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Business and Innovations in Wood Frame Construction – Cross - Sectoral Policy Challenges in Finland

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Abstract:

Public policy actions to promote innovations related business based house construction and related wood use enhancement have been wide in Finland from the mid 1990's on but without many commercially successful innovations. This paper discusses national public policy activities in the two major clusters, real estate & construction and forest & wood product forest industry respectively. Major focus is in the challenges related to cross sectoral innovation processes that do not have position in cluster based national innovation policy favoring supply (technology) push innovation processes in financing in Finland from the mid 1990's up to the mid 2000's. Real estate & construction cluster enterprises tend to be risk averters in connection to new process and material solutions but have gradually from the early 2000's started to adapt customer orientation, networking and building information models based on shared information and communication networks into their business models. Challenges to climate change mitigation and new carbon sinks have improved the potential competitive advantages of wood frame construction with respect to concrete and steel frame solutions. Innovation processes by wood product industry firms imply new orientation if they aim to BtoB demand segment outcomes. Recent Living Business program, characterized by cross cluster center of expertise networks is part of the new innovation policy approach. This try to counteract the prior low interests on cross cluster interactions, that have weakened innovation attempts to react on demand signals.

Keywords: cross sector, policy, innovation, forest, forest cluster, real estate & construction cluster, wooden house industries, joinery industries

Introduction

Wooden house and joinery industries have become identified as low tech industries in Finland with the average investments to R& D at level two percent units counted from the value added. Majority of the firms in these businesses have allocated limited resources to net investments, industry averages in 2005 being 12 % in wooden house construction industry and 17

% in joinery industry (the value added). Palmberg confirms that innovation processes in low tech industry firms are dependent not only on technological opportunities, but also on the performance of the innovation system and on supportive regulatory and competitive environment around the innovating firms (Palmberg 2001). Public financing on innovation activities has been much carried out through national technology programs. They have provided options to coordinate innovation attempts towards industry wide new competitive advantages. Public financing has widely complemented innovation process financing in low tech industries contrary to the common view (see eg. survey in STEP 06/2003). Competence requirements behind the innovation process performance among the firms are frequently and especially among SMEs broader and more multi-dimensional than what are intra firm available. Consequently the knowledge and other resource accomplishment of an innovation process imply the existence of external innovation environment. The latter means framework and resource supply (financial and knowledge resources) available for the firms to complement the intra firm resources. The general conditions described by the standardization and legislation infrastructure must provide the supportive impacts.

Supply push orientation and cluster specific approach characterized innovation policy in Finland up to the late 1990's. Public innovation project support strengthened cluster firms but put inferior interests on cluster interactions what concerns the coordinated value chain development. The latter issues had frequently impeding impacts on the innovation processes among the firms and even industries creating customer values in vertical value chain context. The latter characterization matches with wood product industries supplying products and services to real estate & construction cluster enterprises and other customers. The major points of this survey concern the business interests and transactions among enterprises in wood product industries and real estate & construction cluster respectively. The public actions to enhance knowledge resource supply for the construction value chain enterprises are also discussed.

The focus of the survey is in innovation processes, supporting and impeding factors from the fact that customer valuation extend over the cluster boundary between wood products and real estate & construction. The survey cover a) discrepancies between demand pull and supply push innovation processes, b) means and targets in public innovation financing and c) business culture differences among the two clusters concerned.

Innovation projects both in wood product industries and in real estate & construction cluster have traditionally focused on the progression of supply push product and process innovations. Innovation policy in Finland up to the late 1990's supported that approach. Public technology programs promoting demand pull innovations and more precisely

organizational and marketing innovations, has been initiated to substitute supply (technology) push public innovation promotion from the mid 2000s. Real estate & construction cluster have gradually started to proceed new frame conditions on customer valuation that enterprises in the value chain must cope with in the near future. Product and service demand of the construction business in the upflow of the value chain implies information systems and standardized product and related planning systems of the firms in the wood product industries.

Wood product value chains in house construction

The wood product value chains provide both upflow and downflow challenges for the wooden house and joinery industry enterprises. There is, in the upflow, a fundamental dilemma between the business interests among primary solid wood producers ie. sawmills on one hand and wooden house and joinery industries on the other. Sawmills have divergent optimization target in their production logic. The principle that the whole of the log comes in from the nearby forest must be put to use. This leads to a splitting into numerous product qualities and as a result numerous customer categories the problems of focusing in the stage of further processing are obvious (Nordigården 2007).

Wood dimensions and qualities in the demand of wooden house and joinery industries are specific and leave much of the sawmill output to be supplied for the other buyers. The parallel fulfillment of lean manufacturing in the two parts of the value chain is challenging.

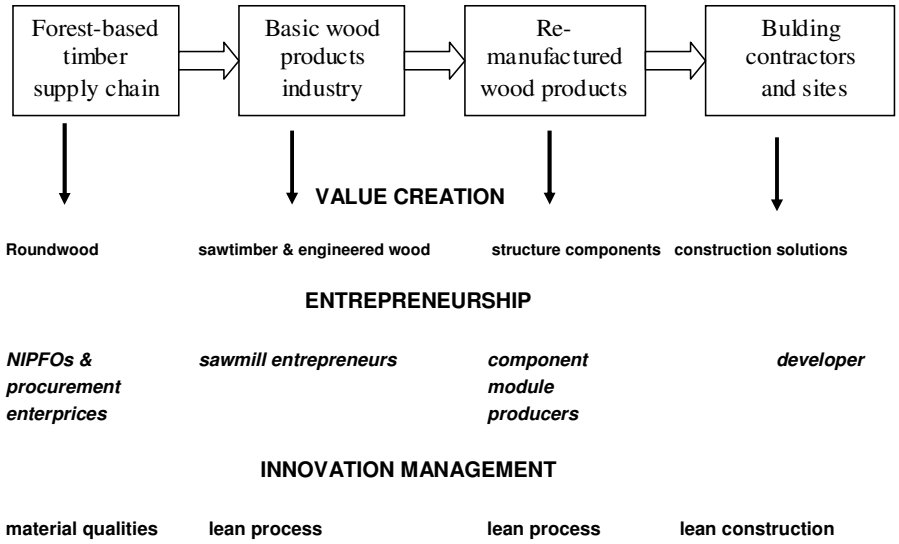

FIGURE 1. Wood construction product value chain – value creation, business stakeholders and core innovation challenges (from Ollonqvist 2006).

Missing links in the downflow of the value chains relate to the diversification of the chain into various types of customer- and market-oriented functional and system solutions. Building contractors and DIY customers have their specific demand segments and trade logic (Nord 2005). Wood products have earlier been compatible with demand in various segments but not any more.

