

# MANAGING INNOVATION: A FOCUS ON OFF-SITE PRODUCTION (OSP) IN THE UK HOUSEBUILDING INDUSTRY

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In addressing problems in housebuilding, several government-backed reports have suggested that off-site production (OSP) could be the solution to both improving quality of construction and addressing skills constraints. However, the industry has been slow to innovate and adopt OSP techniques. There is also an apparent lack of understanding how to adopt OSP appropriately. This research aims to review concepts of innovation and OSP within the context of the UK housebuilding industry, identify the drivers for and barriers against OSP, explore the underlying reasons and variables which determine these drivers and barriers, and ultimately develop a framework for the industry to better understand OSP and appropriate strategies to facilitate sustained innovation and appropriate OSP applications. Results from exploratory interviews with key stakeholders from the industry suggest that technical, human and industrial barriers are highly integrated and inhibit OSP applications. Human perceptions grounded in historic and recent failings, the fragmented nature of the industry's structure and its risk averse culture were found to be significant. Several case studies will be carried out to further explore how key stakeholders can be encouraged to utilise OSP techniques appropriately in a way which overcomes the barriers identified.

Keywords: Appropriate strategy, Drivers and barriers, Housebuilding industry, Managing innovation, Off-site production (OSP).

## INTRODUCTION

Several recent government policy documents have identified concerns over the UK housebuilding industry. Sustainable Communities: Building for the Future (ODPM 2003) sets ambitious housing targets for the period 2003 to 2006. The interim report of the Review of Housing Supply (Barker 2003) claims that under supply of housing is constraining economic growth and prosperity. This report reveals that there is a shortfall in production of between 93,000 and 146,000 homes per annum. The report suggests that new technologies could both improve the quality of construction and assist with addressing skills constraints in the industry. The Joseph Rowntree Land Enquiry (Barlow *et al.* 2002) also argued that there was a substantial under-supply of new housing in the UK. It suggested that around 225,000 new homes will be needed each year in England alone to meet the demand arising from demographic changes and other needs up to 2016. Traditional methods are unable to meet housing demand nor to build products to a high enough standard while off-site fabricators are able to deliver good, factory-built products at the right price. Collectively, these factors make

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a powerful case for increasing the use of off-site production (OSP). However, the OSP practices in housing are lagging behind what these reports expect. The industry has been slow to innovate and adopt alternative construction technologies. However, the process of structured change must occur if the housebuilding industry is to face a sustainable future (Hooper 1998).

Based on the literature review and several exploratory interviews with key stakeholders in the housebuilding industry, this paper aims to identify the drivers for and barriers against OSP, explore the underlying reasons and variables which determine these drivers and barriers, develop a framework for the industry to better understand OSP and appropriate strategies to facilitate sustained innovation and appropriate OSP applications. The research questions were identified through the literature review and the topic was further narrowed down through exploratory interviews with key stakeholders from the industry. Potential case studies have been identified to further explore the relationship between drivers and barriers and their determining variables and to develop appropriate strategies for the industry.

## THE CONCEPT OF INNOVATION

Almost everyone explores innovation from their own perspectives and within their own context. Nevertheless, deconstructing these definitions can facilitate understanding of this nebulous concept. It has been widely accepted that ‘newness’ is one of the basic elements of innovation (Cripps 2002). Rogers (1995) defines it as “*An idea, practice, or object that is perceived as new by an individual or other unit of adoption.*” This “new” does not necessarily mean to all but the unit of adoption, which brings forth the importance of context when defining innovation. Another element is successful exploitation of new ideas. HM Treasury (1998) indicates innovation is the successful exploitation of new ideas and new ways of doing things. A similar definition was provided by Egbu and Young (1998), “*the successful introduction, application and exploitation, within a role, group or organisation, of ideas (process, products, services, technologies and markets) new to the unit of adoption which is designed to significantly benefit the individual, the group or the organisation.*” Van De Ven (1986) outlines four basic factors facilitating and inhibiting the development of innovations, which are new ideas, people, transactions, and institutional context. Gann (2004) suggests that the key points of innovation are the introduction of new and/or improved products, processes and services; technical and/or organisational change; and successful exploitation of new ideas. Barrett *et al.* (2001) break down innovation into “*the effective generation and implementation of a new idea which enhances overall organisational performance.*” Amalgamating these ideas suggests that elements of innovation are identified as newness, unit of adoption, and successful exploitation of new ideas. These elements embrace rich context which should be understood appropriately.

