Linköping University Post Print

Development of timber framed firms in the construction sector - Is EU policy one source of their innovation?

Saana Tykkae, Denise McCluskey, Tomas Nord, Pekka Ollonqvist, Marten Hugosson, Anders Roos, Kadri Ukrainski, Anders Q Nyrud and Fahrudin Bajric

N.B.: When citing this work, cite the original article.

Original Publication:

Saana Tykkae, Denise McCluskey, Tomas Nord, Pekka Ollonqvist, Marten Hugosson, Anders Roos, Kadri Ukrainski, Anders Q Nyrud and Fahrudin Bajric, Development of timber framed firms in the construction sector - Is EU policy one source of their innovation?, 2010, FOREST POLICY AND ECONOMICS, (12), 3, 199-206.

<http://dx.doi.org/10.1016/j.forpol.2009.10.003>

Copyright: Elsevier Science B.V., Amsterdam.

<http://www.elsevier.com/>

Postprint available at: Linköping University Electronic Press

<http://urn.kb.se/resolve?urn=urn:nbn:se:liu:diva-54506>

JOURNAL ARTICLE Submission

**Development of timber framed firms in the
construction sector - Is EU policy one source of their
innovation?**

Saana Tykkä, Denise McCluskey, Tomas Nord†, Pekka Ollonqvist, Mårten
Hugosson, Anders Roos, Kadri Ukrainski, Anders Q. Nyrud, Fahrudin Bajric

† Corresponding author

Division of Industrial Marketing, Department of Management and Engineering,
Linköping University, 581 83 Linköping

Telephone: +46-(0)13 28 28 78

Telefax: +46-(0)13 28 11 01

E-mail: tomas.nord@liu.se

Abstract

To enhance competition in the construction industry, EU policies have created and harmonised functional building codes. Moreover, many actors advocate the construction industry moves towards a lean production, process-based way of working for quality and cost reasons. Here, Timber Framed Engineering approaches are considered to have a competitive and environmental advantage. There is however underlying concerns that conservatism in the construction industry, and lack of timber engineering skills, may be obstacles to change.

This paper therefore assesses whether EU construction policy innovation contributed to innovation at the firm level. Timber framed innovators in six European countries were identified, and their sources of innovation assessed.

The results indicate that timber framed firms have become actors in the construction industry. Firms have made product, process and organisation innovations.

All case firms have similar sources for innovation. The common factor that triggers the firms to innovate is business opportunities that arise from demographic changes in the environment outside the firm, such as environmental sustainability and affordable housing for lower income groups.

To address these opportunities, the case firms implicitly recognised that traditional project and site-based construction

approaches are an incongruity. The firms have consequently established in-house prefabrication, including developed of lean production processes to ensure quality as well as effectiveness.

The firms have all recognised that a fundamental barrier to their business was lack of timber framed engineering competencies in their customers' organisations. Accordingly, a business necessity for the case firms was developing construction design competencies.

Firms benefited from governmental policy instruments that support timber framed R&D and knowledge transfer.

However, firms also gained new knowledge from their own experiences, which they also use in their operations.

Accordingly, policy instruments are not a sole or dominant source for innovation in the case firms. Nonetheless, the change in building codes has been a pre-requisite the firms' commercial developments.

Keywords Innovation, innovation source, timber frame, construction, EU policy

Introduction

Researchers with an interest in the forest products industry have assessed European Union policies. They have concluded that there are no EU policies which have the specific intent to promote timber framed construction. However, a number of other EU policies may indirectly support this construction approach. (Rametsteiner et al., 2009)

The underlying rationale for this perspective is that current EU policy aims to promote sustainable development and manage climate change (EU Lisbon Strategy, Competitiveness and Innovation Framework Programme 2006). Accordingly, to enhance competition and promote more sustainable energy use, building codes have therefore been harmonised throughout EU member states (e.g. EU Council Directives 89/106, 93/68 and Regulation No 1882/2003). These codes place functional requirements, such as fire resistance and thermal insulation, on the building's performance. Such functional codes have replaced previous building codes that included prescriptive material decrees, which essentially banned the use of wood in built-up areas. Thus, harmonised functional codes are perceived to indirectly support timber frame in multi-storey construction (Visscher & Meijer 2007).

Such harmonising EU directives, regulations and building codes have often been formalised in various country-specific building codes (Bregulla et al., 2003, Visscher & Meijer 2007). Latter EU directives have in effect been automatically adopted (Visscher & Meijer 2007). Therefore, today, there is

no formal policy barrier to the enhanced use of wood in European construction, including multi-storey apartment houses (Bregulla et al. 2003). However, there are concerns that there may be local variations in building codes and the forest product industry should be actively involved in removing this barrier (Bregulla et al., 2003; CEI-Bois 2004).

Such building policy innovations awoke keen interest within the sawmill sector, which sees the opportunity to significantly increase the percentage of wood used in construction (CEI-Bois 2004). Moreover, some countries have introduced policies which aim to considerably enhance the construction industry effectiveness by radically changing the industry's processes: instead of constructing on-site, it is advocated building elements be pre-fabricated in factory-type environments, and then assembled on-site (e.g. Postnote 209, Näringsdepartementet 2004).

