerup, we will get a project with a rather complex geometry which is not particularly optimal for element system construction. Therefore, we consider if it would be advantageous to use this opportunity to try out an alternative."*

It seems as if stability regarding the use of production method (i.e. prefab elements) was initially expected by the Casa Nova consortium – although the involved parties were aware that other possibilities might be used. However, over time, it seems as if the consortium has come to appreciate trying out some variety in this dimension. As stated in the following citation: *"The [..] building projects will give the consortium ample opportunities for further development of the technical solutions, testing of new types of constructions [..] and optimisation of assembly as experience and practice accumulate."*

DISCUSSION

So, what does it mean to create and cope with stability and variety in a technology development process? Have we got any further in understanding (1) how a technology develops in relation to variety and stability in the context and (2) what creating and coping with variety and stability over time may imply for involved actors?

So, far we have come up with the following:

(1) a technology development process, in which several actors are involved, can be described as a trial-and-error process through which the technology is formed
(2) in such a trial-and-error process, many different dimensions (i.e. particular elements and interfaces) need to be handled
(3) most dimensions are connected to some other dimensions – qualitatively and/or quantitatively
(4) each of these dimensions may be imagined, at one point in time, to be characterised mainly by stability or variety
(5) the imagined stability and variety may turn out to be possible or impossible to bring about or get acceptance for – within and among actors – or the imaginative actors may simply change their mind
(6) therefore, the stability and variety, which is imagined, may change
(7) this may happen several times
(8) sometimes a change (stability -> variety; variety -> stability) is seen as an opportunity, sometimes it is seen as a problem which needs or preferably should be overcome
(9) since the dimensions are connected, changes in one dimension often lead to changes in one or more of the other dimensions
(10) the possibilities or difficulties can arise due to actions by those who imagined them or those whom the imagined future concerned
(11) stability should be seen in relation to the process and in relation to earlier and other processes…..

REFERENCES

Araujo, L and Harrison, D. Path Dependence, Agency and Technological Evolution. Technology Analysis and Strategic Management 2002; 14; 1; 5-19.

Axelsson B., Easton G. (eds.) Industrial Networks - A New View of Reality. London: Routledge, 1992.

Cox A., Furlong P. Cross-border Trade and Contract Awards. European Journal of Purchasing & Supply Management 1997; Vol.3, No.1: 9-20.

Cox A., Thompson I. Fit for Purpose Contractual Relations: Determining a Theoretical Framework for Construction Projects. European Journal of Purchasing & Supply Management 1997; Vol.3, No.3: 127-135.

David, P.A. Clio and the Economics of QWERTY. The American Economic Review 1985; Vol. 75, Issue 2: 332-337.

Dubois A., Gadde L-E. Supply Strategy and Network Effects – Purchasing Behaviour in the Construction Industry. European Journal of Purchasing & Supply Management 2000; Vol. 6: 207-215.

Dubois A., Gadde L-E. Systematic Combining: An abductive approach to case research. Journal of Business Research 2002; 55: 553-560.

Easton G., Araujo L. Inter-firm Responses to Heterogeneity of Demand over Time. In: Ebers M., editor. The Formation of Inter-organizational Networks. Oxford: Oxford University Press, 1997. pp. 66-94.

Feldman, M. Organizational Routines as a Source of Change. Organization Science 2000; Vol. 11, No. 6: 611-629.

Ford D. (ed.) Understanding Business Marketing and Purchasing. London: Thomson Learning, 2002.

Ford D., Saren M. Technology Strategy for Business. London: Thompson Business Press, 1996.

Ford D., Gadde L-E., Håkansson H., Lundgren A., Snehota I., Turnbull P., Wilson D. Managing Business Relationships. Chichester: John Wiley & Sons Ltd, 1998.

Gadde L-E., Håkansson H. Supply Network Strategies. Chichester: John Wiley & Sons Ltd., 2001.

Gann DM., Salter AJ. Innovation in Project-based, Service-enhanced Firms: The Construction of Complex Products and Services. Research Policy 2000; 29: 955-972.

Garud R., Kumaraswamy A. Changing Competitive Dynamics in Network Industries: An Exploration of Sun Microsystem's Open Systems Strategy. Strategic Management Journal 1993; 14: 351-369.

Hayek FA. The Facts of the Social Sciences in Hayek, FA. Individualism and Economic Order, Chicago: University of Chicago Press, 1948, 57-76.

Holmen E. Notes on a Conceptualisation on Resource-Related Embeddedness of Inter-organisational Product Development. PhD thesis. University of Southern Denmark, Sønderborg, 2001.

Holmen E., Pedersen A.-C., Torvatn T. Co-operating on Technological Development Across Firm Boundaries in the Construction Industry. Forthcoming in Journal of Business Research 2002.