*The context of innovation.* Awareness of the context of innovation applications is of great significance. Firstly, what is new to one company may be ‘old hat’ to another; secondly, how does one judge success in terms of commercial gain or scientific achievement? Thirdly, innovation is time dependent - what is viewed as a success today may be viewed as a failure in the future (Trott 2002). There is no right answer to whether or not innovation should be successful. Some researchers regard innovation as a neutral term, without leading necessarily to success (e.g. Schulze 2003). It should also not be assumed that the diffusion and adoption of all innovations are necessarily desirable (Rogers 1995).

## OFF-SITE PRODUCTION (OSP)

For the concept of OSP, this research takes the definition by (Gibb 1999): “a process which incorporates prefabrication and pre-assembly. The process involves the design and manufacture of units or modules, usually remote from the work site, and their installation to form the permanent works at the work site. In its fullest sense, off-site fabrication requires a project strategy that will change the orientation of the project process from construction to manufacture and installation.” Levels of OSP are shown in Table 1. This study focuses on levels 2-4 given that Levels 0 and 1 are already exploited within the housebuilding sector. However, this study also includes the hybrid system which is a combination of volumetric pre-assembly (at the high value areas, e.g. bathroom pods) and non-volumetric pre-assembly (mainly the panellised systems for the rest of structure) (See Housing Forum 2002; 2004).

**Table 1:** Levels of OSP and definitions

Level 0	Basic materials	With no pre-installation assembly aspects
Level 1	Component sub-assembly	Small sub-assemblies that are habitually assembled prior to installation
Level 2	Non-volumetric pre-assembly	Planar, skeletal or complex units made up from several individual components – and that are sometimes still assembled on-site in ‘traditional’ construction
Level 3	Volumetric pre-assembly	Pre-assembled units that enclose usable space – can be ‘walked into’ – installed within or onto other structures – usually fully finished internally
Level 4	Modular building	<div style="border: 2px solid black; padding: 5px; text-align: center;"> <b>Pre-manufactured buildings - volumetric units that enclose usable space but also form the structure of the building itself – usually fully finished internally, but may have external finishes added on site</b> </div>

(prOSP<sub>a</sub> 2004)

## UK HOUSEBUILDING INDUSTRY

The literature reveals a problematic context for the UK housebuilding sector: *Characteristics of the industry*. Barker (2003) characterises the industry as comprising: low levels of responsiveness to demand; a cautious approach to investment in brownfield development; and low levels of innovation. Ball (1999) also identifies: consumer conservatism exacerbated by the need to ensure ‘saleability’ for the subsequent purchasers; a high degree of instability in housing market cycles and increasing volatility in cycles; the dominance of sub-contracted labour, encouraging the maintenance of existing techniques and skills, with low training levels; the distinctive market structures between the housebuilding and building materials industries, resulting in slow diffusion of innovation; and land development profits and the planning regime may discourage innovation in production and design respectively. *Structure of the industry*. The industry has been claimed as being geographically fragmented. Almost 90% of new homes built in the UK are constructed by private housebuilders (POST 2003). There are currently around 18,000 housebuilders

registered by NHBC, but just under 200 firms produce more than 50 homes per year in the UK (Barker 2003).

*Current challenges facing the industry.* In comparison with other countries, both the nature and the scale of innovation in the UK housebuilding industry is very conservative (Hooper 1998). The housebuilding industry is frequently criticized, not only has the volume of output not responded to meet demand but the nature of housing being produced does not meet the needs of consumers and society as a whole. Production techniques are inefficient and there is a reluctance to innovate and adopt modern methods of construction. The industry holds stocks of land for development which it does not bring forward quickly enough when prices rise, to deliver increased housing numbers. Housebuilders respond poorly to the needs of individual consumers resulting in a large number of complaints. The long-term upward trend in house prices and recent problems of affordability are the clearest manifestations of a housing shortage (Barker 2003). All of these aspects must be viewed within the context of market growth within the sector.

*Innovation (OSP) in the industry.* Greater use of technology can lead to improved quality, and may also assist in dealing with skills constraints. Alternative manufacturing techniques – such as off-site manufacture, and greater use of steel and timber frames would all lead to greater levels of capital intensity (ibid). There is a climate of change in the UK housebuilding industry. Offsite fabrication offers a solution to some of the new demands which present themselves (Housing Forum 2002). Despite the claimed advantages being compelling, they have had little impact in terms of the take-up in the sector. The following sections break down all the drivers for and barriers against the innovation (OSP) in the UK housebuilding industry.