Calls for such process innovations are particularly influenced by lean manufacturing ideas from the automotive industry (e.g. Womack et al., 1990, International Group for Lean Construction). With such process concepts, timber is considered to be a competitive and interesting construction material (Björnfot, 2006; Höök, 2008; Nord, 2008). Additionally, wood is considered a more environmentally sustainable framing material than concrete or steel (e.g. Bregulla et al., 2003; Gustavsson and Sathre, 2006).

A classic definition of innovation is the generation, acceptance, and implementation of new ideas, processes, products, or services (Thompson, 1967). Accordingly,

introducing prefabrication-based processes and use of wood as a load bearing element implicitly requires firms in the construction industry to innovate. However, the construction industry is known for its conservatism and low rate of innovation (Pries and Janszen, 1995; Winch, 1998; Widén, 2006). There are also practical obstacles to timber framed innovation, including the lack of wood engineering skills as well as perceived cost risks (Bregulla et al. 2003; Taylor and Lewitt, 2004; Visscher and Meijer, 2007; Goodier and Gibb, 2007; Pan et al., 2008, Roos et al. 2008.). Moreover, there is a general concern that the construction industry's structure may negatively influence innovation and its adoption (Sardén, 2005; Winch, 1998; Blayse and Manley, 2004; Pries and Janszen, 1995).

Such obstacles raise the concern that, despite policy innovation, firms may NOT innovate. This work therefore addresses the fundamental question: *Has EU construction policy innovation contributed to innovation at the firm level?*

Purpose

From a perspective that is interested in assessing the business opportunities of the forest product sector, this research will assess the sources of innovation in innovative timber frame construction firms to ascertain whether policy is one source of their innovation.

Disposition

Our approach identified firms that are recognised innovators in six European countries, and assess their sources of innovation (Drucker, 1985). The methods and technique section describes analytical framework for assessing

innovation and firm's sources of innovation, as well as the criteria for selecting firms. The use of timber as a load bearing element was one criteria. In the results section, the particular regulatory and business context of six case firms in six countries is then outlined, along with an assessment of the case firm's business concept and processes. In the conclusions and discussion section, the work assesses whether policy was one source of innovation.

Methods and techniques

Policy and business perspectives on innovation

The OECD's definition of innovation (OECD, 2005) is commonly accepted by various actors in the European Union. This definition distinguishes types of innovations:

1. A product innovation is the introduction of a good or service that is new or significantly improved with respect to its characteristics or intended uses.
2. A process innovation is the implementation of a new or significantly improved production or delivery method.
3. A marketing innovation is the implementation of a new marketing method involving significant changes in product design, packaging, product placement, product promotion or pricing.
4. An organisational innovation is the implementation of a new organisational method in the firm's business practices, workplace organisation or external relations.

The role of the state is to establish an appropriate regulatory environment which enables such innovations to occur (Lundvall, 1992).

Innovation is traditionally associated with technological innovation, where firms use R&D processes to develop new, or radically improved, products for markets. Such a technological and linear model perspective of innovation prevailed especially during the first half of the 20th century (Edquist, 2004; Kaufmann and Tödtling, 2001; Galli and Teubal, 1997; Lundvall, 1992). However, theorising on the nature of policy has developed significantly and it is recognised that policy makers must also innovate policies to change the direction of society's development and address intended and unintended policy affects (Art and Van Tatenhove, 2004).

Regarding innovation itself, policy perspective has recently changed from a product-based emphasis to the view that innovation is a process which is systemic (Kaufmann and Tödtling, 2001; Edquist, 2004; Galli and Teubal, 1997; Lundvall, 1992). Similarly, the business literature currently advocates a shift from the perspective that only products themselves are of value to a concept where value is generated in business systems that are innovative in their ways of combining the firms and other actors (firms or customers) resources for service production and delivery (Drucker, 1998; Hamel, 1998; Prahalad, 2004).

Both the policy and business literature considers policy to be an environmental factor that impacts firms by defining the

rules-of-the-game (Ansoff, 1979; Arts and Tatenhove, 2004; Galli and Teubal, 1997; Ghemawat et al, 2001). However, firms' socio-cultural environment, which includes norms, customs and institutions, can also influence industry, business and organisational culture. Since innovation requires learning new ways of doing things, which also necessarily involves a continuous process of unlearning and forgetting old ways of doing thing (Senge 1990), culture can therefore significantly affect firms' propensity to innovate as well as their innovation success (Elenkov and Manev, 2005; Simmie, 2004; Ansoff, 1979; Drucker, 1998, Senge, 1990). In this respect, the construction industry is viewed as particularly conservative, with low innovation rates (Winch, 1998; Bregulla et al., 2003; Taylor and Lewitt, 2004; Widén, 2006; Visscher & Meijer, 2007).

Framework for assessing sources of innovation

Innovation theories address a wide range of perspectives and concepts. Contemporary approaches emphasise an opportunity construction perspective, where actions to construct and exploit the opportunity are key (Venkatraman 1997; Shane and Venkatraman, 2000; Eckhardt and Shane, 2003).

Peter Drucker is recognised as a major contributor to the innovation discipline. He considers the current challenge is to learn to practice systematic innovation. This consists of the purposeful and organized search for changes, and the systematic analysis of the opportunities such changes might offer for innovation. (Drucker, 1995)

At the firm level, opportunities exist outside the firm and its social and intellectual environment, and exist within a firm.

