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## **MAPPING INNOVATION FACILITATING INNOVATION IN THE DANISH CONSTRUCTION INDUSTRY**

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# MAPPING INNOVATION – FACILITATING INNOVATION IN THE DANISH CONSTRUCTION INDUSTRY

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*By adopting a theoretical framework from strategic niche management research (SNM) this paper presents an analysis of the innovation system of the Danish Construction industry. Theories within SNM look upon innovation in a sector as a socio-technical phenomenon and identifies three levels of socio-technical interaction within which sectorial innovation can be explained. The analysis shows a multifaceted landscape of innovation around an existing regime, built in the existing ways of working and developing over generations. The regime is challenged from various niches and the socio-technical landscape through trends as globalization. Three niches (Lean Construction, BIM and System Deliveries) are subject to a detailed analysis showing partly incompatible rationales and various degrees of innovation potential. The paper further discusses how existing policymaking operates in a number of tensions one being between government and governance. Based on the concepts from SNM the paper introduces an innovation map in order to support the development of meta-governance policymaking. By mapping some of the most influential trends and promising niche innovations and relate these to the existing regime, the innovation map can act as a medium in which policymakers, interest organization and companies can develop and coordinate future innovation activities.*

**KEYWORDS:** Innovation, policymaking, niches, SNM, sector development

## INTRODUCTION

The construction industry is often characterised as a tradition bound low innovation sector which struggles with low productivity. Consequently has a small but significant strand of Danish research been conducted around innovation e.g. Clausen (2002), Simonsen (2007) and Vind and Thomassen (2009).

Nevertheless, innovation processes *are* going on at all levels of the construction industry - from the builders at the construction site to the major development programs.

Despite the strong interest in stimulating innovation in Danish industry, the innovation programs are facing striking difficulties. Clausen (2002) concludes in his analysis of sectorial development programs that a mapping of innovation activity in construction industry is needed, focusing the interplay between strategically oriented and formalized activities and informal innovation processes on construction projects. (ibid: p. 13)

In this way it relevant to investigate how the construction industry capacity for innovation can be accelerated so that and how the industry can respond to new societal challenges such as the move towards CO2-neutral societies.

