COMPETITIVE IMPACT OF INDUSTRIALISED BUILDING - IN SEARCH FOR EXPLANATIONS TO THE CURRENT STATE

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Industrialised building has been proposed as a means of satisfying changes needed in the Swedish building sector. Over the last decade industrialised building has also developed as a niche within this sector. Given its potential, however, some stakeholders think that industrialised building has not yet had the impact they expected, and that the building sector is still in need of change to meet demands for cost reduction, quality improvement and longer managerial time-spans. Consequently, questions arise regarding the competitive position of industrialised building today, and the underlying causes for its present state. This study is based on a literature review, assessing industrialised building over recent decades, and on complementary interviews with researchers and practitioners. The findings are summarised in a conceptual model that outlines the sought effects of industrialised building, as well as the forces that drive and restrain change towards industrialised building. The demands on the building sector are the main drivers of change for the industry. However, the market itself is not actively driving change towards industrialised building, and the information and understanding required to support clients' decision on whether to enforce market power in one or the other direction is not readily available. How building clients value different building possibilities is also unclear. Suggested future challenges are to reduce client uncertainty, to improve client power and to facilitate the comparison of performance between traditional and industrialised building alternatives.

Keywords: competitive position, conceptual model, drivers of change, industrialised building.

INTRODUCTION

Demands on the building sector have addressed effectiveness and efficiency issues, and they have been put forth by society, researchers and the sector itself (Egan 1998, Winch 1998, Josephson and Hammarlund 1999, SOU 2000). The demands for changes to improve the sector have resulted in numerous initiatives, not least attempts to benchmark and learn from the manufacturing sector (Koskela 2000, Diekmann *et al.* 2004). More specifically, industrialised building has developed as a niche market within the Swedish building sector (Lessing *et al.* 2005). However, the change has been anything but straightforward. Stakeholders at the governmental level, as well as clients and contractors, believe that industrialised building has not yet had the impact they expected, or hoped for. At the same time the understanding and consensus appears to be low concerning 'why not'. For stakeholders who want to promote change towards industrialised building, or to know whether they should, it is important to understand factors that can drive and restrain such development, and also

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what could be expected from such a potential change. The purpose of the research presented here is to outline the forces that are believed to have been driving change towards industrialised building, the sought effects of industrialised building, and the forces potentially restraining change in that direction. To aid further development and understanding of the competitive impact of industrialised building, a conceptual model is suggested and discussed.

Industrialised building generally involves different levels of onsite and offsite activities, (Höök and Stehn 2008). Different types can be distinguished; (i) offsite prefabrication of materials and parts, (ii) prefabrication of components and subassemblies, and (iii) up to 80 % of the total work completed offsite in a factory environment (Höök and Stehn 2008), see also Gibb (1999). In this report, unless explicitly stated otherwise, all of these types are included in the term industrialised building (IB), while items that are never considered for onsite production (level 1 of offsite according to Goodier and Gibb (2007)) are included in non-industrialised building, further referred to as traditional building (TB).

This research is part of an ongoing study focusing on the client's role in IB in Sweden. The results are primarily drawn from a review of recent surveys, reports and other publications on IB, with the main focus on IB in Sweden. In addition, empirical data were obtained from a case study based on interviews with five different kinds of stakeholders: a building sector organisation, building clients (public and non-public) and contractors (representing different types of IB).The compiled data were then discussed and further analysed in a workshop.