Drucker's seven sources for understanding opportunities are:

Outside a firm or industry

1. Demographic changes
2. Changes in perception
3. New knowledge

Within a firm or industry

4. Unexpected occurrences
5. Incongruities
6. Process needs
7. Industry and market changes

In innovation practice, these sources are often interdependent and aspects of the same phenomenon can be captured in each source (ibid).

A prerequisite for purposeful, systematic innovation is an examination of these sources of new opportunities. Then, innovators need to analytically assess what the innovation has to be in order to satisfy an opportunity. Finally, innovators need to go out and identify potential users so that they can study the expectations, values of needs of such potential users. This process requires both hard work and diligence. (ibid)

Research approach

This work is the outcome of the following research process, which included meetings of the principle authors to align on the research approach and data analysis. Overall, the method

used a qualitative case-study approach (Eisenhardt, 1989; Silverman, 2000; Yin, 2003).

Stage 1: Case selection criteria

To enable assessments of whether business process innovations within the construction industry were facilitated by governments' policies, one case for each country were selected i.e. strategically chosen for study (Patton, 1990; Silverman, 2000). Each case author was asked to examine candidate cases and select an appropriate one based on the criteria below. Cases should:

- Reflect a key issue that the particular nation's government is concerned about
- Be clearly innovative from a business perspective
- Comprise actors that were established on a commercial basis
- Use timber as a load-bearing element

Stage 2: Case data collection

Using these criteria, case authors selected a case firm. To ascertain the firm's business concept and sources of innovation, authors then interviewed people within the firm. The particular persons interviewed all had significant personal experience of the firm and its development. Formally they also held senior positions within the firms and were often owner-managers.

To place each case in context, the case authors were also asked to give a brief outline of the key policies in their country which potentially influence the general business

situation of the sector in that country. In addition, authors were also asked to describe the case firms' business concept.

Stage 3: Data assessment

In due course, as a common effort, the cases and the text as a whole were given a unitary linguistic style. Drafts of this work were then submitted in a review process, which included several meetings of the principle authors. The overall analysis and possible conclusions were discussed within the group of authors and agreed upon.

Results

Austria - Country briefing

The Austrian government has historically subsidised housing to promote a rate of high construction, which has a local development focus stemming from Bundesland-specific building regulations. Recently, harmonised building regulations have been implemented. Focus on sustainability has been increased via policies and subsidies for building low energy consuming single family homes (Euroconstruct, 2007). Although the balance of public spending from central government and federal states will change, subsidies will be maintained at current levels for the next six years. Moreover, subsidies will be more closely linked to environmental protection measures.

Austrian case firm's development

The Austrian case firm has developed a business concept for providing single family homes that are ecologically and environmentally sustainable. The company was founded in

1994 by an expert in the field of renewable energy, who has keen environmental interests.

Much of founder's inspiration for implementation of the firm's business idea is based on the clay. Historically clay is one of mankind's earliest housing cladding materials, which fell out of use. However, experiments with clay and straw were made in the 1980s, which interested the case firm's founding manager. He initially built his firm based on active participation in R&D projects in the field of ecological passive house construction, which were publicly financed by Austria's National Research Fund

Today, this micro sized case firm is part of a network of sixty SMEs that develops environmental-friendly houses in German-speaking countries. Either in partnership with other firms in the network, or individually, the case firm designs low-energy and passive energy houses for individual consumers; manufactures timber framed outer walls, which have clay-based claddings, in a factory-type environment; and assembles the building elements on the consumer's site.

Estonia - Country briefing

Until the 1930s, Estonian houses were mainly one or two stores and constructed from timber. In Soviet times, five-to-nine-storey concrete flats were mainly constructed in city areas.

In the transition period, the general policy approach is *laissez faire*, with construction legislation and standards aligned with EU construction principles and policies (Oidermaa, 2004).

Estonia's national forestry strategy aims to increase the use of wood as a construction material (Ministry of Environmental Affairs, 2003). However, the means for achieving this aim have been limited to some popularization activities.

Despite of population decrease in the transition period, new housing has not been sufficiently large to replace the amortized housing stock (Lättemäe and Touart, 2006). The main aim of contemporary construction policy is to ensure availability of low-cost housing to lower income groups (Ministry of Economic Affairs and Communications, 2008).

Estonian case firm's development

The Estonian case firm was established in 1988, with a focus on export markets where the firm had a price advantage due to its lower labour costs. It began by supplying timber-based structural components for low level flats and holiday homes in Scandinavian markets.

Working at a distance to its markets, the firm focused on its operations so that it could ensure quality before shipping – otherwise on-site error correction would be too costly for them. The firm has engaged an independent international quality control institute to assist it with this work.

As Scandinavian building regulations changed during the 1990s, the firm changed its focus to the production of terraced houses and multi-storey apartment houses. This market development resulted in a series of technical product innovations as well as organisational process innovations. In particular, the company implemented a production process

where as much as possible is produced in-house. The in-house work ranges the structural frame to interior finishing including electricity, water and ventilation. The finished modules are then shipped to the production site for mounting and finishing.

Production of prefabricated houses assumes a thorough construction design, where all actors involved in the construction have a common understanding of the design at an early stage of the process. Handling late changes in specifications is generally problematic, particularly for the focal firm due to the distance to markets. To avoid such problems, today, it is common that the firm's customer provides the architectural design of the building, with the technical design undertaken by the case company. This kind of business model enables the company to be more flexible, at an additional cost.