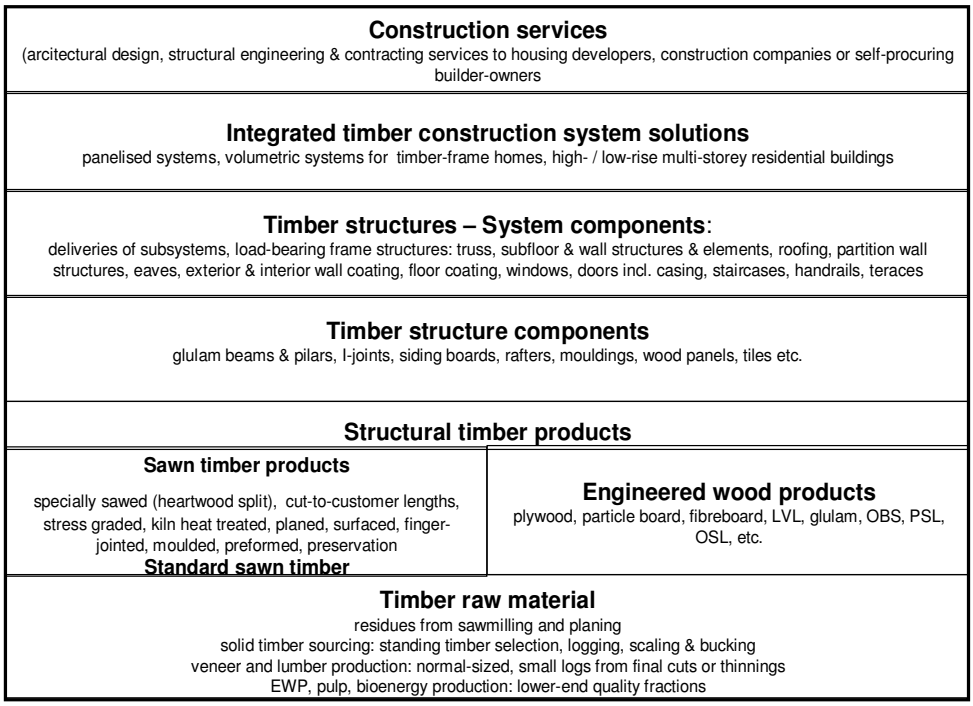

FIGURE 2 Vertical value chain – construction wood products & solutions (from Rimmler & Cooper & Ollonqvist 2006)

The business stakeholders in wood product value chains have been able to exhibit inferior co-ordination between the processes of different stakeholders ie. decoupling points among the actors have not had complicated specifications when compared with other value-adding chains, e.g. in the vehicle, aircraft and telecom industries (Brege et.al. 2005). In addition there is a fundamental challenge concerning parallel optimization of lean manufacturing among wooden house and joinery industries and lean construction among construction enterprises. Construction cluster could not send strong demand pull signals backwards in the value chain what concern technical requirements on systems and components but also and especially those derived from the final customers. On the other hand wood product manufacturers tend to apply divergent product logic: the whole of the log must be put into use leading to numerous product qualities in sawmill

industries (Brege et.al. 2005). Wooden house and joinery industry enterprises are faced with numerous customer categories with their specific tastes and attitudes. All these challenges visible in the decoupling points of the value chain make the use lean principles difficult in the stages of processing solid wood value chains.

The demand of house construction products can be divided into professional Business to Business (BtoB) and end user Business to Consumer (BtoC) construction segments respectively. These segments are separable through the differences in the value chain configuration. House constructing firms in BtoB value chains demand input factors as intermediate input factors. The use of wood components and modules has preserved fair level, partly due to the public regulations (eg. fire regulations) and partly due to the challenges coming from the dominating construction culture. House constructing individuals in BtoC demand segments have gradually increased the use of industrially produced components and modules. The value chains of these products are frequently intra firm making to specific determination of decoupling points systemic. There are fundamental differences in the supply of modularized products in those two major market segments.

Enterprises behind the demand of BtoB construction segment apply standardized planning systems and input factors purchased from the market must match with the planning process specifications and requirements applied by those constructing cluster enterprises. Firms that finally determine the demand specification to construction companies can and frequently do vary, architects, construction planners, constructing enterprise or the project developer, depending the development process approach applied. The BtoB input demand is transferring from simple materials towards integrated modules and components when the standard compatible components are available. House construction in BtoB value chains is gradually becoming industrialized ie. more is based on the assembling of industrially produced components and modules (see Björnfot 2006 and Höök 2008). The industrially produced steel and concrete modules and components have frequently already gained a position of the standardized construction components and units. The substitution of wood with non wood alternatives, explaining the declining share of wood in material use, has partly been due to the low innovation activities behind the upflow supply ie. wood product industries. One explanation to the fair interests on research and innovation processes based on wood in BtoB construction can be the low supply of industrially produced wood construction modules and components.

There are final customers (consumers) and their unique construction projects behind the BtoC construction demand segments. The final consumers prefer custom made solution options in their construction

projects and wooden house industry firms have put much innovation efforts to customize their BtoC solutions. The gradual increase in the demand of industrially produced construction modules and components in BtoC construction is partly due to the increased assortments of custom made alternatives in the industry supply. The production and supply of these modules and components into BtoC markets can be considered customer driven providing thereby company specific competitive advantages connected to the unique solutions. Firms in wooden house industries have preserved their favored position among the final consumers in BtoC construction activities. The latter has directed their business development interests mainly into the BtoC segment development. Wooden house producers have firm specific intra firm planning and production systems that are part of their competitive advantages. The latter orientate into the firm specific solutions of the wooden house suppliers.

The separate evaluation of the two demand structures has not been relevant and necessary until recently. Simple universal basic material parts constituted the major of the wood products used both in BtoB and BtoC value chains and their trade was based on direct trade or subcontracting. The separation became valid for the increased demand of industrially produced construction modules and components first in BtoC demand segments and later in BtoB demand segments, in the latter consistent with the new emerging construction planning. The new planning approach challenge the business opportunities of wooden house industry firms supply in BtoB market segments where compatibility with international open standards and neutral technology universal solutions are required. Another challenge comes from the life cycle approach life long service issues gradually adopted by the professional real estate enterprises and house management companies.

The structure of the paper

This survey paper is organized into five sections. The first (Section 1) evaluates the extent and identification of clusters, wood products in forest cluster and real estate & construction cluster respectively and thereafter identify the intra cluster specifies creating the controversial development identifiable during the cluster approach dominance in Finland's innovation policy. The use of industrially produced wood construction modules has progressed adequately in BtoC demand segments in Finland whereas their use in BtoB demand segments has preserved inferior. The second evaluation (Section 2) discusses the process and management development of BtoB house construction and the competition among materials when industrially produced modules & components are concerned. The outstanding position of time management and path dependent business solutions in BtoB construction have supported the use of standardized solutions in planning

and favored use of subcontracting in input factor markets. Third issue (Section 3) in the paper is the extensive spectrum of public technology programs and public and private joint interest activities in real estate & construction cluster in Finland from the late 1980s. These public technology programs have promoted real estate & construction cluster through material based approaches, construction process development actions as well as environmental and ICT solutions. Fourth issue (Section 4) discusses the public policy attempts to enhance the use of wood in construction and develop innovation infrastructure towards wood based component and module industries. The major challenge faced by the wood product industries comes from the past inferior position of material choice in the construction cluster. The concluding discussion (Section 4) concentrates to the concept material interplay in BtoB construction. Wood has had permanent competitive advantages as frame and outer surface material in BtoC construction but also in BtoB in Modern Wooden Town concept and wood frame solutions therein.