## **DRIVERS FOR INNOVATION (OSP) IN UK HOUSEBUILDING**

The literature reveals several key drivers for utilising OSP in housebuilding as follows:

- *Skill shortages.* A shortage of skilled labour may serve as a driver for increased innovation. Both the reduction in craft skills of the various building tradespeople and the declining numbers of people in most of the trades has been a major concern for Egan and other industry reports (Edge *et al.* 2002). Without changes in labour productivity, even modest growth in output could lead to a requirement for around 70,000 further employees in the housebuilding industry. A more substantial expansion of output would increase this still further, possibly up to 280,000 people (Barker 2003).
- *Addressing government and industry concerns.* The context for the increased interest in off-site manufacture is set by two important factors – the intense pressure within the housing market and a government and industry concern to improve the performance of the construction industry (Housing Forum 2004). A number of recent policy documents (ODPM 2003; Barker 2003; Barlow *et al.* 2002; *etc.*) have identified concerns of undersupply of housing in the UK and suggested that new technologies could both improve the quality of construction and address skills constraints.
- *Demonstrating ‘Egan’ compliance.* The Housing Corporation has launched the ‘KickStart’ initiative and have stated that eventually all projects would need to be Egan-compliant. Several housing associations have formed consortia to bulk-purchase prefabricated housing, the largest being the Amphion consortium which boasts over 20 Housing Association members (Housing Forum 2002).

- *Revisions to the Building Regulations.* Higher standards of energy efficiency required by Revisions to the Building Regulations are often cited as the reason builders are looking at offsite manufacture. Delivery of good quality homes by 'traditional' construction techniques is increasingly difficult and expensive (ibid).

## **BARRIERS TO INNOVATION (OSF) IN UK HOUSEBUILDING**

Barriers to OSP in housebuilding have been identified as follows:

- *Historical context.* Prefabricated housing has been used in the UK during periods of high demand, such as after the World Wars and during the slum clearances of the 1960s. However, problems arose over the quality of building materials and poor workmanship, leading to negative public attitudes to prefabrication (POST 2003).
- *Reluctance to innovate.* Barker (2003) indicates that there is a reluctance to innovate and adopt modern methods of construction. Data suggests that housebuilding in the UK is significantly more labour-intensive than in other countries. It has been suggested that the cause is UK housebuilders' lack of innovation. Suppliers regard the two main limiting factors as market demand (including public perception) and production capacity (Housing Forum 2004). Other issues arise over the cost of modern methods of construction; the industry capacity; its environmental benefits; the quality of such housing; public acceptance; and planning and building regulations (POST 2003).
- *Perceptions of stakeholders.* For an innovative technique to become established, customers, mortgage lenders and warranty providers will need to be persuaded that it will produce durable and safe buildings (Barker 2003). Some builders and developers are worried that the houses may not be wanted by their potential customers and concerned about the impact of technology on brand image. Surveyors unfamiliar with the technology are not sure how to assess the property and have concerns about latent defects or the long-term durability of the structure. Lenders are nervous about the long-term value of the home and whether it represents adequate security for the loan (Housing Forum 2002). The uptake of offsite manufacture is influenced by the perceptions of developers on its advantages and disadvantages. The business drivers and models of housing developers and manufacturers are radically different. There are also differences in the business drivers of speculative and social developers (Housing Forum 2004).
- *Culture of risk aversion.* The risk averse nature of the industry militates against the investments inherent in adopting more capital-intensive approaches. Risks may lead to a reluctance among some housebuilders to undertake significant investment in plant and alternative construction techniques. Barker (2003) suggests that the fragmented structure of the industry, the nature of the UK planning system, the importance of land acquisition and location in determining prices, and the unique market constraints are also associated limiting the possibilities for innovation and inhibiting the adoption of OSP in UK housing. Firms do not, therefore, generally compete through innovation (Hooper 1998).

## **METHODOLOGY**

Initial research objectives and hypotheses were developed from the outcomes of the literature review outlined above. These initial objectives and hypotheses were explored within a set of interviews with appropriate stakeholders in the industry. The

aim was to use the exploratory interviews to shape and refine the research objectives. Seven interviews were carried out with senior staff, which included four architects, a Q.S./ project manager, a housebuilder and a consultant. These exploratory interviews were semi-structured in nature with four guiding themes, each including a couple of potential questions. The interviewees were encouraged to talk openly about their experiences and projects with OSP applications. These interviews lasted around an hour and were recorded and transcribed verbatim. The results of the interviews were categorised in four themes and analysed inferentially as to allow the comparison of views on different cases, either project or OSP technology, from the same stakeholder, and views on the same cases but from different stakeholders, or the summarisation of all responses as a whole for the housebuilding industry. Both results from the literature review and interviews were triangulated in the discussion section. Longitudinal case studies were suggested for future research.

