INDUSTRIALISED BUILDING SYSTEM (IBS) IN MALAYSIAN HOUSING: AN EMERGING INNOVATION SYSTEM EXPLANATION

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The building industry has many challenges, such as growing demand for affordable housing, increasing construction costs, relying on unskilled labour and failing to produce acceptable quality of construction outputs. These challenges are prevalent in most country in the world including Malaysia and have always been associated with adherence to existing practices and a reluctance to accept innovations. This situation has prompted policy-makers in Malaysia to set targets for the introduction of Industrialised Building System (IBS) but the aims have yet to be accomplished. Based on the System Functions approach, this paper aims to create an understanding of the IBS development pattern in Malaysian housing construction from 1963 to 2010. The data was collected from archive data and verified with interviews. From the findings, positive perception in IBS and government policy on IBS development are the two inducement mechanisms identified. Meanwhile, uncertainties of IBS opportunities among potential construction clients, inadequate knowledge of relative between investments and benefits, inconsistencies of demand for IBS application, lack of IBS suppliers, and unpreparedness among construction designers and contractors are the discovered blocking mechanism. Based on this development pattern, the blocking mechanisms identified are stronger vigorous and have decelerated IBS development in Malaysian housing projects.

Keywords: Malaysian housing construction, industrialised building system, technological transition, innovation system, system function.

INTRODUCTION

Historically, IBS was introduced for housing construction in 1964 in Malaysia when the first prefabrication project was constructed in Kuala Lumpur. IBS is defined as a "construction technique in which components are manufactured in a controlled environment (on-site or off-site), transported, positioned and installed into a structure with minimal additional site works" (CIDB 2003a). This system has been regarded as a solution to the weaknesses in the existing practices, such as low quality, safety

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issues, wastage and excessive reliance on unskilled foreign workers (e.g. Abdul-Rahman and Alidrisyi 1994, Agus 1997, CIDB 1998, CIDB 2001, Din 1984, Lim and Zain 2000). The construction practices that rely on large number of wet trade labours and construction processes mainly done on-site are common for Malaysian construction industry (CIDB 2003a). Therefore, several housing projects were constructed using IBS, such as, Pekeliling flat, Kuala Lumpur, flat at Rifle Range, Penang, Taman Tun Sardon flat, Penang and few housing developments in the state of Selangor. However, most of the housing projects were constructed using the conventional practices, as IBS Survey 2003 indicates only 15% of construction projects in the year 2003 used IBS (CIDB, 2003b).

At the end of 1990s, IBS was believed by the Malaysian government to be a better approach for the construction industry in Malaysia. The IBS Strategic Plan was published in 1999. The Malaysian government thought IBS created better conditions in the construction industry, such as through the reduction of unskilled workers[2], less wastage, less volume of building materials, increased environmental and construction site cleanliness and better quality control (CIDB 2003a). In 2003, the government set the industry to use IBS in all construction projects by the year 2010. To achieve the objective, numerous actions have been implemented such as providing IBS training programmes to public and private sectors, creating IBS construction projects, forming labour policy, implementing research on IBS and also marketing of the IBS application. However, these efforts have not made head-way. In 2006, only 10% out of total construction projects were constructed using IBS (CIDB 2007a). Meanwhile, the percentage of foreign workers in the construction industry increased from 44% of the total workforce in 2006 to 69% in 2007 (CIDB 2007b) which is far more than the target of 55% by the 2005. Therefore, this paper aims to create an understanding on the IBS trajectory in Malaysian housing construction from 1964 to 2010. In order to fulfil the purpose, this paper has chosen to proceed from the technological innovation system framework. A thorough understanding of the importance of functional fulfilment in the context of technological innovation system will help the policymaker in Malaysia accelerate the diffusion of IBS in the Malaysian housing industry.

The paper is structured as follows. First, an overview of technological change literature will be presented and will introduce the Technological Innovation System and System Functions that will be used in this paper. Second, the paper will describe how the data is collected and analysed. Third, the paper will explain the results of this study and this is followed by a discussion and conclusions.