### Ambition

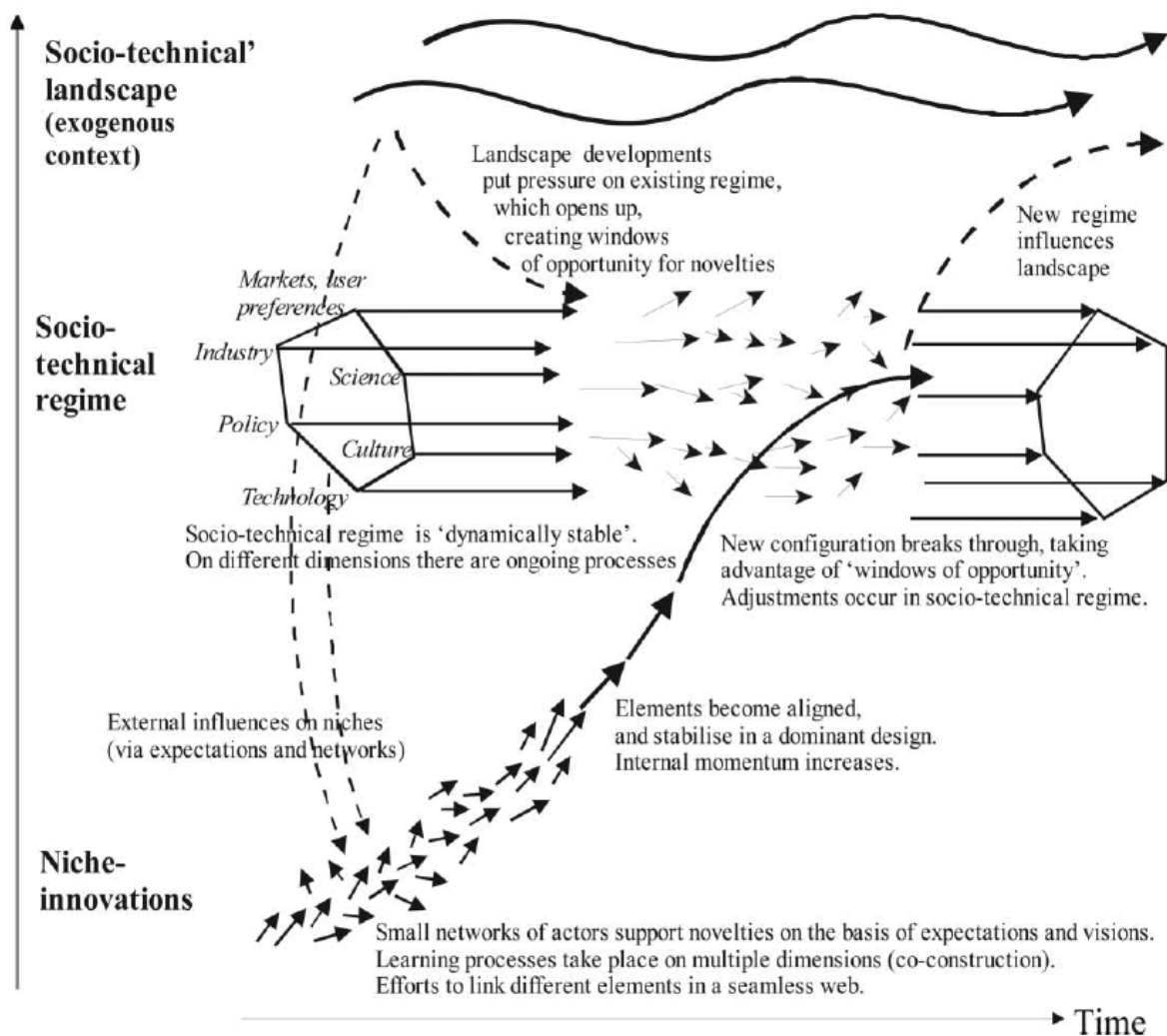
The ambition of the paper is to present an analysis of the innovation system in the Danish construction industry (Thuesen et al 2011) and discuss strategies by which innovation activities can be stimulated and coordinated.

### Theoretical framework

The research of the innovation system of the Danish Construction industry draws upon a theoretical framework from strategic niche management research (SNM) (Schot and Geels 2008).

Theories within SNM look upon innovation in a sector as a socio-technical phenomenon and identify three levels of socio-technical interaction within which sectorial innovation can be explained (Schot and Geels 2008, p. 545) and is illustrated in the following figure.

Figur 1: Innovation in an innovationssystem explained in three levels (Schot & Geels 2008, p. 546)