## RESULTS

The results are presented below under four themes drawn from the analysis:

### **Theme one - Concepts of innovation and OSP**

Innovation was claimed to embody new things, ways, approaches to problems, either in physical products or processes, or the changing of people's mind. The key characteristics of innovation were claimed as: to be new; to be practical and productive; to be easily integrated into existing process; to be incremental and sustainable. Most of interviewees agreed that OSP and innovation are overlapping – innovation includes some OSP techniques but much more, while part of OSP techniques have long been used. The question of how to judge if an existing innovation can still be regarded as an innovation after having been adopted for some time was raised. There remain many people who perceive OSP as experimental and associated with many uncertainties, especially cost.

### **Theme two – OSP in the UK housebuilding industry**

Level 1 and 2 of OSP have been widely accepted and to some extent integrated into their business. However, interviewees claim they either feel reluctant to start to consider to adopt level 3 and 4 of OSP in terms of housebuilding. Most interviewees claimed they needed to be convinced of the advantages of OSP, particularly volumetric techniques.

### **Theme three – Exploring drivers for and barriers against OSP**

Government promotion was claimed as the biggest driver for OSP applications. Cost and time certainties, short on-site duration, better quality, partly addressing skills shortages, better control of health and safety, clients' influences were also mentioned. Barriers against the take-up of OSP applications can be grouped into technical, human and industrial barriers. *Technical barriers* include extra cost incurred, short lead time allowed, the need to freeze the design early on, site specifics or constraints, and interfacing problems between systems. *Human barriers* included unfavourable attitudes from many architects and designers, the negative perceptions caused by historical and recent failures in OSP practices, misunderstanding on addressing skills shortages, lack of knowledge of adopting OSP, the risk averse attitude of most clients, and insufficient training on site levels. *Industrial barriers* included problems in achieving economies of scale, the fragmented structure of the industry, the nature of the planning system, and insufficient manufacturing capability.

Human perceptions seem the most critical part of human barriers. It exists in all stakeholders. Aspects of human perceptions included perceptions on technical aspects,

cost, the structural requirements associated with social, security, privacy and noise problems, and perceptions grounded in the historical failings of OSP technology. The underlying reasons for these human barriers were claimed as relating to: a lack of research, historical failures and recently built unfavourable projects, a lack of integration of project team and long-term cooperation and difficulties in planning in the long term. There are different drivers and barriers claimed for different housing projects due to relevant site conditions, housing types and stakeholders involved. Social developers were seen as looking more for better quality and private developers focus more on profit-making. The types of social housing developments are normally more standard. OSP has been more used in social housing.

**Theme four - How to promote OSP applications**

Some solutions to overcoming barriers against OSP were discussed. They were to get more demonstration projects to convince people of the benefits of OSP, to be more objective in briefing clients the advantages and disadvantages of adopting OSP, to improve training in installation techniques, to improve knowledge of stakeholders on OSP, to develop long term cooperation among stakeholders, and to address interfacing and tolerance issues.

**DISCUSSION**

**Concepts of innovation and OSP**

The literature and interviews suggest that innovation has a different meaning depending upon the time and industry in which innovation is adopted and stakeholders who may perceive innovation from their own perspectives. To better understand innovation, the study on its context should therefore cover as many aspects as possible, such as time-related, spatial, political, economic, social (Craig et al. 2000), technological, environmental, legal etc. In this research, the context of innovation has been classified against four aspects: macro-time related; micro-time related; macro-spatial; and micro-spatial (Figure 1). Full appreciation of the context model will be of importance to the identification of the drivers and barriers of innovation (OSP).

**Figure 1:** Context model of innovation

		<b>Macro</b>										
		<b>Macro-time related</b>		<b>Macro-spatial related</b>								
		pre-war	post-war	1960's	late 1990's	to current	political	economic	social	technological	environmental	legal
<b>Time</b>		project scale	innovation scale				innovation itself	unit of adoption	stakeholders	industries	geographical	
		<b>Micro-time related</b>		<b>Micro-spatial related</b>								
							<b>Micro</b>					
												<b>Spatial</b>

The results of interviews reveal that OSP needs multi- and better- skilled workforce and it actually involves a transfer of skills from the site to the factory. The situations for different levels of OSP techniques in different housing developments are not same. Housebuilders are beginning to use standard components. However, there is clearly

scope for much greater use of off-site assembly. More radical approaches to OSP involve prefabricating entire rooms or apartments off site. This approach has been taken forward in a small number of housing developments, particularly in social housing owing to Government funding being tied specifically to the use of OSP techniques (Barker 2003).