The firm aims to enhance efficiency by maintaining a database of the various technical solutions that emerged from its past projects. This database is consulted when designing new projects.

The firm has worked to incrementally improve its products and processes. The firm has however made a major product innovation to construct more complete housing elements. This required several process innovations due to the increased complexity of the construction components as well as functional and safety requirements.

Finland - Country briefing

Sustainable construction is supported in Finland through technology, research and development programmes. The regulatory framework and the energy tax are two important instruments. Subsidies are also used for energy audits and saving agreements, which play a central role in the implementation of energy efficiency. The effects of these tools on the residential sector are still not evaluated (Itard et al., 2008)

In 1997 new legislation allowed the construction of three or four-story residential and commercial buildings, with timber frames and wooden façades, without special permits. The change in legislation led to a large number of development projects related multi storey timber frame construction (Puurakentaminen, 2000). The new product solutions were tested in several pilot projects, which had the intent of enhancing the use of wood in construction.

The main area of access has been in low rise town projects. The timber frame house construction concept “Modern wooden town” has become competitive and widely applied since the late 1990s (Ollonqvist et al., forthcoming).

The share of pre fabricated element housing has increased from 48 % in 1996 to 68 % in 2008 in low rise single house construction and the share of timber frame is almost 90 %, among the latter. In addition the share of timber frame is dominant in DIY house construction.

Finnish case firm's development

The case firm was founded in 1982 and is one of Finland's largest domestic manufacturers of roof trusses in Finland. Based on perceived opportunities in the timber framed construction, the firm extended its range of operations to flooring.

Cost competitive floor solutions were considered a key challenge that impeded the viability of multi storey timber frame house construction. The firm therefore developed tested a number of timber-concrete composite solutions. The flooring innovation required good sound insulating performance between flats of different levels. The developed concept also proved well suited for base floor and roof construction of terraced houses. Customers include large Finish construction firms, trade networks and consumers.

The firm's design department produces modular or customised designs based on basic data, obtained from the customer's structural engineer, using certified software application.

The firm has invested heavily in IT-automated technology. All timber used in the production is measured, planed, stress graded and stamped mechanically using the firm's own equipment. The company uses computer-assisted sawing techniques, laser controlled manufacturing lines, and on-line design production. The large capacity of the plants and close co-operation between the sales, production and transport departments ensure reliable delivery times.

The firm is the only roof truss manufacturer in Finland that is awarded with international certificates and environmental ISO standards.

The firm works in a close co-operation with technical and commercial R&D facilities in the public and private sectors.

The firm is concerned about the environment and its operations aim to reduce negative impacts on the environment via:

- continuously monitoring the environmental impacts of its activities
- optimizing the use of materials, raw materials and energy
- using procurements suppliers who take environmental aspects in consideration

Norway - Country briefing

In Norway, timber framed is the dominant approach when building houses. However, timber is seldom used in multi storey buildings in urban areas. Recent data indicates an increase in multi storey housing and so the market size of timber frame housing has consequently decreased substantially (Statistics Norway, 2009).

Recent developments in policies, legislature and construction technologies may be in favour of timber-based construction from environmental, economic and competitiveness perspectives. Innovations in wood construction are also supported by public authorities in order to increase value added in the forest sector and because timber is considered a building material with favourable environmental properties. An example of joint public and industry strategy to promote

wood was the Norwegian Wood program initiated in 2008 when Stavanger was the European City of Culture. Norwegian Wood gathered actors from the whole innovation system to establish and realize sustainable urban timber construction projects.

Norwegian case firm's development

The Norwegian case firm is part of one of Norway's larger sawmill and wood manufacturing groups. In 1950 the group started producing module-based housing and shelters. The Building Systems division is presently one of three divisions within the company. All three divisions sell to industrial and retail customers, as well as to builders and contractors in Scandinavia and Europe.

The company has noteworthy production facilities for producing building components for residential housing, industrial purposes (temporary barracks) and public buildings e.g. kinder gardens.

The increase in multi storey construction has resulted in a decrease in consumption of wooden building materials. In order to regain the lost market share, the firm is therefore increasingly focusing on the market for multi storey construction. To do this, the firm developed new timber-based construction technologies – making extensive use of governmental initiatives to develop timber based multi storey building technologies and urban construction systems.

The case firm's building division supplies flexible system solutions: interior walls, modular buildings, electrical installations and load-bearing gluelam structures for projects and contract customers primarily in Norway and Sweden. Completed modules are transported to the building site for assembly.

The division is continuously developing concepts and systems in close collaboration with customers and experts in the fields of architecture, design and construction. The firm can design buildings as well as create the engineering design for the building components that it manufactures. The firm also has its own construction workers to assemble the building. The case firm considers that developing such competencies were necessary for their business since traditional actors were unwilling to work with new materials and building systems.

Based on their experiences of what 'works', the firm has incrementally developed a lean production process. The focus on lean building design arose from the need for improved efficiency and cost minimizing construction practices: construction cost (not life cycle cost) tend to be a key determinant for choice of building material and construction technology. Minimising construction costs is therefore a competitive necessity.