DEMANDS ON THE SWEDISH BUILDING SECTOR - DRIVERS OF INDUSTRIALISED BUILDING

Governmental interventions and structural change

The building sector in Sweden, as in many other countries, has been subject to public and government interest and intervention due to the importance of the sector to the economy. Low levels of competition, poor efficiency and high costs in the sector have been recurring themes in state investigations for decades (SOU 2000). During the 1990s new rules and regulations for the sector were introduced. The housing market was deregulated and tax incentives and subsidies were repealed (SOU 2002, Apleberger *et al.* 2007). The Swedish government's Directive 2002:24 also acknowledged a change in the relationship between building buyers and suppliers, with regard to the clients' knowledge and responsibility for the long-term management of built properties (SOU 2002). The change was described as a move from:

- a situation in which a large number of competent clients/builders built properties to be managed in the long-term by themselves or by local property management organisations, using their own building resources or contracting local builders and craftsmen, to
- a situation in which fewer companies with national coverage of the Swedish building market constructed buildings for others to manage, frequently for tenant-owner associations, using in-house sub-contractors and suppliers.

In addition, the building sector's failure to undertake necessary measures to secure quality standards led to a quality council being formed in 2001, with the purpose to incorporate a quality management systems approach (SOU 2002).

Undersupply of housing and skilled workforce

During economic booms the building market tends to overheat, while during recessions the industry can soon be in profound crisis. The structural changes at the beginning of the 1990s coincided with a recession, and the late 1990s and the early years of the 21st century saw the Swedish housing sector reach an all-time low (SOU 2000). This led to undersupply and a housing shortage, with the need for "more dwellings at reduced costs" becoming a frequent topic in public debates (Apleberger *et al.* 2007). Due to the low level of building activity in Sweden at the end of the 20th century, fewer people chose to acquire building trade qualifications. Consequently, during the time of prosperity that followed, companies experienced recruitment problems due to undersupply of skilled workers (Statskontoret 2009).

Outperformed by manufacturing industry

The problems facing the building sector, as such, are not unique, and the experiences of other industries dealing with similar problems through the application of new concepts, ideas and technologies have been the subject of growing interest and debate amongst building sector stakeholders (Barlow 1999, Winch 2003). Comparisons have shown the building sector to be outperformed by the manufacturing sector. The Building Cost Commission concluded in a report presented in 2000 that the building industry increased its total productivity by an average of 1.7 % a year and work productivity by an average of 2.9 % a year, over the period 1965 to 1996. Corresponding figures for the manufacturing industry were 2.9 % and 3.9 % per year, respectively. The Commission also concluded that building is characterised by a lower transition pressure than other domestic industries, which can be explained by the low level of competition and localness of the building industry (SOU 2000).

Demands for change

The building sector's rigidity and inability to change have been recognised in government enquiries (Egan 1998, SOU 2000), by researchers and by the profit-driven industry itself (Dubois and Gadde 2000, Frödell *et al.* 2008, Statskontoret 2009). In order to meet these stakeholder demands for change, IB has been proposed both in Sweden and in other countries, as a means of improving the competitiveness and effectiveness of the building sector (SOU 2000, Goodier and Gibb 2007, Pan *et al.* 2007). The drivers that influence the building sector in Sweden seem to be similar to those operating in the UK. Goodier and Gibb (2007) identified two factors driving interest in offsite work, besides the sector's own interest in improving performance: an increased demand for housing and increased governmental pressure to learn from the manufacturing sector, regarding (inter alia) productivity, profits, defects and safety issues.

The change drivers impinging on the building industry and associated demands driving IB are summarised in Table 1.

DISTINCTIONS BETWEEN TRADITIONAL AND INDUSTRIALISED BUILDING

Two important questions emerge from the previous section; what characteristics of TB create problems for the sector and what characteristics of IB are perceived as enabling it to resolve these problems? IB has developed over the last decade as a niche sector of the building market in Sweden, but still is, in many respects, only a small part of the overall, TB context. Traditional and IB are not as diametrically opposed as black

Table 1: Change drivers impinging on the building sector and associated demands that promote IB

CHANGE DRIVERS	DEMANDED CHANGES
Governmental interventions and structural change - Governmental investigations - New rules and regulations - Deregulation of the housing market - Building tax subsidies and incentives repealed - Changed relationship between buyers and suppliers Undersupply of housing and skilled workforce - Structural change (building sector/market) - Economic recession Outperformed by manufacturing industry - New concepts, ideas and technologies - transition pressure and globalisation/internationalisation	Change and improve - Time to build (shorten) - Cost (decrease) - Quality - Productivity - Working conditions - Environmental impact - Profitability

versus white, and there are clear overlaps between them. However, for the purposes of identifying what stakeholders are hoping to 'leave behind' in a change towards IB, and what they hope to gain, TB is regarded here as the antithesis of IB in a number of important respects, as outlined below.