Value Chains and Cluster Boundaries

Cluster approach applying modified Porter diamond model has been adopted among the public policy tools to identify interconnections and evaluate potential regional policy impacts when aiming to enhance industrial and regional development (eg. recent IRE Working Group on Regional clustering and networking as innovation drivers by 15 member regions http://www.innovating-regions.org/groups/projects.cfm?sub_id=26). The cluster approach activity concentrates to key products, actors and include their interconnections with business relationships but omits public actors. Cluster identification is based on core products/ services. The producers of these products constitute the core of the cluster. Value chain identification constitutes the necessary first step when identifying the cluster. Transaction interface between the customer and the producer provides the key cluster identification. Cluster identification put efforts to pick up necessary relationships and industries connected to the production of the identified the key products. National and European Union cluster activities thereby frequently comprise business networks and other regular relationships among the firms.

Cluster approach can in the value chain context become impeding if the inter cluster coordination in the value chain is weak or missing. Inter cluster peculiarities and controversial development due to the cluster approach dominance among forest cluster and real estate & construction cluster are identifiable in the innovation policy in Finland up the late 1990's. Cluster oriented public programs and support tend to put priorities to intra cluster product and process development due to firm specific support. Past innovation policy has accentuated technology push innovations thus

fostering module and component innovations. Business cultures, production processes and thereby business arrangements have been different. The module and component innovations created by wooden house and joinery producers in solid wood industries have not had good match with the BtoB construction processes. Modern Wooden Town concept and related value chains discussed later in this paper have been an exception.

Wood Product Industries - Forest Cluster in Finland

Forest cluster in Finland cover, in addition to industries producing primary wood based products (sawnwood, wood plates, pulp and paper), secondary wood based industries (wooden house and joinery producers, wood furniture and paper and board product industries as well as extensive KIBS sub sector and industries for machinery &, equipments & automation. Wood product industries covering primary product (sawnwood, planed wood, wood plates) and secondary product (wooden houses and joinery products) enterprises are among the major input factor providers to real estate & construction cluster (see. Virtanen & Hernesniemi 2005).
Pulp and paper industries have dominated forest cluster development and cluster innovation policy in Finland. Domestic wood product value chains do not hold strong position in Finnish forest cluster dominated by pulp and paper industries (60 % of total turnover) & export orientation in the whole cluster (57 % of turnover). The extensive position of pulp and paper & paper product industries has remained stable throughout the increase by around one third increase during the decade from 1995 on when measured by the total turnover added value and the value of export challenges

TABLE 1 Forest Cluster in Finland 1995-2005

Forest Cluster

	turnover				**added value**				**export**			
	1995		**2005**		**1995**		**2005**		**1995**		**2005**	
	M €	**%**	**M €**	**%**	**M €**	**%**	**M €**	**%**	**M €**	**%**	**M €**	**%**
Primary wood prod industries (sawmilling, planing..)	*2156*	*14*	*2905*	*15*	*576*	*11*	*394*	*7*	*1362*	*16*	*1481*	*14*
Primary wood plate industries	*656*	*4*	*902*	*5*	*244*	*5*	*310*	*6*	*469*	*5*	*733*	*7*
Secondary wood prod (wooden houses, joinery..)	***844***	***6***	***2027***	***10***	***299***	***6***	***665***	***12***	***301***	***3***	***554***	***5***
Wooden house industries	***279***	***2***	***669***	***3***	***99***	***2***	***219***	***4***	***120***	***1***	***222***	***2***
Joinery industries & other	***565***	***4***	***1358***	***7***	***200***	***4***	***446***	***8***	***181***	***2***	***332***	***3***
Pulp and paper industries	9830	66	11655	59	3313	66	3317	61	5850	68	7634	70
Paper product industries	680	5	868	4	228	5	302	6	295	3	276	3
furniture	749	5	1316	7	355	7	474	9	347	4	260	2
TOTAL	**14915**		**19673**		**5015**		**5462**		**8624**	58	**10938**	56
change				32				9				27

The growth in aggregate production turnover and export in the cluster has been occurred at the expense of deteriorating added value especially when primary wood product industries are concerned. The deteriorated added value can be traced behind the raised interests towards supportive development actions for the secondary wood product industries These interests, partly due to extend the export capacity in BtoB construction value chains, are discussed next.

The share of wood product industries (primary & secondary) from the total turnover has increased from 25 % in 1995 by five percentage units to 30 % in 2005. The wood product industries (primary & secondary) share from added value 22 % in 1995 has increased by three percentage units to 25 % in 2005. The wood product industries (primary & secondary) share from export was 24 % in 1995 and 26 % in 2005.

Secondary wood product industries in Forest Cluster

The outcome from the major differences between primary and secondary wood product can be identified in the added value share of production. Primary wood product industries account two thirds of the added value share acquired in wood plate and secondary industries has remained around 35 % of the total turnover.

TABLE 2 Wood product Industries in Finland 2005

Wood Product Industries

	turnover	%	**add value**	%	a v share
	M€		**M€**		
Primary wood prod industries (sawmilling, planing..)	2905	44	544	36	19
Primary wood plate industries	902	14	309	20	34
Secondary wood prod industries	**2027**	31	**665**	44	33
Wooden house industries	*669*	*10*	*183*	*12*	*27*
Joinery industries	*1178*	*18*	*402*	*26*	*34*
other	*180*	*3*	*80*	*5*	*44*
TOTAL	**6534**		**1524**		23

Public effort has been directed to the development of secondary wood product industries mainly towards the enhanced wood use in BtoB construction. The latter interest can be understood by the dominance of wood frame and exteriors in BtoC house construction. However, it is not possible to create expansion over the natural increase in the aggregate wood

product demand in BtoC demand segment. The latter is due to the current high share of wood frame in the total demand. The exception are the markets of log house export where the competitive advantages of Finnish firms are clear contrary to those in ordinary wood frame.

The major business strategy of wooden house industry enterprises aim to attain high diversification of house alternatives supplied for the consumer choices at competitive prices. The development of competitive advantages among wooden house industries are based on a) the development of supply driven product development and b) process development towards high cost competitiveness. The major innovation driver comes from market competition and intra firm innovation processes aim for incremental product and process innovations.

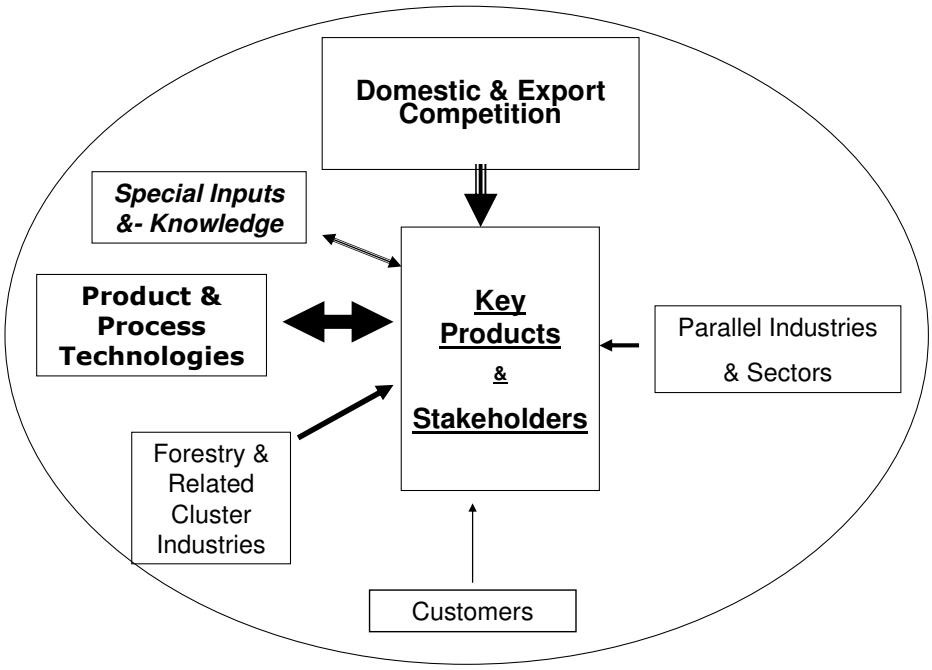

FIGURE 3 Forest Cluster and Innovation Orientation in Wood Product Enterprises

Real Estate & Construction Cluster

Construction components and modules produced by the wooden house industries are demanded in the downflow of the value chain, in real