Scotland - Country briefing

The Scottish region of the United Kingdom has its own legislative framework. As well as a general housing shortage, one major housing challenge in Scotland is redevelopment of

the run-down residential areas that were established in the immediate post-war period, late 1960s and early 1970s.

To facilitate a significant increase in the number of new houses, throughout the past decade, the Scottish and UK regulatory environment increasingly placed emphasis on Modern Methods of Construction to promote innovation and efficiency in the industry (POST 209, 2003). Moreover, the UK national government choose to establish a Centre for Timber Engineer at Napier University in Edinburgh. The purpose of this centre is to transfer knowledge between academia and the network of Scottish timber-framed construction firms that have grown in the past decade (Turner, 2009). During the past decade the share of timber-frame housing has risen and presently accounts for more than 80% of annual new construction.

Scottish case firm's development

The Scottish case firm was established as an engineering spin-off from a larger firm that went bankrupt in the early 1990s. At its inception, it was a micro sized firm with timber engineering design competences for construction applications: while Scotland lacks a timber framed housing culture, its stone and concrete buildings have wood-framed roofing structures.

The regulatory environment increasingly placed requirements on traditional house builders to produce at least 25% of their houses using MMC approaches (POSTNOTE No. 209, 2003). As this regulatory framework came into place, the case firm's owner-engineers recognised that established house

builders lacked timber engineering design, construction and assembly competences. They therefore developed a business concept to become a timber frame supplier to the major house builders in the UK, who organise a network of regional offices that plan and develop the houses.

A key aspect of the case firm's offering to house builders regional offices is cooperating with architects: the firm transforms the architects' house designs into timber engineering design plans – advising where designs could be adjusted to be more viable. Working at an early stage with architects also means that the firm has house construction plans 'on the shelf' when construction site managers initiate projects. The firm then liaises with construction site managers to plan and manage that particular site's production and assembly needs; produces the structural building elements (outer and load-bearing walls, floor cassettes, roof frames) in a factory type environment; ensures JIT delivery of those elements to the construction site; and, via partners, assembles the prefabricated elements on-site.

The Scottish case firm recognised that their business success depends upon a broad service concept, with stringent approaches to quality and delivery reliability.

The case-firm therefore also developed its own production processes to secure both quality and delivery reliability. This work included cooperating with its suppliers about long term business prognoses, detailed short term delivery needs, as well as delivery quality and reliability performance. Lean

production and JIT approaches are a well-established business practice.

The case-firm also worked extensively with its partner firms that assemble the pre-fabricated elements at the customers' building sites – providing specialist training on timber frame specific techniques and, ensuring partners also approach the work with due quality and reliability diligence.

The case firm initially perceived scepticism to the entire MMC approach amongst their customer's construction site managers and workers. However, as they worked with site managers to plan the work, and consistently delivered in time, the site managers found that build time for multi-family houses was almost halved from 44 weeks to 24 weeks. This overall improvement in construction completion rates was valued. And, the entire service was appreciated particularly during a rapidly growing market that was experiencing labour shortages.

Site managers' confidence in the case-firm's track record resulted in business growth: the firm found that they systematically increased their share of business at the regional operations centres they had entered. The case firm now has an expansion strategy of entering regional offices and growing its share of the customers' supply business.

The case firm has self-financed its own growth by 33% p.a. for the past decade – including expanding production capacity and expansion into new regions of operation.

Sweden - Country briefing

The annual residential construction rate has fluctuated during the past 20 years but on average been around 20 000 apartments per year. The share of timber frame housing is approx. 90% in single-family housing but only about 10% in multi-family housing.

A revision of the Swedish building regulations, partly based on the Building Product Directive of EG, meant a change from material based to functional based regulations (Boverket, 1995). Thus, after a century long ban, timber was again allowed in buildings taller than two storeys (Näringsdepartementet, 2004).

Sweden's three largest cities, Stockholm, Gothenburg and Malmö have experienced significant population growth rates during the past decade due to general demographic changes. There are perceived general housing shortages in these regions, particularly for students and the elderly that are in need of care. There is also a need to renew the housing areas that were built in the 1960s and 1970s, increasing the local population, so that they can attract modern amenities. Accordingly, there is a need to increase the number of small apartments.

The Swedish government has two concerns: improving house cost and quality through enhancing construction industry competitiveness, and promoting development of the sawmill sector. A number of reports and studies argue that these goals can be achieved by timber based prefabrication if housing elements (Näringsdepartementet, 2004), including promoting

changes towards a more industrial logic of construction (SOU, 2003; Sveriges Byggindustrier, 2007; SOU, 2007).

Swedish case firm's development

The case company is medium-sized construction company, which is family owned. Based on early information from some customers about anticipated market changes, the firm has moved its business concept from a general housing contractor towards a focus on private developers of housing for students, elderly people and families who need affordable housing. To meet customer quality and cost demands, the case company developed off-site production using a modular construction system.

Based on customer requests for tenders, the firm designs the housing and makes an offering that includes coordinating all activities from design to the finished building. One aspect of this offering is providing developers with the documentation that is necessary for construction approval. The firm then prefabricates housing elements in a factory-type environment, including mounting kitchen, bathroom and bedroom fittings as well as interior design finishes. The completed modules are then transported to the building site for assembly.