Traditional building

Koskela (2000) identifies three main 'peculiarities' of building at the project/production level; site production, one-of-a-kind production and temporary organisation.

The key characteristic of TB is, in many respects, that almost all of the production occurs at the building site. Building site-related issues that are often described as problematic include:

- Effective, proper handling of materials onsite (Apleberger *et al.* 2007)
- Working conditions, health and safety of the work force (Leather 1988, Gibb 1999)
- Environmental issues, disturbances to the site's surroundings (Gibb 1999)
- Infrastructure solutions (Cigén 2003)

The difficulties within the sector to change and develop has by some researchers also been associated with the building site production, suggesting that changes that occur do so within the isolated setting of the respective building sites (see, for example, Green 1999, Pheng and Hui 1999, Höök 2008).

Various groups, companies and individuals team up to tackle every new building project, forming a temporary organisation. This manner of organising building tasks has been criticised for failing to support knowledge transfer and long-term, systematic approaches to improvement (Vrijhoef and Koskela 2005). Temporary organisations require resources to establish the organisational needs of each new project, to initiate and maintain operations, and to ensure that people cooperate within the project. Therefore, temporary organisations are believed to operate less efficiently and effectively than other organisations (Josephson 1994). The constant relay-race, in which different actors with different goals and interests (Sacks 2004, Sardén 2005) pass the baton from one sub-contractor to another, requires coordination (Apleberger *et al.* 2007) and sometimes lengthy negotiation. The fragmented building process also

demands high levels of competence, which may not be readily available (Statskontoret 2009).

In recent years, work culture at a project level has also emerged as an important research topic. The concept of culture at the onsite, project-based level relates to the normative or traditional way of "doing things" (Höök 2008). Even when expressing a willingness to change, individuals seem reluctant to do so (Bröchner *et al.* 2002). The work culture within the building industry appears to be deep-rooted (Höök 2008), conservative and slow to change (Bulhões *et al.* 2006). Obstacles that have been suggested include (inter alia) the mindset of people and the 'common sense' approach that prevails in the sector (Ward and McElwee 2007), and building trade-wide rules and project management routines (Kadefors 1995, Höök 2008).

Characteristics of TB, commonly identified during the interviews included:

- Conservative/rigid/hard to change/strong culture
- Known and proven/well-tested (but not necessarily optimal) solutions
- The norm for currently existing rules/regulations, clear frameworks and roles
- Large numbers of actors with contractually regulated relationships, multiple deliveries in a fragmented production chain, handing over work/responsibilities in a relay race
- Skilled craftsmen/workforces with extensive practical knowledge of building
- Craftsmen jargon ("make it work", fixing things as they occur)
- Process flexibility (handling changes as they occur, meeting new demands from customers even during the production stage)
- Product flexibility (prototype nature/unique product)
- Uncertainties concerning costing/ additional costs commonly arise

Industrialised building

In contrast, the characteristics of IB suggested by the interviewees were:

- Is part of the TB context/is often only part of any building project
- Offers potential for development (both of IB per se and the building sector as a whole)
- Negative attitudes and associations (due to experiences of prefabs during the 1960s)
- Prerequisites are not well-understood/are unknown (to external actors)
- Detail design/clear and distinct control
- Product standardisation (technical solution and/or design, component orientation)
- Process standardisation, manufacturing process, learning through repetition
- Cost and quality advantages
- Improved precision/predictability (cost, delivery/time, quality)
- Improved working environment
- Shortened time onsite, more efficient handling of resources and logistics onsite

These characteristics are generally consistent with definitions and previous descriptions of industrialised building,(see, for example, Lessing *et al.* 2005, Apleberger *et al.* 2007). Meiling (2008) also suggests that industrialised housing is part of the house building industry, but has a different set of characteristics which can be categorised into three main types: (1) prefabricated versus onsite building, (2)

process-oriented versus project-oriented design and production, and (3) one clear process owner versus many stakeholders.