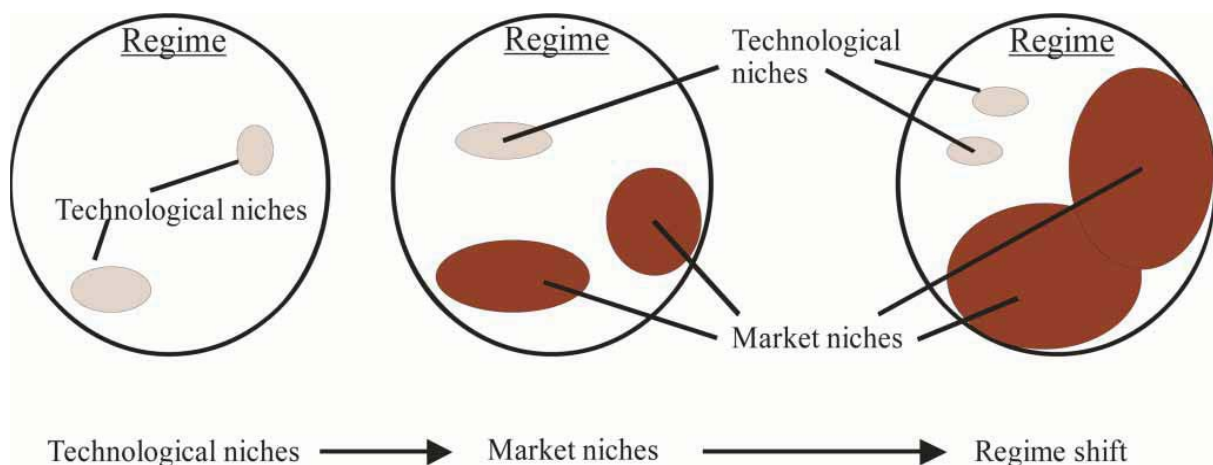


Niches form the micro-level where radical novelties emerge. The socio-technical regime forms the meso-level, which accounts for the dominating stabilized socio-technical pattern of interaction which is reproduced by institutionalised learning processes. The macro-level is formed by the socio-technical landscape, an exogenous environment beyond the direct influence of niche and regime actors (e.g. macro-economics, deep cultural patterns, macro-political developments).

According to Geels and Kemp (2007) have researchers within sociology of technology and evolutionary economics stressed the importance of niches as driver of innovations, from where new socio-technical regime can be developed (Schot 1998 and Livinthal 1998). Niches work as incubations environments for new ideas by being protected from the traditional selection mechanisms of the marketplace.

By distinguishing between market and technological niches Schot & Geels (2008) explains how innovation can be achieved through institutional learning processes linking technological niches to niche markets. These changes could potentially lead to regime shift as outlined in the following figure.

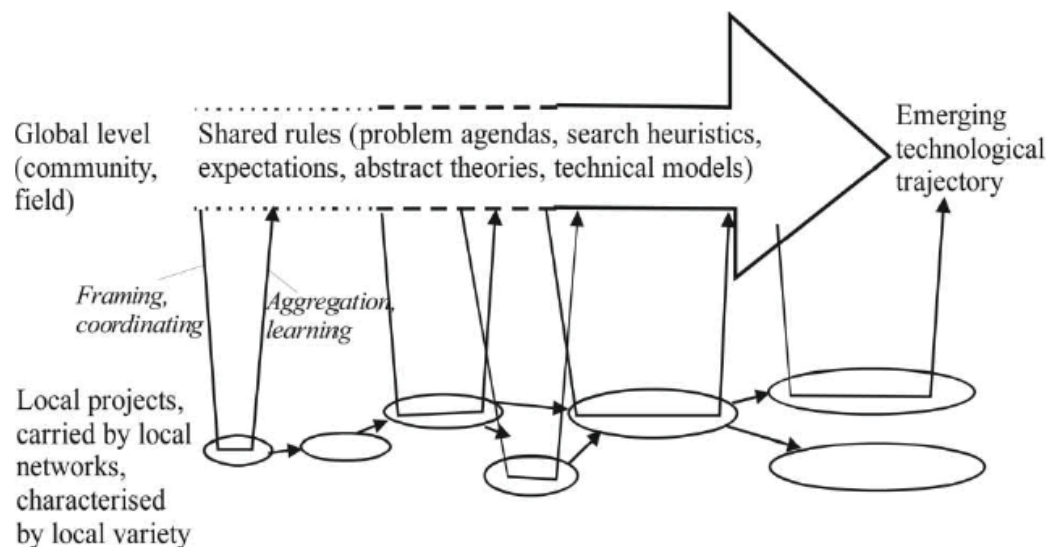
Figur 2: Regime shifts from niche development (Schot & Geels 2008, p. 540)



The regime is challenged as (1) technology matures in some closed technological niches (2) these technical solutions addresses a limited market need (3) and through the growth of the markets the technologies further matures and win wider acceptance in the entire regime.

An important premise for the development and maturation of ideas in the form of niches are learning processes and the building of social networks that support new innovations and investments (Schot et al 1994, Kemp et al 1998 & 2001 and Hoogma et al 2002). The development of niches through these activities is achieved through ongoing project-based learning processes which over time provides a certain direction / rationality as outlined in the following figure.