The firm has incrementally developed a lean production design and building system based on standardised prefabricated volume elements with a light-weight timber frame system. Dependent on requirements from customer groups and type of apartment the volume elements are configured differently. Exterior elements tend to be customised for each project, although there are also plans to

partly standardise these. Production development has been done in cooperation with universities and research organisations.

The firm considers much of its success has arisen from early contact with customers' real estate trustees and developers, as well as agreeing design layout and fittings at an early stage. This has resulted in possibilities to improve internal production processes and to deliver qualitative products. Knowledge is generated through the repetitive procurement and production process with early client involvement.

Conclusions and discussion

The results of the research indicate that there are firms that have become actors in the timber framed construction industry. Using the OECD's definitions as an analysis framework we can see that the case firms have shaped similar *types of innovations*: the firms have created *product innovations* by designing new timber-based building elements or volumes; *process innovations* by designing lean production processes to produce these timber-based housing elements; and, *organisational innovations* by establishing off-site production as well as taking responsibility for construction design, and often onsite assembly, from traditional actors.

Sources of innovation

Table 1 summarises and exemplifies the *sources of innovation* for the case firms, which have also been somewhat similar. The common factor that triggers the firms to innovate is business opportunities that arise from *demographic changes* in the environment outside the firm, such as environmental

sustainability and affordable housing for lower income groups. Firms clearly perceive these issues as creating new housing demands. Common examples are growing regions and new sustainability and environmental concerns.

Table 1 around here

To address these opportunities, the case firms implicitly recognised that traditional construction approaches have an *incongruity*: project and site-based production is inefficient and tends to have a poor quality. The firms have consequently established in-house prefabrication, including developed of lean production processes to ensure quality as well as effectiveness.

The firms have all recognised that a fundamental barrier to their business was lack of timber framed engineering competencies in their customers' organisations. Accordingly, a business necessity for the case firms was developing timber framed design competencies and interacting with their customer's architects at an early stage. The Swedish, Scottish, Norwegian and Estonian cases in particular seized opportunities in provide a comprehensive offering by operating directly with customers and eventually end-customers. The Finnish and Austrian cases however have a more internal focus.

One aspect of the construction process *incongruity* is that the various case firms had a new *process-need* i.e. off-site prefabrication. Developing prefabrication processes, as well

as timber engineering design, necessitated firms acquire *new knowledge*. The firms did this partly via internal development as well as by establishing or interacting in research projects with various organisations. The emphasis that some national governments simultaneously placed on policies which aimed to remove the construction process incongruity and promote more process-oriented construction approaches has been important in some cases, particularly in the Scottish firm. More generally, governmental policy instruments that support timber framed R&D and knowledge transfer have benefited case firms. However, such policy instruments are not a sole or dominant source for innovation in the case firms.

The use of timber as structural material was an opportunity that arose from a process need perspective. The change in building codes, from local prescriptive material decrees to common European Union functional concepts, was accordingly a pre-requisite for the process incongruity to be resolved. A similar development is apparent in the Swedish, Estonian, Norwegian cases where incumbent construction actors were restricted by their traditional behaviours, which opened opportunities for new business models including close interaction of clients to production processes.

An interesting observation is that demographic issues, such as environmental concerns and social housing needs, are a common underlying business opportunity for firms as well as an underlying policy concern.

Complexity

According to the above discussion on the sources of innovation, it is concluded that the case firms have multiple, interdependent sources of innovation. While policy may only be linked some sources, firms have mainly acted on business opportunities, which are the dominant driver for innovation along with deploying new knowledge at the firm-level.

The finding that deploying new knowledge at the firm level is a key issue supports general theorising about organisational development and renewal. This finding also supports the literature that conclude policies can have both positive and negative impacts on innovation in the construction (Seaden and Manseau, 2001). It would therefore be of interest for future research to assess the extent of innovation in case firms, the impact innovation has on the efficiency of the construction process, and the relative influence policy changes have in comparison to business related opportunities.

The case firms also found it necessary to undertake certain tasks that their customer firms traditionally performed themselves. Give this, and the general theoretical discourse on the significance of network perspectives, it would be interesting to ascertain the influence of customer firms and other actors on the case firm's innovations.

The cases also differ. These differences also illustrate that construction is a local activity, which is influenced by local, regional and national traditions, culture and policies. The 'European' construction industry tends to operate as a

number of distinct national business systems, each of which has been established based on their nation's specific historical premises. Despite the introduction of the CPD (Construction Product Directive) and the main concern of EU of establishing harmonization and free movement of goods and services, there may still be differences between building regulations in many European countries (Sheridan et al., 2003). Policy changes at the EU level must therefore become reflected in regional and national legal and cultural systems (Winch, 2000).

Acknowledgements

We are grateful to the case companies for supplying us with valuable information and the EU Cost Action 51 for enabling us to meet.

We also acknowledge that all authors have made a contribution both by supplying their country cases and via discussion and analysis of all the cases. Additionally, we note Ms Tykkä contribution to the theory chapter, Dr McCluskey with the Introduction and theoretical sections and Dr Nord as coordinator.