Gibb (1999) summarises the potential cost savings of building offsite as follows: productivity cost savings from offsite fabrication; onsite cost savings due to shorter building periods, less onsite work and fewer workers; cost savings from reductions in transportation, more efficient use of onsite crane works, and reduced unplanned onsite remedial works; and changes to project cash flow. The factory production of prefabricated parts and systems purportedly improves the management of building processes and resources as value-added activities move up the supply chain into a more controlled environment (Nasereddin *et al.* 2007). This in turn promotes reproducibility in design and production, which is another characteristic aligned to the academic definition of IB (Björnfot and Stehn 2007, Höök 2008, Meiling 2008). Moving production from scattered, multi-site locations to a single factory site enables management to gain a strategic perspective, including such aspects as a process overview, which can highlight possibilities for the integration of processes, flows and work design, and allow performance to be measured systematically. Together with the benefits of a weather-protected offsite environment, this approach also improves the handling of materials, the quality of the finished product, and the provision of healthy and safe working conditions (Gibb 1999). Moving production (partly) offsite potentially also reduces disturbance and work-space requirements onsite. According to Gibb (1999), the reduced duration of onsite work is the principal benefit of offsite fabrication, achieved by the overlapping of off- and onsite activities together with the potentially increased productivity achieved in a factory environment. Clients want to be able to control their risks by reducing unknowns. According to Gibb (1999), the use of standardisation is the main way to increase predictability.

Traditional building versus industrialised building

The characteristics identified by the interviewees appeared to be largely the same, and were generally found to be in line with the results of the literature review. During a follow-up workshop, the characteristics were further discussed with the client and contractor interviewees, and the main distinctions between TB and IB are summarised in Table 2.

TOWARDS INDUSTRIALISED BUILDING - OR NOT?

Government investigations and published research seem to favour IB, suggesting it can meet the demands for improvement in the building sector. The client interviewees surveyed in this research also initially presented mostly negative aspects of TB, while their descriptions of IB were initially more favourable. One of the clients commented, when confronted with this observation, that the perception of TB is a view of ‘what is’ while IB is viewed more as ‘what could be’. This suggests that the positive characteristics of IB are potential rather than real attributes at the present time. Another client interviewee maintained that IB had not yet achieved the impact he had hoped for, and suggested that this might be because IB still generally accounts for a small part of an overall TB project. This description is consistent with the results of government investigations. All the contractor interviewees agreed on the limited impact of IB to date. They reasoned that this was because regulations were not well suited for the IB process, individuals’ attitudes were still tainted with experiences of the 1960s prefabrication programmes, and there were problems with clients not understanding the process and the need for the timely delivery of information. Many

Table 2: TB characteristics versus IB characteristics

TRADITIONAL BUILDING	INDUSTRIALISED BUILDING
High external clarity (culture, regulations frameworks, roles, phases - steps and sequences)	Low external clarity (culture, regulations frameworks, roles, phases - steps and sequences)
Handling uncertainties/agile production	Aims to reduce uncertainties/standardise production
Flexibility (product)	Standardisation (product)
Flexibility (process)	Standardisation (process)
Craftsmanship, highly skilled work-force, experienced in building and handling uncertainties/acting agile	Industrialisation, factory-workers, standardisation of methods
+ Several negative characteristics concerning the effects of building onsite	+ Several positive characteristics concerning the potential effects of building offsite, in a fabrication facility

of these issues have been described in previous research reports, as shown in the following sections.