TECHNOLOGICAL CHANGE

This study focuses on the lock-in of the existing system, which according to Lovell and Smith (2010) means the extent to which the entrepreneurs face difficulty to develop, diffuse and implement their new idea into the market. The UK housing study by Lovell and Smith (2010) argue that the method of housing construction based on labour incentives have been locked through several changes in technology and institution. Hence, they labelled this phenomenon as ‘masonry agencement lock-in’:

[2]By reducing wet-trades through IBS, the dependency on foreign workers will also diminish, thus gaining the billions of Ringgit currently being transferred out by the foreign workers to their home countries, and reducing inherent social problems involving these foreign workers (CIDB 2003a)

when efforts to bring the new methods have been unsuccessful although the new methods offer more benefits.

Lovell and Smith (2010) argue that this lock-in happens because the interaction between the technological system and the governing institutions keeps the infrastructure of the existing practices in place despite the known weaknesses in existence practices. Thus, the technological systems are seen to be complicated as they are linked with the social system that comprises the public and private sectors. In addition, it is impossible to focus on a single factor to unlock the system, but it cannot be denied that this factor would lower the existing system viability when it changes the selection environment (Schot *et al.* 1994). Hence, when the new technologies are developed and in the same time the changes in the selection environment occur, these will lead to the emergence of a new TIS. However, the changes in the selection of environment do not necessarily favour any specific technology. This has been shown in previous research by Finnimore (1989) where the growth of houses from factories was explained by analysing the development of an emerging TIS in the construction industry in the UK.

The growth of an emerging TIS can be categorised by identifying the development phases of the technology, for example the exploration phase, take-off phase and stabilisation phase (Rotmans *et al.* 2001). To unlock the existing practices, it is important that the new TIS develops successfully and takes over the existing practices' system. Thus, what are the factors that explain this successful growth of a specific TIS and how can we trace it?

The determining factors of the successful development, diffusion and implementation of a related technology can be traced from all activities within the innovation systems (Edquist, 2001). These activities are also called as 'System Functions' (Johnson, 2001). This approach was developed by Jacobsson and Johnson (2000), who defined it as "a contribution of a component or a set of components to a system's performance'. Hence, in order to understand how technology is developed, diffused and implemented, the functional pattern of TIS will be described and analysed through time in this study. As indicated by (Edquist, 2001), the study expects that the more the functions are fulfilled, the better the TIS will perform, and therefore the better the development, diffusion and implementation of innovations.

Drawing from the System Functions derived from the literature, the mapping of tentative technological change activities will be presented. It includes only the most relevant activities in the technological change process. By mapping these functions that occur over time, it provides a structure to explain the process of technological change and contributes to understand how the innovation system emerges, changes and could be encouraged appropriately. In this paper, the point of departure is the seven functions identified from the literature review. The following activities will briefly describe each function in Table 1.

The System Functions can be expected to interact with and reinforce each other in multiple ways (i.e. positively or negatively) which will influence the performance of the technology change. Bergek *et al.* (2007) indicates positive System Function fulfilment can lead to virtuous cycles of processes that strengthen each other and lead to the momentum build-up and create a process of creative destruction within the existing system. In contrast, a declining System Function is characterised by one or more vicious cycles when the System Functions interact and reinforce each other in a negative way. Thus, this paper maps the functional patterns in the case of IBS

implementation in Malaysian housing construction to provide insights into how the process of momentum builds-up in this system happens.

Table 1: Set of System Functions

System Functions	Description
Entrepreneurial Activities	This function is measured by using the number of new entrants, diversifying established firms, number of pilot projects, and number of different types of applications
Knowledge Creation and Development	Three typical indicators are used to measure this capability over time; number of training programmes, number of R&D programmes, and investments in R&D and training
Positive External Development	This function needs to capture the strength of these functional dynamics by searching for external economies in the form of political power, pooled labour markets, specialized intermediaries and information knowledge flows
Direction of Search	This function is analysed by using three different sources of information; from the government policies that set targets to use a specific technology, extending new regulatory pressure and tax regimes, and incentives for new technology; from new articles/reports and future development of technologies that indicate the potential growth of emerging technology; from the articulation and perception emerging from the demand side
Market Formation	This function is analysed by number of niche markets out of market size, number of lead users, customer groups and specific incentives that can improve the chances for new specific technology
Resource Mobilisation	This function is analysed by detecting whether or not construction actors perceive access to sufficient resources as problematic, the changes in volume of human resources, and also changes in complementary assets in IBS construction
Legitimisation Mechanisms	This function involves analysis of the interest group's growth that could be expected to engage in the emerging technology that may increase this legitimacy