Figur 2: Niche learning processes (Schot & Geels 2008, p. 544)



It is precisely this common sense making which integrates the niches and develop its own sense of identity - a rationality that legitimizes the stakeholders' actions even though they may be in opposition to the dominant regime. Jensen et al (forthcoming) explain the rationality based on three mutually constitutive concepts an interpretive resource, a sector representation and a strategic orientation. Thus, they want to explain how a "tool" (the interpretive resource), forms a certain image of the existing regime (sector representation) and develops corresponding practices (strategic orientation). Rationality in the niche can thus be explained by using a key metaphor in which a set of problems (the sectorial representation) can be unlocked with a corresponding solution (strategic orientation) by the key (the interpretive resource).

Since the rationalities of the niches may differ, niches not always represent the same innovation potential. Thus is Geels and Kemp (2007) operating with three different degrees of radicalism reproduction, transformation and transition, as outlined in the following table (page 445)

Table 1: innovation potential at different levels of radicality (Geels and Kemp 2007, p. 445)

	<b>Reproduction</b>	<b>Transformation</b>	<b>Transition</b>
Levels involved	Regime dynamics	Pressure from landscape Adaptation and reorientation in regime	Pressure from landscape Increasing problems in regime, and attempts at re-orientation New innovation in niches that eventually break through
Role of actors	Incumbent regime actors	Pressure from outsiders Incumbent regime actors respond through re-orienting Innovative trajectories	Pressure from outsiders Incumbent actors fail to solve regime problems Outsiders develop new innovations

## METHOD

Based on the theoretical concept, the collection of empirical material for analysing the innovation system draws on multiple sources like qualitative workshops, semistructured interviews, existing analysis and analysis of central texts.

The analysis of the existing regime draws upon a Foucauldian analysis of the development of the Danish construction industry (Gottlieb 2010) combined with an analysis of the past 25 years of development of construction based on the driving myths of construction (Thuesen et al 2009). Finally the IT element is covered through Berard (2006) and Jensen (2011).

The analysed niches in Thuesen et al (2011) have been selected according to their innovation potential and the main drivers of the development being either the governmental or sectorial driven. The niches are the established concepts around Lean Construction, BIM (Building Information Modelling) as a part of a general digitalization of the Danish construction industry and an emerging niche around new industrialization termed "system deliverances". The empirical material for analysing the niches consists of two qualitative workshops, eight qualitative interviews combined the central texts and theories of the niches. The material was collected in the period from the autumn of 2009 to the spring of 2010 starting with execution of the two workshops in communities around the niches followed by semi-structured interviews (Kvale, 1996) of persons in playing different roles the niche development. By asking the persons similar and different question based on their role it was subsequently possible to identify coherency and differences in their understanding of the niche and its relation to other niches and the existing regime. The material from Thuesen et al (2011) is supplemented by material on BIM from Berard (2006) and Jensen (2011).

## ANALYSIS

The analysis of the innovation system is structured in three sections, firstly focusing on establishing an understanding of the predominant regime, secondly juxtaposes the three niches and finally analyzing the niches up against the existing regime.

### **The construction regime - developed through generations**

The existing regime is developed through generations in a process characterised by periods of more and less stability and moments of radical changes in the construction practices. Although the moments of change encapsulates periods of fundamental different construction practices as between the premodern (-1945), modern (1960-70) and postmodern (1980-) construction the historical practices are to some extent sedimented in the present postmodern construction practices. Based on a historical analysis (Gottlieb 2010) the postmodern construction regime is identified as having the following characteristics according to the theoretical dimensions Technology, Industry, Market /customers, Policy, Culture, Education and research.