estate & construction cluster by a) final customers for consumption in BtoC segments (pre fab houses 52 %, log houses 15 % and b) intermediate inputs in BtoB segments (8 %. In addition there is the export demand (pre fab houses 6 %, log houses 19 %). These market segments do not overlap because of the company specific customer value solutions and corresponding value chains in BtoC segments. Input/ Output (IO) relations connect industries and sectors through the intermediate demand. The latter is the demand of upflow outputs for input factors in downflow of the value chain. There is also output demand for final consumption. IO relations are among the major indicators applied in internationally developed cluster evaluation. These connections have also qualitative dimension meaning the mode identification of the transactions between the industries. Transactions among value chain /value network partners constitute permanent participation into the value creation compared with the trade subcontracting.

End user constructors behind BtoC demand segment are transitory actors in the real estate & construction cluster (66 % domestic and 15 % export of total wooden house industry turnover) without permanent incomes from the construction companies or taxes or other payments from their activities. They buy construction components and modules as final consumers paying added value tax as a part of the outlay from the transactions.

Subcontracting dominate real estate & construction cluster input business

Real estate & construction cluster count house and infrastructure construction as the core activities in Finland. Real estate management & maintenance and property services & repair are included into this cluster. Apartment buyers and real estate developers are the final customers for house construction. Construction component industries and construction technology & knowledge intensive business services (KIBS) would be included into the core activities when construction cluster is formulated as international (see. Virtanen & Hernesniemi 2005).

Professional constructors behind BtoC demand segment (8 % domestic and 10 % export of total wooden house industry turnover) have their major incomes from construction sector and pay taxes and other payments from these activities. Professional constructors buy components and modules as intermediate inputs paying added value tax only from their contribution into the final value of the output when it shall be sold to the final customer (consumer). The final customer can be an investing company or other real estate developer and the intermediate input transaction is internal inside the real estate & construction cluster. Innovation processes are currently highly demand driven ie. the empirical or scenario attitudes

and preferences are at their basis. Innovation processes are becoming networked meaning co operation and partnering with architects, construction planners and construction expertise together with the input component providers. Knowledge sharing and joint information platforms constitute the infrastructure of the innovation processes.

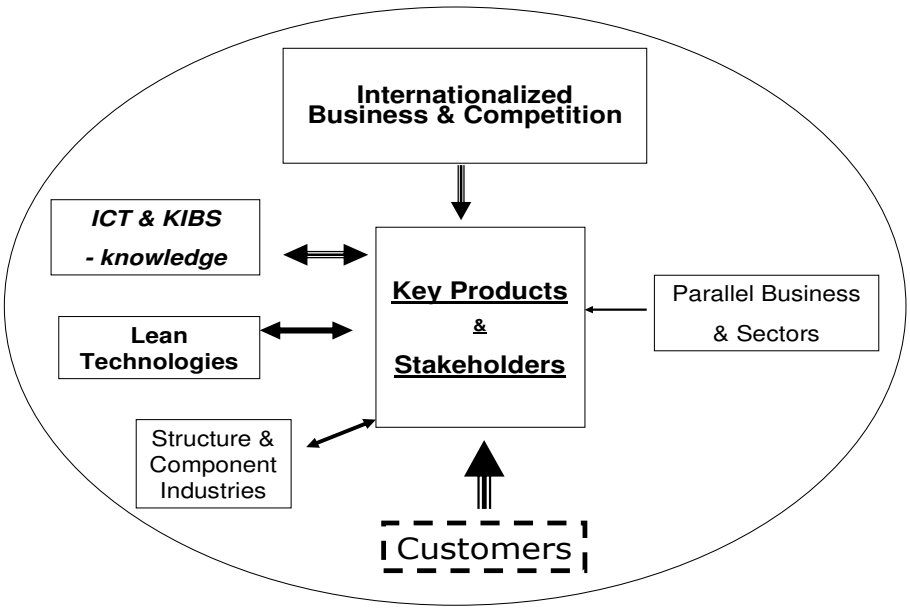

FIGURE 4 Real Estate & Construction Cluster and Innovation Orientation in Cluster Enterprises

Process development in professional construction

The outstanding position of time management and path dependent business solutions have dominated mainstream BtoB construction processes. Björnfot considers construction practitioners supported the unique construction process structures (eg. many different participants, one-of-a-kind projects, a conservative industry, etc.) in Swedish professional wood frame construct context (Björnfot 2006). Koskela have presented similar issues, though from an international perspective (Koskela 2000).

Subsequent, separately arranged construction planning and construction process have supported the use of unique project mode and the preservation of routines based on standardized in situ construction. Subcontracting solutions characters upflow relations in professional

construction between the constructor and input factor providers. High material wastes and inefficiencies and mistake costs are frequently identified in these processes. The major outcome for the mode above have been a) high knowledge and professional requirements in situ, b) waste & residues growing up to 10-20 % even to 35% of total costs of construction project and unarranged recycling waste & residues creating environmental externalities c) need for repairs and additional work phases defects to be up to 10% of the production costs; about 30% of the costs originated from design, 40% from site work, and 20% from machines and materials (Forsberg & Saukkoriipi 2007)

Traditional unique project approach and in situ construction mode in professional construction has made the industrialization in BtoB construction slow when industrial wood product components and modules are concerned. The initials for construction process development (towards lean construction) in EU area can be traced to the Egan report in UK (Construction task force 1998). This attempt was preceded by Constructing the Team- analysis (Latham 1994). The similar attempts did not come much later in Scandinavian countries. Vision 2020 study in Sweden (Flanagan 2002) and real estate & constriction cluster vision 2010 in Finland (Real Estate & Construction Cluster Vision 2010. 2005) share the same findings and task force attempts (see Koivu & Björnsson 2003). Recent key actor seminar for the real estate & construction cluster evaluated the feasibility & main routes for construction and building material industry value chain formation. They also projected the outcomes: a) customer based value creation approach, b) standardized services, systems, products (modules & components), c) process management development and d) feasible management approach for business internationalization (Koivu & Björnsson 2003). The identified main principles by the representatives from large-scale industry & SMEs did share the targets derived from lean thinking principles in that context.