References

- Ansoff H. I., 1979. Strategic Management. Palgrave Macmillan. ISBN 0-333-19686-4.
- Arts B. and Van Tatenhove J., 2004. Policy and power: A conceptual framework between the 'old' and 'new' policy idioms, in: Policy Sciences 37: 339–356 Springer.
- Björnfot, A. 2006. An exploration of lean thinking for multi-strepy timber housing construction – contemporary Swedish practices and future opportunities. LTU-DT 06/51, Doctoral thesis. Luleå University of Technology, Luleå
- Blayse, A. and Manley, K., 2004 'Key Influences on Construction Innovation', Construction Innovation, Vol. 4, No. 3, pp 1-12
- Bregulla, J.R., Grantham, R. Johansson, H-E. and Enjily, V., 2003. Barriers to the enhanced use of wood in Europe: Particular attention to the regulatory barriers. Report prepared by Building Research Establishment (BRE) as a part of the "Roadmap 2010" programme of the European Confederation of Woodworking Industries, CEI-Bois, 19p. <http://www.cei-bois.org/roadmap/reports.html>.
- Boverket 1993. Boverkets ByggRegler. BFS 1993:57 BBR1. The National Board of Housing Building and Planning, Karlskrona
- CEI-Bois, 2004. Roadmap 2010 for the European Woodworking Industries. European Confederation of woodworking industries. Brussels
- Drucker P., 1985. Innovation and Entrepreneurship, Collins; 1st edition.

- Drucker P., 1998. Management's New Paradigms. *Forbes* 162 (7): 152-177.
- Eckhardt, J. and Shane, S., 2003. "Opportunities and Entrepreneurship", *Journal of Management*, 29(3): 333-349.
- Edquist, C., 2004. Systems of Innovation – A Critical Review of the State of the Art, in : *Handbook of Innovation*, J. Fagerberg, D. Mowery and R. Nelson. Oxford University Press.
- Eisenhardt K. M. 1989. Building theories from case study research. *Academy of Management Review*, 14(4) 532-550
- Elenkov, D.S., M.I. Manev, 2005. Top Management Leadership and Influence on Innovation: The Role of Sociocultural Context, in *Journal of Management*, Vol. 31; 381-401, Southern Management Association. Sage Publications.
- EU Lisbon Strategy, 2006. Competitiveness and Innovation Framework Programme.
- EU Council Directive 89/106., 1988.
- EU Council Directive 93/68. 1993.
- EU Regulation (EC) No. 1882/2003., 2003.
- EUROCONSTRUCT 2007. European construction market trends to 2010: Country reports. 64th EUROCONSTRUCT conference, 22-23 November, Vienna Austria
- Ghemawat P., Collis D.J., Pisano G.P. and Rivkin J.W., 2001. *Strategy and the Business Landscape. Core Concepts*. Prentice Hall. ISBN 0-13-028976-0. 143 p.
- Gustavsson, L. and Sathre R., 2006. Variability in energy and carbon dioxide balances of wood and concrete building

- materials. *Building and Environment*. Vol. 41, no. 7, pp. 940-951
- Galli R. and M. Teubal, 1997. Paradigmatic Shift in National Innovation Systems, in: C. Edquist: *Systems of Innovation. Technologies, Institutions and Organizations*. London and Washington, Pinter.
- Goodier C, Gibb A., 2007. Future opportunities for offsite in the UK. *Construction Management and Economics* 25 (6):585-595.
- Hamel G., 1998. The Challenge Today: Changing the Rules of the Game. *Business Strategy Review* 9(2):19-26
- Höök, M., 2008. Lean culture in Industrialized Housing – a study of Timber Volume Element Prefabrication. LTU-DT-08/21. Doctoral thesis. Luleå University of Technology, Luleå.
- Itard, L., F. Meijer, E. Vriens and H. Hoiting, 2008. Building Renovation and Modernisation in Europe: State of the art review, Technische University Delf.
- Kaufmann, A. and Tödtling, F., 2001. Science-industry interaction in the process of innovation: The importance of boundary-crossing between systems, in: *Research Policy*, 30 (5), 791
- Lättemäe, R., Touart, K., 2006, Eesti eluasemeturu struktuur ja areng, *Kroon ja Majandus*, 2: 34—39, in Estonian.
- Lundvall, B-Å., 1992. *National systems of innovation: Towards a theory of interactive learning*. London: Pinter.
- Ministry of Economic Affairs and Communications, 2008
National Housing Development Plan 2008—2013.
[<http://www.mkm.ee/index.php?id=1733>], in Estonian.
Collected at 2009 04 21

- Ministry of Environmental Affairs, 2003. The Strategy of Estonian Forestry to 2010, [<http://www.envir.ee/metsandus/arengukava/arengukava.html>] in Estonian. Collected at 2009 04 21
- Nord, T., 2008. Prefabrication strategies in the timber housing industry – a comparison of Swedish and Austrian markets. LTU-DT-08/51, doctoral thesis. Luleå University of Technology, Luleå.
- Näringsdepartementet, 2004. Mer trä i byggandet – Underlag för en nationell strategi att främja användning av trä i byggandet. Ds2004:1. Fritzes Offentliga publikationer. ISSN 0284-6012.
- OECD, 2005. Oslo Manual: Guidelines for Collecting and Interpreting Innovation Data, 3rd Edition.
- Oidermaa, E., 2004. Ehituspoliitika ja Eesti ehitusseadusandluse areng Euroopa Liiduga liitumise kontekstis, Eesti Majanduspoliitilised perspektiivid Euroopa Liidus. XII teadus- ja koolituskonverentsi ettekanded-artiklid, 461—471, in Estonian.
- Pan W, Gibb, A.G.F, Dainty A.R.J., 2007. Perspectives of UK housebuilders on the use of offsite modern methods of construction. Construction Management and Economics. 25 (2):183-194.
- Patton, M.Q., 1990. Qualitative evaluation and research methods. Thousand Oaks, CA, US.
- Postnote No. 209, 2003. Modern methods of house building. Parliamentary Office of Science & Technology.
- Prahalad CK. 2004. The Blinders of Dominant Logic. Long Range Planning 37:171–179