Contextual rigidities constraining realisation of the potential of industrialised building

Institutions may be acting as barriers to change in the building sector, as suggested by Kadefors (1995). In Sweden, such institutional barriers may include: government regulations; formal standardisation; the tendering system; entrenched roles and interests; and the standardisation of skills, knowledge, learning and routines (Vennström 2008). All of these have historically developed to fit, regulate and support the traditional concept of the building process. The overall building culture, based on the standard approach to TB, also seems to influence the organisational culture of industrialised housing (Höök 2008). Höök (2008) suggests that cultural influences have led to industrialised housing practices that lack standardisation of work and routines, employee commitment to settled strategies, and top-management support and strategies. Other studies have also shown that the housing companies utilise the benefits of indoor (i.e. offsite) building without adopting a manufacturing culture, and thus miss the supposed benefits of production and product quality control (Meiling 2008). The benefit remaining from IB might thus be reduced to simply offering a weather-protected environment for the offsite part of the building project.

Negative associations and client uncertainty

Even if contemporary IB companies in Sweden aim to create good architectural designs and variety, they are in many ways still associated with the "million-programme" of the 1960s, characterised by standardised buildings of impoverished architectural merit (Gerth 2008). Furthermore, research has shown that clients still experience uncertainty concerning any industrialised alternative (Höök 2008). According to Höök (2008) this uncertainty seems to be associated with the previously mentioned historical prejudices connected to the "million-programme" and to the use of timber (commonly used as framing material in IB in Sweden), which altogether is perceived as typifying low quality, short-time durability, limited flexibility and 'low-quality-design'. The prefabrication of volume elements also changes the roles of actors and the production process differs from that of TB (Höök and Stehn 2005), which enhance client uncertainty.

The role of the client

According to Statskontoret (2009), one of the recurring problems of the building sector is that clients are not facilitating IB. Clients in general are not buying buildings that can be produced in series. This prevents both advantages of scale and learning. Even though the investigation (Statskontoret 2009) concluded that the building sector is significantly affected by changes in the trade cycle and political factors, it also suggested that there is a potential for improvement, not least concerning the role of the client. By exercising market power, the client can affect the development of the sector. The investigation noted, however, that different clients were driven by different factors for their work, and that an important issue is how well life cycle costs and long term property management are evaluated.

The relative significance of traditional versus industrialised building characteristics

During the workshop, clients were asked to evaluate the characteristics of TB and IB. Even though all the participants highly valued the effects of offsite building (see table 2), TB was also highly regarded, as illustrated by the following comments; "flexibility comes at a price and, albeit unwillingly, clients pay" and "the traditional building process is perhaps not optimal, but it is well-known, with clear frameworks supporting it".

Fluctuations

Ways in which IB companies accommodate the ups and downs of the trade cycle were also discussed as a matter of importance during the workshop. Even though there are potential cost savings associated with IB, the direct costs of fabrication facilities must also be considered (Gibb (1999). For IB companies with large investments in production facilities, processes and product development, the management of costs to adjust for fluctuations in the trade cycle may be even more problematic than for building companies in general.

The restraining forces are summarised in Table 3.

Table 3: Forces restraining change towards industrialised building in Sweden

CHANGE RESTRAINERS
Contextual rigidities constraining realisation of the potential of industrialised building
Negative associations and client uncertainty
The role of the client
The relative significance of traditional versus. industrialised building characteristics
Fluctuations

THE COMPETITIVE IMPACT OF INDUSTRIALISED BUILDING IN SWEDEN

From the previous discussion and Tables 1-3, the following conceptual model is suggested (Figure 1).