Lean principles in construction

Lean principles are in the Womack & Jones specification grouped into five areas. The first one (value) put focus on customer value identification that will be interpreted in the second (value stream) meaning the value creation process through standardized principles and tools covering the whole process from materials to finished good and services. The third principle (flow) stresses continuous development of processes and practices with quality improvement included within the fifth principle (perfection) to eliminate waste not only as material but also in unnecessary use of human resources. Lean approach, by the fourth principle (pull instead push), mean production for a specified customer and firm produces only what customer want to pay Lean work culture is implemented with

team formation and applying transparent processes (everybody knows everything). (Womack & Jones 2003).

Lean Thinking in Construction implies: a) the customer value definition, b) construction process formation to be able to achieve this customer value target c) assembling where waste and unnecessary actions are eliminated and d) all steps that create value are linked in a continuous sequence, e) each of the steps are continuously improved so that customer value could gradually be enhanced (Björnfot 2006). Production in construction is currently based on thinking from both craft (traditional construction practices) and mass production (mainly prefabrication). Lean thinking, originally developed for the manufacturing industry, should be applicable to construction.

Lean Thinking in Construction, systematically developed by an International Group for Lean Construction, has stated the principles of lean value creation in construction. covering: project definition & design management, production system design, prefabrication, assembly and open building, lean within ICT, safety, quality and environment, contract and cost management (website of the International Group for Lean Construction http://www.iglc.net/)

Project definition phase of is crucial: what is the aim with the production, how to reflect customer requirements and translate them into product specifications in all value creation stages (Freire and Alarcón 2002). *Design* provides the product with characteristics that fulfill customer requirements. *Construction* is considered manufacturing like economic activity through the principles of flow process design (Kagilou 2008). *Lean Project Delivery System* (LPDS) handle construction phases as interrelated contrary to the traditional view of the construction composed of independent phases (Ballard and Howell 2003). LPDS contain rules, procedures, and a set of tools to control the flow of work between trades enabling improved flow of production and characteristics to pull through work plans (Ballard & Picchi & Sacks 2008). *Prefabrication* covers in house manufacturing and assembling in modules components prior to final in situ installation. However some prefabrication can be done at construction site, but for majority it occurs off site. *Open building system* involves design, construct and operate rules in the built environment that the user can relate to and is willing to maintain and defend. Open building advocates a layering of the built environment along the lines of control to coordinate yet decouple decisions allocated to different levels. There are rules to guide design-for-manufacturing and design-for-assembly in the construction world. They advocate a) detailed engineering to fabricators and installers as a co-product process, b) linking orders for prefabricated products to the installation activities, c) designing and making parts of the facility in comprehensive units, d) structuring supply chains for flow (Ballard & Cuperus & Matthews

& Milberg 2008). *Legal and financial infrastructure by contract and cost management* covers design, construction and operation of buildings and structures. Key targets in this context are the proportions between risks, incomes and profit shares. Construction is a high risk business with uncertainty and variation included in each phases (definition, design, assembly, commissioning). Contract & cost issues extend to a) structure by the project definition, objective setting and identification of constraints (relational contracting, setting target values and costs) for value generation as well as waste elimination b) project execution toward the objectives and within the constraints (project governance; designing to target values and costs)and c) learning from breakdowns (unintended deviations from standard/plan) and from experiments (intended deviations from standard/plan).

Lean construction is a comprehensive set of actions developed by an international R&D consortium towards cost competitive value creation. Lean construction is much an intra firm issue but extend to contracting partners. Communication and cooperation between the stakeholders in the value creation belong to lean management issues.

Towards universal construction information systems

A recent international joint interest network Erabuild carried out standardization and information tool activities towards international open standards and neutral technology (Erabuild 2008.). The coordinated task outcome target, to enable efficient information flow during the complete lifecycle of the building and beyond unified the national R&D programme targets and International Alliance for Interoperability (IAI) outputs, to provide sustainable tools for information & communication management to be applied in construction and facility management & repair activities and provide access to that information for the participating members. The network, initiated in 2004, comprised funding organizations from 9 countries (Austria, Denmark, Finland, France, Germany, the Netherlands, Sweden, Norway and United Kingdom). Network applied Building Information Modeling (BIM) approach. BIM is a building design and documentation methodology covering Architecture, Engineering and Construction (AEC) model targets to be delivered with digital representations for communication among the building activity partners. BIM facilitates information exchange and interoperability in digital format with 2D or 3D representations in those CAD- oriented systems used in Europe. Traditional CAD vendors within the AEC sector can provide BIM applications and support reliable and efficient data exchange between different applications providing creation and merging with cross domain models. Architecture, Engineering and Construction models covering also Facilities Management (AEC / FM) are needed for wood construction

modules and components. The use of BIM in the design phases makes it possible to monitor change during the design process. This can be seen as an advantage for some parties in the AEC/FM industry because it is easy to track changes, while others may feel this as limiting their ability to make changes during the design process. The restrictions in R&D resources by the companies of wooden house and joinery industries in Finland impede frequently their abilities to adopt BIM.

Public innovation promotion on construction cluster

Public interests towards innovation processes can be classified into a) innovation system creation and maintenance, b) resource allocation to knowledge creation & distribution and c) single & joint contributions to innovation systems by firms. There are three innovation systems, national (NIS), sectoral (SIS) and regional RIS, identifiable in Finland. The technology programs discussed next are involved into national and sectoral objectives & tasks. Technology programmes, among the major innovation policy tools in Finland, are broad constellations of development projects focusing on a particular field of technology. The areas of technology to be supported have normally become selected through strategic scanning carried out by the Finnish Funding Agency for Technology and Innovation (Tekes), industry and other relevant stakeholders respectively. Strong cluster orientation has been earlier dominant in the innovation policy actions and support of Tekes. Technology push innovation projects towards new products and production processes have dominated in their financing. Inferior cluster interactions and value chain coordination excluded the progressive impacts discrepancies between demand and supply and business cultures what concerns wood use in construction. The basic idea of the programming approach has been to channel technology development efforts into large entities tailored for a particular field of technology, theme or some cluster specific issues.

There is a major change in R& D orientation within the real estate & construction cluster identifiable during 1990s. This transfer can be summarized: 1) The quality and results of business-driven R&D have improved, 2) The competing and dispersed group of actors (enterprises, public agencies and associations) have created dense, common goal-sharing inter-organizational networks, 3) The R & D focus has extended from the building process to the whole life cycle of the constructed objects (Uusikylä et.al. 2003).

The most important is however considered the shift from supply (science) push to demand (market) pull orientation thus picking up the tradeoff between the individual customer tastes and willingness to pay and the cost efficiency through standardization.