Håkansson H. (ed.) International Marketing and Purchasing of Industrial Goods: An Interaction Approach. Chichester: John Wiley and Sons, 1982.

Håkansson H. (ed.) Industrial Technological Development. A Network Approach. London: Croom Helm, 1987.

Håkansson H. Networks as a Mechanism to Develop Resources. In: Beije P. et al., editors. Networking in Dutch Industries. Leuven/Apeldoorn: Garant, 1993, pp. 207-223.

Håkansson H. Organization Networks. In: Sorge A., Warner M., editors. The IEBM Handbook of Organizational Behaviour. London: Thompson Business Press, 1997.

Håkansson H., Laage-Hellman J. Developing a Network R&D Strategy. Journal of Product Innovation Management 1984; Vol.1, No.4: 224-237.

Håkansson H., Snehota I. Developing Relationships in Business Networks. London: Routledge, 1995.

Håkansson H., Havila V., Pedersen A-C. Learning in Networks. Industrial Marketing Management 1999; Vol. 28: 443-452.

Håkansson H., Waluszewski A. Path-dependence: Restricting or Facilitating Technical Development, in D. McLoughlin and C. Horan (eds.), Interactions, Relationships and Networks: Towards the New Millennium, Proceedings from the 15th IMP Conference, Dublin, 1999.

Håkansson H., Snehota I. The IMP Perspective. Assets and Liabilities of Business Relationships. In: Sheth JN., Parvatiar A., editors. Handbook of Relationship Marketing. London: Sage, 2000.

Håkansson H., Ford D. How Should Companies Interact in Business Networks? Journal of Business Research 2002; 55:133-139.

Langlois, RN. Scale, Scope and the Reuse of Knowledge, in S.C. Dow and P.E. Earl (eds.), Economic Organization and Economic Knowledge, 1999. Vol.I, pp. 239-254, Cheltenham: Edward Elgar.

Langlois RN., Robertson PL. Firms, Markets and Economic Change. London: Routledge, 1995.

Loasby B.J. The Organisation of Capabilities. Journal of Economic Behavior and Organization 1998; Vol. 35: 139-160.

Loasby BJ. Market Institutions and Economic Evolution. Journal of Evolutionary Economics 2000; 10: 297-309.

Loasby, BJ. Time, Knowledge and Evolutionary Dynamics: Why Connections Matter, Journal of Evolutionary Economics 2001;11; 393-412.

Lundgren, A. Technological Innovation and Network Evolution, London: Routledge, 1995.

Loefmarck Vaghult, A. The Quest for Stability: A Network Approach to Business Relationship Endurance in Professional Services. PhD thesis. Uppsala University, Department of Business Studies, Uppsala, 2002.

Miozzo M., Dewick P. Building Competitive Advantage: Innovation and Corporate Governance in European Construction. Research Policy 2002; 31: 989-1008.

Nelson, RR. and Winter, SG. An Evolutionary Theory of Economic Change, London: The Belknap Press of Harvard University Press, 1982.

Pries F., Janszen F. Innovation in the Construction Industry: the Dominant Role of the Environment. Construction Management and Economics 1995; 13: 43-51.

Ryle G. The Concept of Mind, London: Penguin Books, 2000 (first printed 1949).

Snehota, I. Notes on a Theory of Business Enterprise. PhD thesis. Uppsala University, Department of Business Studies, Uppsala, 1990.

Teece DJ., Pisano G. and Shuen A. (1997) Dynamic Capabilities and Strategic Management, in N.J. Foss (ed.) , Resources, Firms and Strategies. A Reader in the Resource-Based Perspective, pp. 268-285, Oxford: Oxford University Press, 1997.

Waluszewski A. Framväxten av en ny Mekanisk Massateknik - en Utvecklingshistoria. PhD thesis. Uppsala University, Department of Business Studies, Uppsala, 1990.

Welling D., Kamann JD. Vertical Cooperation in the Construction Industry: Size Does Matter, forthcoming in The Journal of Supply Chain Management: A Global Review of Purchasing and Supply 2002.