DATA COLLECTION AND DATA ANALYSIS

In order to map the system functions of IBS development in Malaysian housing from 1963 to 2010, the data was collected from archive data and verified in the interviews. The archive data was mainly taken from publicly available documentation. It included official reports produced by public entities, case studies, press releases, academic reports and information from other sources, such as websites. Later, the interviews were conducted with key actors in the IBS technological system in Malaysia. Respondents are believed to be the most experienced on IBS development and have played an essential role in the effort to bring all the IBS related issues in a framework in Malaysia. Thirty one interviews were conducted with respondents falling into the following categories: government head of department, company director, project manager, architect, engineer, quantity surveyor and researcher.

From the data collected, the data was grouped and stored in the database according to time and the System Functions classification. To build functional patterns, the indicators for each function were similarly weighted. Some of the indicators had positive contributions to the development of the technology while others had negative contributions, such as negative perception of the innovation. Each indicator was counted and distinguished with either positive or negative scores.

RESULTS

From the data collected, the functional fulfilment of IBS development in housing construction in Malaysia from 1963 to 2010 was examined. By analysing the functional pattern of IBS's innovation system, it will explain the IBS development pattern in Malaysia.

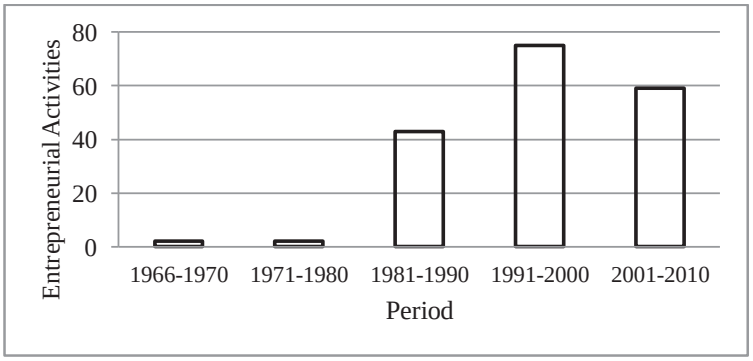

Figure 1: Movement pattern of System Function 1: Entrepreneurial Activities

At the beginning of the period 1964-1975, there were entrepreneurial activities via market formation for IBS housing projects by the Ministry of Local Government and Housing (Figure 1 and Figure 5). These projects were influenced by the direction of search (Figure 4). Later, the inability to achieve the expectation in the direction of search after the completion of the projects had lead to negative perspectives on IBS (Figure 4). Unorganized entrepreneurial activities and lack of support that favour IBS more than the existing system had let down the direction of search. Therefore, there was no correlation between the functions. This failed to lead to the build-up of a virtuous cycle among functions that are needed to propel this emerging method of construction in Malaysia as the functions were not fulfilled.

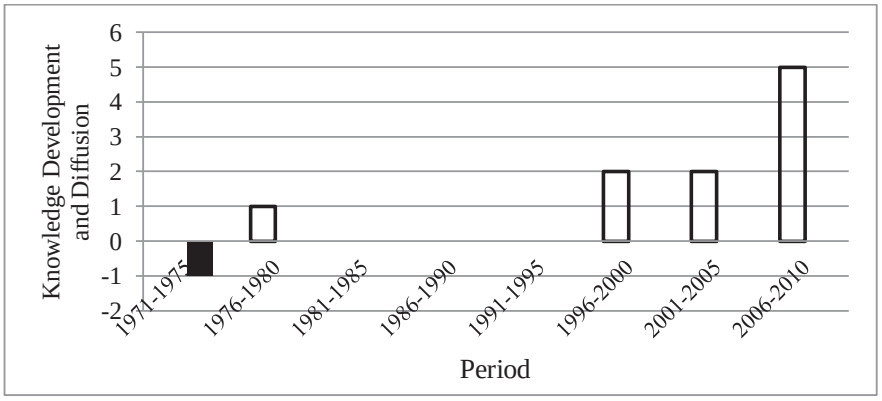

Figure 2: Movement pattern of System Function 2: Knowledge Development and Diffusion