Table 2: Overview of the building regime

<b>Dimension</b>	<b>Characteristics</b>
Technology	<p>Building materials: many different materials are in play all though there has been a preference around concrete elements since the introduction in the 60'ties.</p> <p>Processes: Phase models, in-situ production, planning tools based on Critical Path Method (CPM) wide spread, but "islanded" use of information technology, project management as the predominant management philosophy.</p>
Industry	<p>The organization of the industry is characterized by strong interest organizations representing many different professions like crafts, engineers, architects, contractors, and material producers. The value-chain is fragmented with a strong separation of design and production.</p>
Market and customers	<p>The market is heterogeneous and characterized by fluctuation. The customers are addressed by the architects, who tailor unique projects specifically to the customers' individual needs.</p>
Policy	<p>The sector is regulated around competitive bidding, tendering systems, shared standards and general conditions for work and supply. The development of the regulation happens in close collaboration between the interests organizations and the governmental anchoring (Danish Enterprise and Construction Authority, EBST), but also increasing EU.</p>
Culture	<p>The cultural organization of the industry is based on professions which are sustaining craft differentiated education institutions with a strong element of apprenticeship learning processes. The building organization has over time developed a strong separation between design and production favouring the development of cultures around problem solving. The institutional learning processes have the past 30 years, been centred on the myth about the unique building, make the actors perceive the nature of the build process as complex or even chaotic. Final there is a strong focus on collaboration rethorics among actors in the future development of the industry.</p>
R&D	<p>The organization and division of labour is mirrored and reproduced by the educational system. This system spans a wide way of cultural knowledge's from tacit and embodied situated in crafts to explicit and scientific in the academic professions. The central management practice is Project management, which is inscribed in the educational system and is influencing the research agendas.</p>

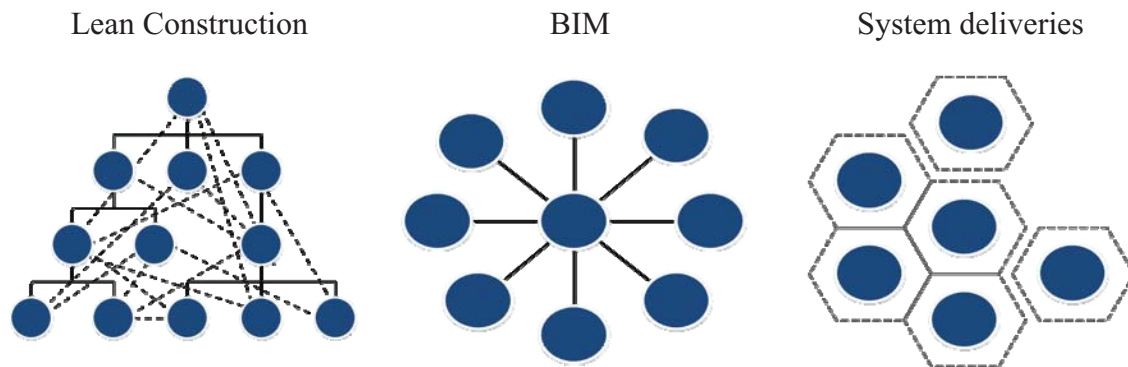
The regime is situated within a broader societal context which challenges it and creates new possibilities of innovation. Trends like globalization, climate change, an aging population, new technological breakthroughs partly destabilize the regime making it vulnerable to niche innovations and other dynamics. When this happens it can be understood as windows of opportunities for change of the existing regime.

### **Niches represent different sources of innovation**

This window of opportunity might be addressed by different niches. We will here look closer to the niches around the Lean Construction, BIM and System deliveries illustrated in the following figures.



Figur 4: Illustration of niches



While the niches all try to address the regime, they represent different logics for building developments that are more or less compatible. The table below summarizes some of the key differences in rationality between the three niches.

Table 3: Different rationalities of the niches

	<b>Lean Construction</b>	<b>BIM</b>	<b>System deliveries</b>
Key (Logic)	Hierarchy of process planning tools around LPS	The object oriented 3D model / BIM	Mass-customization
Understanding of the existing regime (Sectorial representation)	The complex and chaotic building process makes long-term planning impossible.	The construction industry as a series of inconsistent and uncoordinated information flows	The construction industry as an under-modularized mode of production characterized by project-specific problem solving and short term collaboration, which hinders innovation and specialization
Solution (Strategic orientation)	Development of tools and processes for optimizing value and flow based on short term planning and involvement of crafts	The development of a shared object-oriented classification and information infrastructure able to ensure unequivocal information capable to coordinate the complexity of the construction process	Project independent design and production of modular and customizable products and services through product platforms, strategy partnerships and value-chain integration