- Pries F., and Janszen F. 1995. Innovation in the construction industry: the dominant role of the environment. *Construction Management and Economics* 13(1) 43-51
- Puurakentaminen, 2000. VTT julkaisu
- Rametsteiner, E., Weiss, G., Ollonqvist, P. & Slee, B. 2009. Policy Integration and Coordination: the Case of Innovation and the Forest Sector in Europe. COST Action E51. OPOCE, Luxembourg
- Roos A, Woxblom L, McCluskey DR. 2008. Architects', and Building Engineers', and Stakeholders' Perceptions to Wood in Construction – Results from a Qualitative study. In Bergseng E., Delbeck G., and Hoen H-F.(eds.) p. 184-194 in Proceedings of the Biennial Meeting of the Scandinavian Society of Forest Economics, Norway April, 2008. *Scandinavian Forest Economics* No. 42, 2008
- Sardén, Y. 2005. Complexity and learning in timber frame housing - The case of a solid wood pilot project. LTU-DT-05/43, doctoral thesis Luleå University of Technology, Luleå
- Seaden G. and Manseau A. 2001. Public policy and construction innovation. *Building Research & Information*, 29(3) 182-196
- Senge P., 1990. "The Fifth Discipline: The Art and Practice of the Learning Organisation", Currency/Doubleday, New York, 2nd revised edn, Random House Business Books, 2006.
- Shane, S. and Venkataraman, S., 2000. "The Promise of Entrepreneurship as a Field of Research", *Academy of Management Review*, 25(1): 217-225.

- Sheridan, L., Visscher, H. J. and Meijer, F.M. 2003. Building regulations in Europe part 2: A comparison of technical requirements in eight European Countries, Delft University Press, Delft
- Silverman D., 2000. Doing qualitative research. London, Sage Ltd.
- Simmie J., 2004. Innovation and Clustering in the Globalised International Economy, in: Urban Studies 2004; 41; 1095
- SOU, 2002. Skärpning Gubbar. Om konkurrensen, kvaliteten, kostnaderna och kompetensen i byggsektorn. Bygghälsan, Stockholm, Finansdepartementet, Fritzes Offentliga Publikationer.
- SOU 2007. Utmärkt! Samhällsbyggnad. Slutrapport från Bygghälsan. Statens Offentliga Utredningar Fi2004:15. Fritzes Förlag, Stockholm
- Statistics Norway, 2009. Statistical Yearbook 2008.
- Sveriges Byggindustrier, 2007. Fakta om byggandet 2006. BI Analys, Stockholm
- Taylor, J. E. and Levitt R.E., 2004. A New Model for Systemic Innovation Diffusion in Project-based Industries, in: CIFE Working Paper #WP086. Stanford University.
- Thompson, J., 1967. Organizations in Action. London: McGraw-Hill.
- Turner, P., 2009. CTE The first six years. Director's Report. CTE.
- Venkatraman, S., 1997. The Distinctive Domain of Entrepreneurship Research, In Katz, J. and Brockhaus, R. (eds.) Advances in Entrepreneurship, Firm

Emergence, and Growth. Greenwich, Connecticut: JAI Press.

Visscher, H and Meijer, F., 2007 Dynamics of building regulations in Europe. International Conference on Sustainable Urban Areas, ENHR, 25-28 June 2007, Rotterdam, Holland

Widén K., 2006. Innovation diffusion in the construction sector. Ph.D. Thesis. Lund University. ISBN. 91-85257-93-1.

Winch, G., 1998. "Zephyrs of creative destruction: understanding the management of innovation in construction", Building Research and Information, Vol. 26 pp.268-79

Winch G. 2000. Construction business systems in the European Union. Building Research & Information, 28(2) 88-97

Womack, J.P., Jones D. T. and Roos D. 1991. The machine that changed the world: the story of lean production. New York, Harper Perennial

Yin, R. 2003. Case study research: design and methods. Sage, Thousand Oaks.

Table 1: Major sources of innovation at each case firm

Sources of innovation	Austria	Estonia	Finland	Norway	Scotland	Sweden
Demographic changes	Underlying housing need – and need for housing that is more affordable					
	More centralised government	Transition period	Require urban solutions	Require small apartments and urban solutions	Require a renewal of existing housing areas	Require small apartments
New knowledge	<p>Manufacturing production principles</p> <p>Timber frame design</p> <p>(Partly supported by governmental instruments)</p>					
Incongruities	The construction industry's project based practices are incongruent with the need to create quality housing more efficiently – prefabrication using manufacturing process can significantly improve quality and efficiency of the industry					
Process needs	As well as developing competences to ensure quality and efficiency in prefabrication production process, innovative firms need to gain competences in construction design, and often assembly, so that they can deliver into the construction industry					