Between 1978 to 1989 the cycle of system function identified started with knowledge development and diffusion activities (Figure 2) and positive externalities development (Figure 3) which later lead to entrepreneurial activities (Figure 1). However, the acceleration of entrepreneurial activity did not take place widely. An explanation for this can be found in the small market formation (Figure 5, i.e. IBS was applied for only low-cost housing projects) and with the limited positive expectation on IBS (Figure 4, i.e. to lower the construction cost). Furthermore, the fixed ceiling price requirement for low-cost housing was too low to be fulfilled by IBS as the technology suffers from a poor price to performance ratio and uncertainties exist in many

dimensions of the system. In conclusion, during this period, there were interactions between the system functions, i.e. direction of search, entrepreneurial activity and knowledge development and diffusion, compared to the earlier period, but the strength of the collective functions was not enough for a breakthrough.

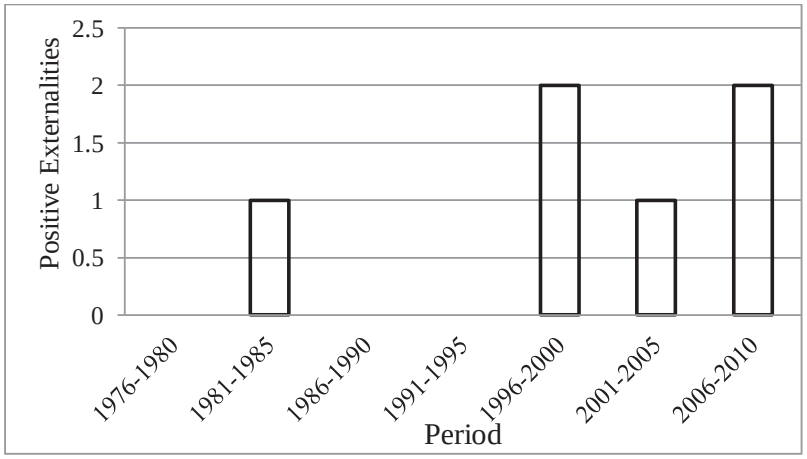

Figure 3: Movement pattern of System Function 3: Positive Externalities Development

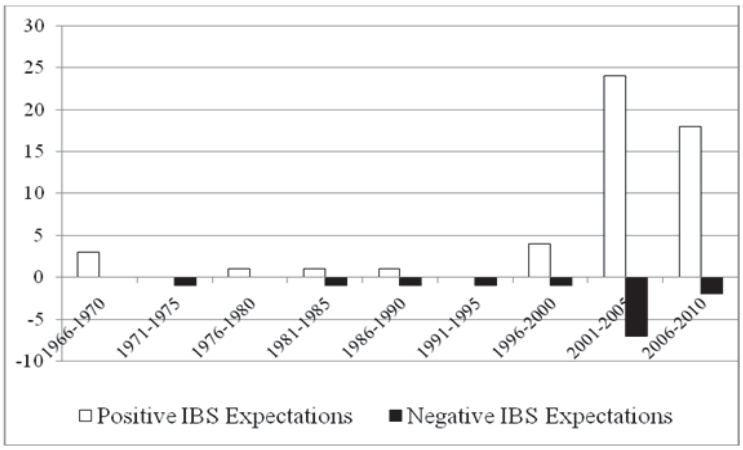

Figure 4: Movement pattern of System Function 4: Direction of Search

In the early 1990s, the entrepreneurial activities were identified. These activities were influenced by the government direction of search to provide houses for every Malaysia and the positive expectations on the IBS. The application of IBS in the construction of sports facilities for the Commonwealth Games in 1998 contributed to positive externalities development (Figure 3) as it gave impact to IBS in housing construction in Malaysia (Figure 1). It also lead to knowledge development and diffusion (Figure 2) where there was interests for research activities related to the production of cheaper building materials and techniques, particularly in IBS. However, the positive IBS development in housing construction in Malaysia was blocked due to the economic downturn at the end of 1990s (Figure 3). To conclude, the negative externality had blocked the dynamics of the other functions such as direction of searching for knowledge development and diffusion, entrepreneurial activities and market formation which favour the IBS development over the existing system during the early of this period.