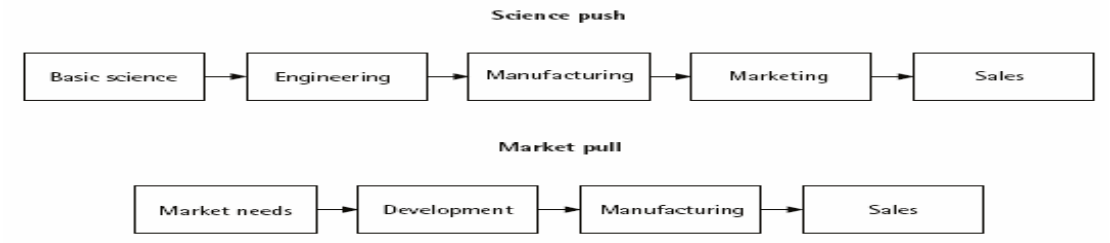

FIGURE 5 Innovation process - initial and process stages
(Schienstock & Hämäläinen 2001, Rimmler & Cooper & Ollonqvist 2006)

The role of Tekes, the main government financing and expert organization for research and technological development in Finland, has been important in the strategy development towards competence improvements in real estate & construction cluster. Technology programmes (18 of which 9 started between 1992-1995 and 9 started between 1996-2002) have covered a wide range of activities from building materials (wood, concrete, stone, steel totaling 78 M €) to building techniques and processes (totaling 100 M €)as well as thematic fields (environment, health aspects, ICT integration etc. totaling 46 M €) and renovation (6 M €.).

TABLE 3 National Technology Programmes 1992 -2006 - Real Estate & Construction Cluster and Wood Product Industries see http://www.eccenet.org/Activities/Res-Dev/finland0502.pdf

Programme **1992 - 1995**	**Time span**	**Finance M €**	**TEKES M €**	**Main Stakeholders in addition to Technology Development Centre (TEKES)**
Tech Progr for **Concrete** Industry	1992–1995	1,4	0,7	SBK; Construction & Constr mat Ind VTT; Tampere Technical University
Renovation	1992–1996	4,4	-	Ministry of Environm; Min of Trade & Ind Tekes; Const ind; Real Estate Enterprise Ass
RYM - **Environmental** Tech in Constr	1994–1999	23,7	11,9	VTT; Min of the Environm; Industry; Helsinki Univ of Tech, Fin Arch Assoc
Hansa **Renovation**	1994–1996	1,2	-	Ministry of the Environm; Ministry of Trad & Ind; Constr ind & related associations
Industrial **on-the-spot building**	1995–1998	2,1	1,0	10 large firms in construstion value chain
New meth for **constr processes**	1995–1998	1,8	-	Fin Assoc of Build Owns, ConstClient Ass
Wood in Construction	1995–1998	22,0	8,8	Wood Info Inc & Rwood Researc Inc Helsinki Univ of Tech Forest Ind fims
Finn**steel** Technology Progr	1995–2000	10,5	4,7	Steel Struct Ass, Steel Ind
Smart & Modular Building **Automation**	1995–1999	17,6	-	Finnish Ass of Build Own & Constr Clients Electricity Contr Ass 140 firms
1996 - 2002				
ProBuild – Prog **Building Process**	1997–2001	80,0	4,9	Constr cluster firms & assoc
Vera – Constr **Prog Infrasturcture Netw**	1997–2002	43,0	20,0	Construction Firms; architects; IT firms
Added Value **Wood** Chain	1998-2003	34,0	17,0	The Wood Industry Inc & Forest Ind fims
Healthy Constr, Indoor Climate & Qual	1998– 2002	22,0	11,0	Ministry of Environm; Res Insts, Universities Construction Ind
Rembrand – **Real Est Mgmt & Services**	1999-2003	22,0	11,0	Finnish Ass of Build Own & Constr Clients Res Insts, Universities, Construction Ind
KIVI - Tech & Dev Progr for **Stone** Industry	1999-2002	10,0	5,0	TE Centre North Carelia, Nat Stone Firm Ass
Progress - **Green Development** in Real Estate & Construction Business	1999-2001			60 firms
Infra - **Infrastructure** construction	2001-2005	32,0	16,0	Ministry of Trafic & Comm, City of Oulu, Firms
Cube Building **Services**	2002-2006	40,0	20,0	House Tech Dev Centre of Fin Inc (coord.)

The major cluster stakeholders were in an interview research asked to consider the supporting and impeding impacts achieved through the real estate & construction cluster technology programs. The latter was carried out as a part of an extensive specialist evaluation on real estate & construction cluster technology programs (Uusikylä et al 2003). The

programs that were considered most supportive by the experts aimed to improve the quality of R&D activities, the level of knowledge and know-how: Smart & Modular Building Automation, Vera – Construction Program Infrastructure Networking, ProBuild - process information management based on comprehensive ICT system and Rembrand - Real Estate Business Management. Majority of the technology programs reviewed have considered to produced modest impacts what concerns international networking and cooperation The material based technology programs, steel and wood material programs, received low scores from the experts. Finnsteel program had rather low expectations beforehand and the outcomes were evaluated fair. Wood in Construction programme was evaluated by the experts as one of the biggest disappointments among all programs. Program had more than average expectations wrt other material programs but outcomes, considered by the experts, nearly non-existent (Uusikylä et al 2003).. The judgment on material programs was that their strategic positioning was not adequate. They should not have been initiated before demand research ie. the major technology programs in construction technology.

Real Estate & Construction Technology Promotion - Value chain approach

Promotion towards innovative solutions in real estate & construction cluster has further developed on the basis of Real Estate & Construction Cluster Vision 2010 action by construction cluster NGOs. The latter, broad based strategy action towards the identification of new competitive advantage options in the global competition business infrastructure, initiated program activities towards the adaptation of lean principle in construction (Real Estate & Construction Cluster Vision 2010. 2005). New technology program Sara (Value Networks in Construction), carried out during 2003–2007 (with total budget 33 M€ where Tekes share 15 M€), had parallel technology program interests. Tekes, the program initiator and major financer, defined program focus a) a unifying link between the individual diversified technology programmes within real estate & construction cluster and b) international competitiveness improvement among cluster firms and networks. Sara program projects developed eco-efficient solutions for multi-storey and low-rise buildings and provided tools to facilitate the adoption of building information modeling in construction. Substantial resources were allocated towards life cycle procurement models, customer-oriented commercialized housing and office solutions, low rise urban construction as well as project and customer feedback management systems. There were more than 100 individual projects occupying350 organizations. Construction product industry had already improved their value-generation capability by upgrading product deliveries to system deliveries: one of the

major targets of Sara was to upgrade system deliveries towards deliveries compiling services in addition to products. Program interests were organized along the principles supporting lean construction enhancement through initials to customer value identification, construction service generation, quality management and productivity improvements (Sara TEKES 2008)

Public innovation promotion on enhanced wood use

The conservatism towards R&D together with fragmented and inflexible business structures in real estate & construction cluster have created challenging frame conditions for the processes towards innovative wood components and modules into BtoB demand segments. The latter can provide a reason for the low appreciation among real estate & construction cluster stakeholders what concerns innovation system creation and maintenance (mode a) solutions Neither Wood in Construction technology program (WinC) during 1995 – 1998 nor Value Added Wood Chain technology program (VAWC), during 1999–2003 discussed next, did find cross sectoral new solutions with real estate & construction cluster. Public interests in resource allocation to knowledge creation & distribution (mode b) and single & joint contributions in innovation systems (mode c).towards innovation processes in wooden house and joinery industries have been intensive and successful as discussed later.