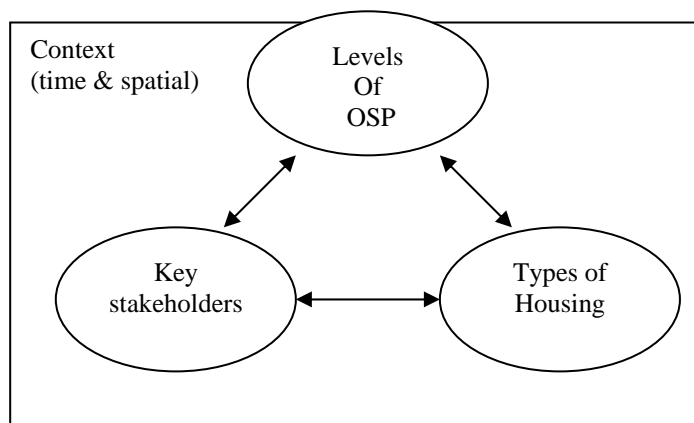
### Drivers for and barriers against innovation (OSP)

Edge *et al.* (2002) claim that, whilst there is no real technical barrier to increasing standardisation and prefabrication in housing, there may be considerable resistance to innovative housing amongst clients and the wider public. However, results from this study reveal technical, human and industrial barriers are highly integrated and the human perceptions exist in all stakeholders including clients and the public.

Views from stakeholders involved in housing developments depict human perceptions as seriously affecting the OSP applications. The human problem of managing attention and the strategic problem of institutional leadership in the management of innovation are discussed by (Van De Ven 1986). People and their organisations are largely designed to focus on, harvest, and protect existing practices rather than pay attention to developing new ideas. Innovations not only adapt to existing organisational and industrial arrangements, but they also transform the structure and practices of these environments. The strategic problem is one of creating an infrastructure that is conducive to innovation.

In this study, aspects of human, process and context are revealed as being much more complex. Human aspects involve all key stakeholders, process aspect includes the integration of OSP levels with housing types, and the context embraces scales of time and spatial (Figure1). There are different drivers and barriers for different housing projects due to relevant site conditions, housing types and key stakeholders involved. As illustrated in Figure2, levels of OSP, key stakeholders and types of housing are the key variables which determine the drivers for and barriers against OSP uptake.

**Figure 2:** Key variables determining the drivers for and barriers against OSP uptake



### Appropriate strategies to facilitate OSP applications

The vast majority of innovation problems stem from a mismatch between technological possibilities and market demands. Different kinds of innovation are appropriate at different stages of a product life cycle. Managers must develop appropriate leadership styles and organisational configurations to facilitate each type. The particular innovation profile should be linked to the organisation's strategy, which should, in turn, be driven by an assessment of external opportunities and threats (Tushman and Moore 1988). Managing innovation involves mediating between



external forces for change and internal forces for stability. Effective innovation over time involves developing the leadership styles and executive team that can create the conditions to facilitate both short-term efficiency and long-term adaptability. The manager and his or her team must develop their own learning abilities and, in turn, facilitate the organisation's ability to adapt. Organisation learning is at the heart of managing innovation (Van De Ven 1986). The development of an innovation demands close collaboration across the supply chain. This study is also to help the industry develop appropriate strategies and, in turn, appropriate structures, human resources, and cultures to facilitate sustained innovation.

## CONCLUSIONS AND FURTHER RESEARCH

Though OSP has been proffered as a solution to the problem of housing undersupply, the innovation practices in housing lag behind what they should be and the industry has remained reluctant to take up innovative OSP techniques. This paper has reviewed the concepts of innovation and OSP within the context of the UK housebuilding industry, identified the drivers for and barriers against OSP and explored the underlying reasons and variables which determine these drivers and barriers. The findings of the literature review and exploratory interviews reveal that technical, human and industrial barriers are highly integrated and inhibit OSP applications, and human perceptions grounded in the fragmented industry structure and the risk averse culture have stymied developments in this area. Levels of OSP, types of housing, and key stakeholders involved are identified as key variables which determine the drivers for and barriers against OSP applications. For sustained innovation and OSP promotion, a balance between short-term efficiency and long-term adaptability should be maintained and appropriate strategies should be developed in terms of appropriate structures, human resources, and cultures.

In future research, longitudinal case studies will be used out to further explore the relationships between key variables and drivers for and barriers against the adoption of innovation (OSP) in the UK housebuilding. These will reveal the ways in which the factors outlined in this paper combine to impact upon the decisions as regards OSP technology. Such knowledge should enable strategies to be developed to overcome diverse barriers to innovation in OSP within the housebuilding sector.

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