As discussed above, the major forces driving change in the Swedish building sector include government intervention and structural change, under-supplies of housing and a skilled work-force, and the potential for improvement presented by examples from the manufacturing industry. The demands originating from these drivers could be

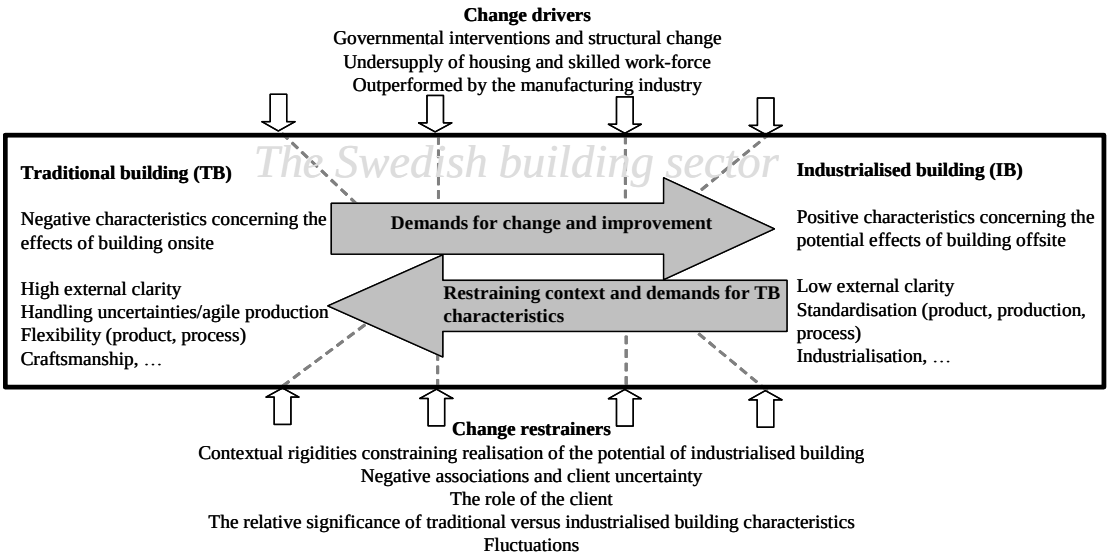

Figure 1: A conceptual model

consistently met by the potential characteristics of offsite building, supporting the notion that IB is likely to be a key issue in the future. However, even though the building sector has been routinely investigated there is a lack of data to facilitate comparisons between IB and TB. How well are the IB companies realising the potential of offsite production, and how does this stand in comparison to historical performance and in comparison to the performance of contemporary onsite, TB companies? Without such knowledge the market power held by clients will remain weak and will not support change towards meeting the demands for improvement. Furthermore, there is a lack of knowledge regarding the distinction between building clients' wants, and which of these 'wants' most affects their buying decisions. If industrialised builders can offer solutions to clients that realise some or all of the potential of offsite building, would this lead to the client accepting their offer – and thus strengthen the drive towards IB – or would the positive characteristics of TB be of higher importance to the client? For example, does flexibility generate waste or improve value? Is the client's need for flexibility a result of their familiarity with the traditional building culture, and therefore not necessarily related to a higher value, or is it a factor that is essential in order to reduce costs, improve quality and manage time more effectively in the client's organisation and/or business system?

Two main lessons can be deduced from this research. Firstly, that the market, i.e. the building client base, is not an apparent force for change towards IB, and the information and understanding required to support clients' decisions whether to enforce market power in one or the other direction is not readily available. Secondly, it is unclear how building clients evaluate the different possibilities of IB compared to what may be lost when abandoning the TB process, and also how well this corresponds with the needs and values of end customers.

The challenge for IB companies is to provide better performance data for evaluation as well as for market communication, i.e. to reduce client uncertainty. For the building clients, the challenge is to learn more about IB, with respect to both its potential and the driving and restraining forces that influence its realisation, in order to make better educated investment decisions, i.e. to improve client power. Finally, the challenge for researchers is to facilitate the comparison of performance between traditional and

industrialised building alternatives, i.e. to develop robust measures and methods that address both effectiveness and efficiency.

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