Wood in Construction I – Technology Programs in Finland

WinC technology program aimed to 1) create internationally competitive basic production in wood construction, and 2) improve the manufacturing process to make production more efficient, environment friendly, and to enable high-quality wood construction in Finland. WinC was characterized by the evaluation survey members as a part in the wood hype at that time in Finland (Uusikylä 2003). The government had launched its Puun Aika (Age of Wood) programme but the background in constructing with wood was missing. Wood structure solutions had according to the evaluation never broken through into mass-scale building processes in Finland. The evaluators faced with difficulties when assessing the real impacts of the programme. No evidence was found to the programme document statement concerning direct impacts of the program behind the increased use of sawn timber in building by 35% and exports of manufactured wood products by 15% during the program implementation stage. WinC was concluded one of the last material based technology programmes by Tekes and program outcomes relatively poor like in other material based programs. There was no overall strategic focus for the programme but a reflection from the narrow interests among wood

construction component and module producers what real estate & construction cluster will benefit (Uusikylä 2003).

VAWC technology program listed programme targets: a) increased the use of wood and enhanced value added characteristics and b) promotion of international co-operation in wood processing and related industries. Research disciplines covered wood material science, wood technology, wood process technologies and business networking. The programme supported new business solution development for the increased construction use of wood in EU. Cross-disciplinary cooperation in research, product development and marketing were aimed to stimulate European and global networking. Wood product SMEs were encouraged to work with large enterprises in the sector to increase their expertise and enhance their customer base. Program was designed to support the development and expansion in building components and systems including design, assembly and other technical services networking enterprises across Europe. The fair knowledge dissemination from the concrete outcomes of the technology programs has been among the challenges faced by wooden house and joinery industry firms.

Wood in Construction II – Promoting Enhanced Expert Knowledge Supply

The establishment and maintenance of knowledge creation & distribution systems can provide indirect support to individual innovation processes by providing R&D and management knowledge for the demand of individual firms. Resource allocation to knowledge creation & distribution has been carried out in Finland through two channels a) Centre of Expertise for Wood Products (CEWP), national network of universities & research institutes and b) WoodFinland (WF) network management expertise service are discussed in this chapter.

CEWP, carried out during 1999 – 2006, was arranged as a part of national Centre of Expertise programme framework (OSKE I). The program framework, introduced in 1994, aimed to foster regional specific development in the field of expertise that the area has existing competitive advantages. Networked mode was applied in CEWP contrary to other regional CEs. National network of universities & research institutes for wood product innovation processes provided knowledge and expertise services also for the related SMEs (Paajanen et.al. 2007). CEWP was arranged into seven themes of expertise:

Theme	Key stakeholder
Modern Wooden Town	- *Wood Studio, University of Oulu*
Large-Scale Wood Engineering	- *Tampere University of Technology*
Living with Wood and Design	- *Helsinki University of Art and Design*

Diversification of Wood Utilization - *Finnish Forest Research Institute*
Development of Technology - *Lappeenranta University of Technology*
New Business Concepts - *University of Vaasa / Levón Institute*
Developer Forum - *Helsinki University of Technology*

Modern Wooden Town was organized as a planning concept for low rise intense detached and semi detached town and land use planning (Karjalainen 2003). The wood construction component and module innovation supply options in low rise apartment house construction concept were available in town planning concept. Aesthetic and material properties available in wood configuration could also be taken into effective use in this context. Wood structures together with related components and modules achieved their competitive advantages as part of Modern Wooden Town concept and the wood solutions supported Modern Wooden Town concept. This concept mode, covering 150-300 low rise apartments (in single, detached and low rise storey houses), has been implemented in about 20 developer managed BtoB construction projects in different part of Finland. Modern Wooden Town concept is one of the projects in the newly started next generation living innovation development project "Living Business" knowledge & competence enhancement cross cluster program to be discussed later.

Wood in Construction III – Promoting Wood Product Value Chains

Wood Finland program mode, adopted as a part of rural development, has been solely forest sector program with minor inter sectoral solution with real estate & construction cluster enterprises. Wood Finland, Phase I during 1992-1994, was implemented in a close connection with National Rural Development Program of that time and proceeded i) creation of pilot (reference) projects based on locomotive firms and ii) wood (softwood log) delivery co operative of non industrial private forest owners. Wood Finland, Phase II during 1998- 2005, had three objectives: 1) networks between SMEs on regional basis and connections to locomotive firms operating in international markets, 2) creation of new wood components and modules especially for construction and 3) enhancement of technological and business management knowledge creation among in SMEs (Salonen & Järnefelt 2006). Eleven partnership networks of SMEs was the project outcome: 4 managed and coordinated by locomotive company with international business activities and 7 regional networks of SMEs for national market activities.

Wood in Construction IV – European Town & Community Planning Promotion

Wood construction promotion was continued through two parallel Wood construction promotion programs under the flagship Wood Europe Campaign during the mid 2000's. Public policy promotion was directed to town and community planning to enhance wood frame construction. Wood Construction Development programme (WCD) 2004-2010 and parallel Wood Product Industry Business and Entrepreneurship (WPIBE) programme 2004-2010 constituted a joint attempt to adopt a) value chain approach into public innovation policy on wood construction & products and b) to allow real estate & construction cluster boundary crossings. WCD had uban & suburban residential area town plan approach and one-family house solutions in program focus. These were supported by the targets of a) knowledge enhancement, financing reorientation and international competitiveness (Figure 6) .

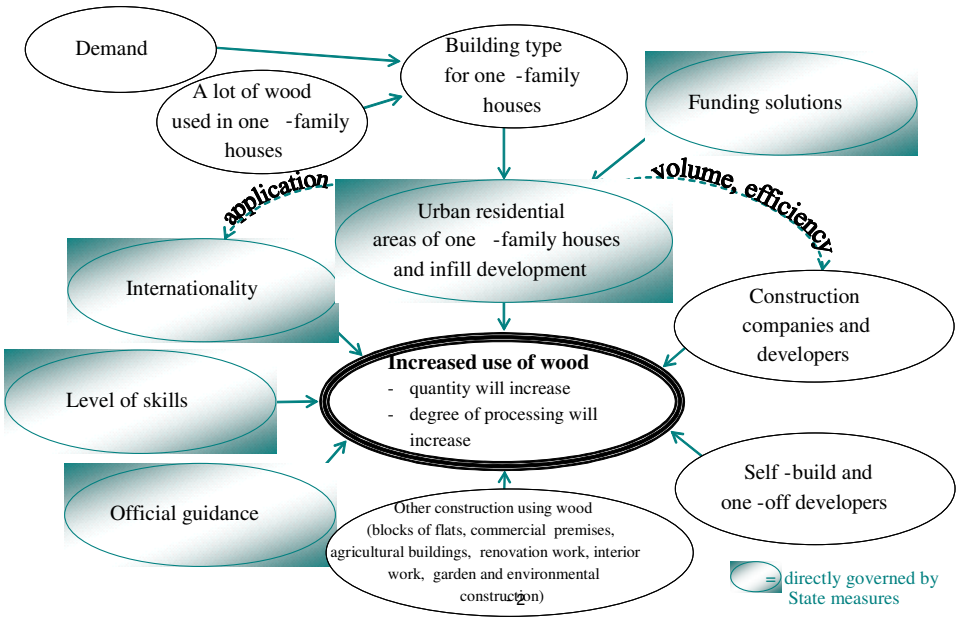

FIGURE 6 Wood Construction Development Programme 2004 – 2010: sturcture & objectives. Figure by the courtesy of Merja Laitinen -The Housing Finance and Development Centre of Finland (ARA)