The three niches perceive the existing regime from various perspectives and are consequently formulating different problems and solutions. In LC is the building process considered as complex and even chaotic, which prevents long-term planning. As a result is LC developing tools and processes for optimizing value and flow based on short term planning and involvement of crafts symbolised in the Last planer system LPS. The perspectives offered by the BIM and System deliveries niche is different as they claim that the building process can be tamed and standardized so that information flows and processes can be coordinated. System deliveries also notes that the short-term collaborative constellations often prevents the

development of the industry, and thus seeks to create a better process understanding across the actors enabling value-chain integration. As the different niches don't have identical understandings of the regime their diagnosis of the regimes problems are different. Their different diagnoses and keys (logics) also allow different strategic development directions. While LC is trying to handle the complexity of the building process through short-term planning, the BIM concept is trying to manage complexity through common systems and standards for information exchange (interoperability) and final are System Deliveries strategy to reduce complexity through modularization.

While the niches have different rationalities, they are also major differences in terms of radicalism. This is supported by a combination of the various dimensions of compatibility between the niches and the overall regime as illustrated in the following table.

Table 4: Different radicality of the niches

Dimension	Regime	Lean Constr.	BIM	System deliveries
<i>Technology</i>				
Production	On-site	On site	On site	Off-site
Optimization of design-production	limited	Modest	Modest	Significantly
Application of IT	Limited	Limited	Significantly	Modest
<i>Industry</i>				
Value chain	Fragmented	Fragmented	Fragmented	Integrated
Design and production	Separation	Separation	Separation	Integration
Driver of development	Interest Organisation	Interest Organisation, Contractors	Interest Organisation, Consultants	Contractors, architects, producers
Focus	Project	Project	Project	Products/service
<i>Market and customers</i>				
Varians	Unique	Unique	Unique	Unique & standard
Design-production	Specific	Specific	Specific	Generic
<i>Policy</i>				
Political focus	Significantly	Limited	Significantly	Limited
Use of standards	Significantly	Limited	Significantly	Limited
Participation of Interest organisations	Significantly	Modest	Significantly	Limited
<i>Culture</i>				
View of buildings	Unique	Unique	Unique	Unique & standard
Perception of the building process	Complex/chaotic	Complex/chaotic	Complex	Standard/complex
Collaboration	Limited	Significantly	Modest	Significantly
Learning vehicle	Individual	Individual/project	Individual/system	Company
Development culture	Sector dialog	Project dialog	Sector dialog	Company dialog

R&D

National research activities	-	Limited	Modest	Significant
Development horizon	Short	Short	Short	Long
Origin of research	Inside CM	Inside CM	Inside CM	Outside CM
Educational anchoring	Significant	Significant	Modest	Limited

The differences in compatibility offers different potential for sectorial innovation, while Lean Construction tries to change the regime from within reproducing the existing building practices (*reproduction*) system deliverances fundamentally tries to reorganize the regime from outside (*transition*). In between these BIM is trying to digitalize the existing regime while not fundamentally changing the organisation of the industry (*transformation*). The different levels of innovation potential are enabled by general trends in the landscape. Thus are all the developed by international traffic of knowledge and ideas from the globalization. Furthermore is the BIM and system deliverance specifically enabled by the widespread adoption of IT. The niches are thus having different innovation potential as summarized in the following table

Table 5: Different radicality of the niches

	Lean Construction	BIM	System deliveries
Potential	Can strengthen the effectiveness and value-creation within the existing regime Short ROI – can be implemented at project level	Enables a more efficient exchange of information between building partners. Enables a greater complexity in construction	Addresses productivity challenge Delivers product of high quality, faster and cheaper
Barriers	Can't facilitate cross-project optimization – pursuing economy of scale. Requires change a in cultures	Hard to get all parties to agree => implementation is difficult. Can't optimize across the value chain – pursuing economy of scale. Long ROI	Long ROI Can't be realized at the project level, but requires a market of a certain size and extensive knowledge of customer needs Requires reorganization of the division of labor in regime.