Table 2: Overview of Casa Nova phases and building projects etc. (over two pages)

Organisations involved											
Name of phase/project	Pre-qualifi-cation	Concept development	Marieparken	Thrigesvej	Rugårdsvej	Tøjhushaven	Grønhøj	Snerlehaven	Marina Park		Hald Ege
Consulting engineer firm	Cowi	Cowi	Cowi	Cowi	Cowi	Cowi	Cowi	Cowi	Cowi	Cowi	Cowi
Main contractor (geographical unit) project leader (internal consultant)	Skanska (København)	Skanska (København)	Skanska (København) C Tejsner	Skanska (Herning) P Rezepka (C Tejsner)	Skanska (Odense) S Bonnerup (P Rezepka)	Skanska (Herning) P Rezepka	Skanska (København) F B Jensen	Skanska (?) (S Bonnerup)	Skanska (Aalborg) C Tejsner	Skanska (Herning?)	Skanska (?)
Architect firm	Nova 5	Nova 5	Søren D. Schmidt	Nova 5	Nova 5	Nova 5	Vandkunsten	Søgaard & Hansen	Vandkunsten	Nova 5	Nova 5
Wood supplier	Palsgaard Træ	Palsgaard Træ	Tåsinge Træ	Palsgaard Træ	Tåsinge Træ	Lithuanian supplier	B.M. Byggeindustrri Hobro A/S	?	B.M. Byggeindustrri Hobro A/S	?	?
Client	Fagforeningens boligforening v/ 3B Fælles-adm.	Fagforeningens boligforening v/ 3B Fælles-adm.	Hørsholm Almennyttige boligselskab v/DAB	Lejerbo	Arbeidernes boligforening	Lejerbo	Fagforeningens boligforening v/ 3B Fælles-adm.	Kolding Ældrebolig selskab	B. Flyvholm og Bolig-kontoret v/Andelsbolig-foreningen Himmerland		Skt. Jørgen
Municipality	None	None	Hørsholm	Herning	Odense	Randers	Ballerup	Kolding	Aalborg	Silkeborg	Viborg
Others involved (considered but not involved)		Teknologisk Institutt, (Moelven LNJ Limtræ, Rockwool)	Teknologisk Institutt								
Organisational form	Intensive co-operation	Co-operation and task partitioning	All-in	All-in	All-in	All-in	All-in	All-in	All-in	All-in	All-in

Technology related issues											
Name of phase/project	Prequalifi-cation	Concept development	Marieparken	Thrigesvej	Rugårdsvej	Tøjhushaven	Grønhøj	Snerlehaven	Marina Park	NN	Hald Ege
Main idea	MSTF	MSTF	MSTF	MSTF	MSTF	MSTF	MSTF	MSTF	MSTF	MSTF	MSTF
Time period	1994	1995-1997	1997-98	1998-99	2000-01	2000-01	2000-01	2000-	2001-02		
No. of dwellings			36	72	64	14	46	46	99	40	28
Adjacent buildings			None	None	Yes, infill (partly)	Yes, infill	None	None	None	None	None
Type of tenant			Social housing	Social housing	Social housing, youth and family	Social housing, family	Social housing, partly tenant ownership	Social housing, elderly	Social housing and private semi-ownership	Social housing, youth and elderly	Social housing and semi-owned, also elderly-suited
Type of building and no. of storeys	5 ½ storey block	5 ½ storey block and less	3 x 2-storey row houses 2 x 3-storey blocks	3 x 3-storey blocks	3 x 4-storey blocks	4 ½ storey	Row house	3-storey	4 x 3-storey blocks	2-storey row house	Row house
Facing	"wood"	Western red cedar (2 types), larch, pine, bricks, rockwool plates, dressed masonry	Yellow brick, dressed masonry, cedar	Cedar, zinc plates	Fire-pressure impregnated, unplaned Norwegian spruce	Dressed masonry in socket wall, zinc plates		Cedar with details in mahogany	Siberian larch	Larch, galvanised steel	
Bathroom		"should be waterproof"	In situ construction in concrete (lk)	Prefab bathroom units in concrete (lk)	Prefab bathroom units in concrete (lk)		In situ cast concrete				
Staircase			In situ construction in concrete (lk)	Fire protected wood	Light elements in fire protected wood construction						
Elements/prod-uction method used on site			Prefab wood elements	Prefab wood elements	Prefab wood elements + end wall elements assembled on site	Prefab wood elements	Prefab wood elements + platform-frame principle for internal sepa-ration walls				
Assembly direction			Horisontal (?)	First horisontal, then vertical							
Logistics	Considered	Not in focus	Not in focus	Increasing focus	Increasing focus	Increasing focus					
Building system (and wood element variants)	Wall elements with gypsum, floors and joints (few variants, highly industrialised)	Wall elements with fire-proof gypsum, floors and joints	Wall elements with fire-proof gypsum, floors and joints (256 of 276)	Wall elements with fire-proof gypsum, floors and joints (200 of 800/900)	Wall elements with fire-proof gypsum, floors and joints	Wall elements with fire-proof gypsum, floors and joints	Wall elements with fire-proof gypsum, floors and joints	Wall elements with fire-proof gypsum, floors and joints	Wall elements with fire-proof gypsum, floors and joints	Wall elements with fire-proof gypsum, floors and joints	Wall elements with fire-proof gypsum, floors and joints