Future - Towards Sustainable Development in European Wood Construction

There have been increasing public policy interests to enhance the use of wood modules and components in BtoB construction. European enhanced construction wood use programs have launched cross sectoral program

initials. Snow 2005 summarizes the main issues in rethinking construction in the opening conference of the international research and development project (GATE - Building New Opportunities for Timber) by a) promoting coordinated national activities towards programmed rethinking & re-engineering of construction processes. but also innovation projects beyond the existing cluster interfaces, b) reorganizing contracting by substituting the lowest price mode with whole life cost criteria as the contracting base & performance measures for evaluation and c) supporting best practice dissemination by approved purposes, progress and commitment to start constructing differently and in a sustainable ways. http://www.gate-project.org/index_en

Wood Construction - Living Business Competence Cluster Programme

The Centre of Expertise (CofE) programme executors in the Ministry of Interior accepted "Living Business" knowledge & competence enhancement cross cluster program as one of the themes of expertise in the second Centre of Expertise programme (OSKE II) in 1997. CofE is a fixed term governmental programme umbrella for 2007-2013 representing the view of Vanhanen I Government to improve regional competitiveness in line with the national and European policies. Living and housing, constituting the core themes of the program, are expected to be transformed from products into services. This shift implies house construction to be developed towards user-orientated living solutions and services. The purpose is to generate a new way of thinking and operate. The business of living shall promote the shift from a production-based operational model to a user-based supply of housing, products and services. CofE programme challenges regional actors into the joint interest cross cluster networks. Single projects, to be established within the Living Business programme, aim at developing and piloting product and service solutions for living and housing in genuine user environments. The aimed areas of application include urban living, solutions for special needs housing and senior citizens' housing in particular, as well as energy-efficient and environmentally friendly construction and living.

Concluding Remarks

Construction element prefabrication has long historical perspective in wooden house industries in Scandinavia with parallel national development features. Wood Construction Element prefabrication started as BtoC detached house components and modules business as a part of urbanization in extensive volumes from the1950s. Standardized booths and barracks were produced by some enterprises both in Sweden and Finland. The latter products, supplied into BtoB demand segments, had exterior

characterized by the volume element technique. These component and module products covered also integrated solutions and were supplied as volume element products. Factory product development progressed from simple products towards higher amount of customization and flexibility, without abandoning high degree standardization (see Kouti 1965 and Höök 2008). Wooden house industries faced with strategy reorientation in the 1990s: in Sweden from 1995, when the Swedish building codes were changed and in Finland from the early 1990s on due to the radical demand decrease in the economic recession. Wooden house manufacturers became more clearly specialized into two different subgroups. Some firms continued producing for BtoB demand segments focusing either on commercial buildings (schools, office-buildings) or in Sweden also the market of multi-storey housing. Majority of the firms focused producing detached houses for BtoC demand segments.

Wood construction element prefabrication for BtoB demand segments imply value chain specific managerial skills in real estate & construction cluster. Functional specialization strategies are the major prerequisites among the wooden house manufacturers to become competitive in BtoB construction value chains. Partnering in those value chains imply modularity process arrangement solutions adaptable into the system and architecture information structures. Innovations in BtoB construction system context imply a) common vision shared by the majority of the players in the system & abilities to communicate currently in BIM information infrastructure, b) common commitment to the direction and co-ordination of resources covering also ICT solutions applied in AEC / FM systems and c) new and innovative material and mental resources (Brege et.al. 2005). Wood product industries are among the key actors to co-ordinate the business inside the value-adding wood product chains. Development challenges have clearly been identified in a research survey concerning Sweden (Brege et.al. 2005). The challenges in co-ordination have been clearly noted in earlier Swedish programmes where the co-operation between players was noticed to be fair or non existent (VINNOVA Branschforskningsprogram för skogs- och träindustrin. http://www.vinnova.se)

The challenges related to value chain architectural innovations are limited when compared with those in system innovations. The identification of the decoupling points and specifications there are important for all partners (see figure). The upflow and downflow challenges related to wooden house and joinery industry are discussed earlier. The major challenges concern the decoupling points between the clusters ie. wood products and real estate & construction respectively. Modular innovations and development are carried out under the conditions of system

specifications and those in the decoupling interfaces (see Björnfot 2006 and Höök 2008).

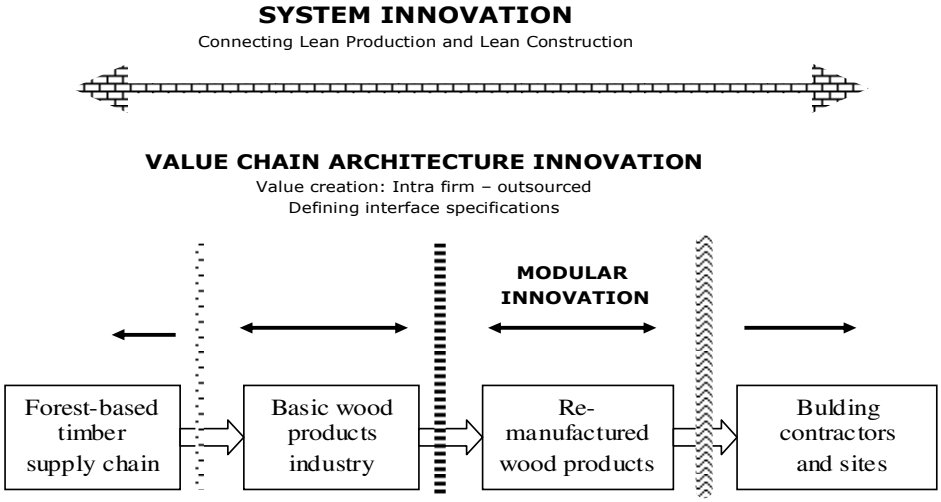

FIGURE 6 Innovation categories: system, value chain architecture, modular-
- wood product value chain (Ollonqvist. 2006)

Innovations in the business networks are the major challenges what concerns development of lean principles in wooden house and joinery industries and construction enterprises respectively. The recent SWOT analysis in Sweden could identify weaknesses when construction wood component and module are concerned 1) the production orientation in the business management of sawmills, their lack of customer added value orientation and technology push innovation patterns and 2) missing innovation system supporting BtoB constriction in wooden house and joinery industries, their low value chain development orientation and high competition boosted by fragmented demand and supply (Brege et.al. 2005).
The use of new technologies implies newly formulated management & organizational solutions and also new approaches on the customer interface in addition to new products or production processes,. Global business logics have challenged the role of managerial knowledge in business networks and imply strong public support resources into organizational (network management, utilization of cluster co operation) and marketing (customer orientation, product life cycle management, global business) innovation processes.

Author's presentations in SSFE meetings are referred to:

Forestry and Forest Based Entrepreneurship & Innovations in Rural Development Context – Finland.

Forest policy workshop of Scandinavian Society of Forest economics (SSFE) 14.8.2007 Saariselkä, FINLAND

Cross- Sectoral Innovation Policy Challenges in Wood Frame Construction.

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