The conflicting rationalities among the niches internally and towards the regime put emphasis on development of policy practices and tools, which will be able to handle these differences.

## DISCUSSION

A central part of the existing regime is a strong discourse on creating sectorial development through consensus and dialog between the various stakeholders in the industry primary represented by the interest organizations.

This principle, that also permeates Europe, as illustrated by the French term (*Dialogue Social*), is a historical part of Danish political culture and has been termed "cooperative tradition" and "corporatism" (Jorgensen 2002, Rothstein et al 1999). However the practice of focusing on creating a consensus on "one" specific developmental agenda is made difficult by the industry's diverging interests and niche incompatibilities. Attempts to create one development agenda leads to a low level of innovation and lock the industry in a development path which only a few will find comfort in. Consequently policy practices attempting to create common goals and visions risk preserving the existing construction practices and hinder the development of a more innovative sector.

There is therefore a need to develop a set of regulatory practices that is able to handle ambiguities with different interests and incompatibilities, while attempting to turn this premise into a strength by creating a framework for experimental activity. The shift in regulatory practices is outlined in the following table.

Table 6: Regulatory practices

	1945-	1990s-
Societal frame	Modern	▶ Postmodern
Understanding of the sector (Sectorial representation)	Irrational, traditional and unable to meet the acute housing shortage	▶ Many different symptoms of the sector in imbalance
Development agenda (Solution)	One (industrialisation)	▶ Many (Lean Construction, BIM, system deliveries ...)
Policy practice	Central control and coordination of the development	▶ Decentralized coordination and central framework management
Basis for policy	Leadership (set the agenda, create the rationale)	▶ Reflexivity (Understanding of the niches rationalities and their compatibility)

The basis for adopting this alternative approach to regulation of industry is the development of analytical skills to identify, conceptualize and organize existing and new niches and their rationalities. Moreover to develop strategies and allocate resources to the accelerate translations of niches through informed experimental activity and anchoring community formation around the niches.

The consequence of the diversified strategies means that the common industry initiatives will move from being attempting a "unipolar" development to become "multipolar" with multiple centers. It also means that (even) more emphasis is made on using companies as innovation drivers.

A central premise for the facilitation of innovation through in this perspective is the development of a "language" through which the industry can understand and articulate innovation and strategies. Here it is appropriate to draw on the theories presented in this paper. Through concepts as niches, regimes, etc. these theories offers a typology which can be ordered in a map. Such a map could provide an overview and orientation points for



navigating in the innovation system. Moreover, the map could clarify the interfaces of key players such as the different interest organizations and governmental institutions. Consistency and transparency in the innovation activities can be developed internally among government agencies and between public and private players including construction companies. This will enable the construction industry quickly to respond to new innovation opportunities locally as well as globally.

## CONCLUSION

Based on the theoretical framework from strategic niche management research (SNM) the paper presents a strategy for understanding and facilitating innovation activities in the sector by mapping the predominant regime, overall societal trends and different niches.

The analysis shows a multifaceted landscape of innovations around an existing regime, built in the existing ways of working and developing over generations. This regime is challenged from various niches and the socio-technical landscape through micro and macro trends. The detailed analysis of the three niches (Lean Construction, BIM and System Deliveries), and their compatibility with the existing regime, show how they represent partly incompatible rationales and various degrees of innovation potential.

There is therefore a need to develop a set of regulatory practices that is able to handle these ambiguities with different interests and incompatibilities. Such a practice should be based on analytical skills to identify, conceptualize and organize existing and new niches' rationalities, focus on developing strategies and allocate resources to informed experimental activity and anchor community formation around the niches.

By mapping some of the most influential trends and promising niche innovations and relate these to the existing paradigm, the innovation map can act as a medium in which policymakers, interest organization and companies can develop and coordinate future innovation activities.

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