Figure 5: Movement pattern of System Function 5: Market Formation

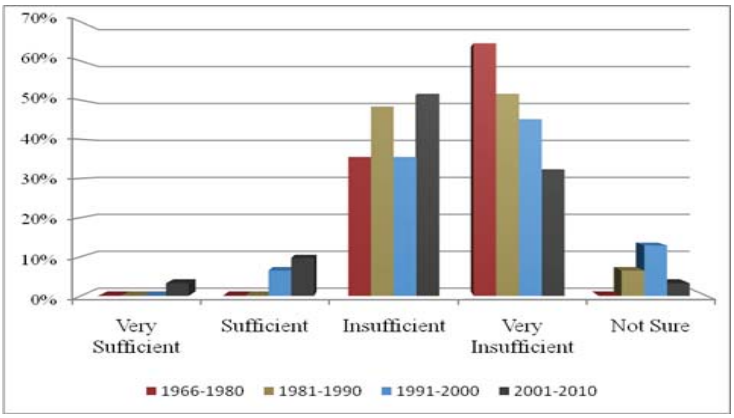

Figure 6: Movement pattern of System Function 6: Resource Mobilisation

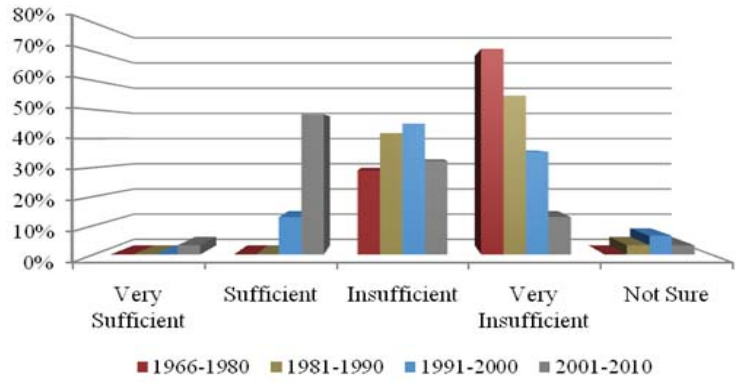

Figure 7: Movement pattern of System Function 7: Legitimisation Mechanisms

Since the beginning of 2000, there has been various functions fulfilment on IBS's innovation system in Malaysia. With the influence from direction of search, the government saw great opportunities to promote IBS in Malaysia (Legitimisation by government). In addition, the knowledge development and diffusion (Figure 2) activities have also strengthened the government decision to adopt IBS in all public projects which are valued above RM10 millions starting from 2008 (Figure 7). It has influenced the entrepreneurial activities (Figure 1) through market formation (Figure 5) for IBS in public projects. However, the lack of resource mobilisation on IBS has affected the entrepreneurial activities and direction of search for IBS to break through the existing practices. In summary, this period can be considered as a more positive period for IBS as compared to other periods. However, the weakness in the technological resources mobilisation has failed to create the dynamic interaction between the overall system functions of IBS in Malaysia.

DISCUSSION

The chronological description of IBS development in Malaysia housing construction can be summarised in the functional patterns which are:

Entrepreneurial activities– a few construction firms, such as contractor, consultant and developers have adopted IBS in their housing projects;

Knowledge development and diffusion – several IBS housing projects and training on IBS which are mostly organised by the public sector;

Positive externalities development – the application of IBS in all public projects;

Direction of search – government R&D funding, positive expectation on IBS market;

Market formation – two pilot projects, allocation of number of IBS houses, all public project, albeit fragmented;

Resource mobilisation – Government projects funding, poor adjustment by the higher educational sector.

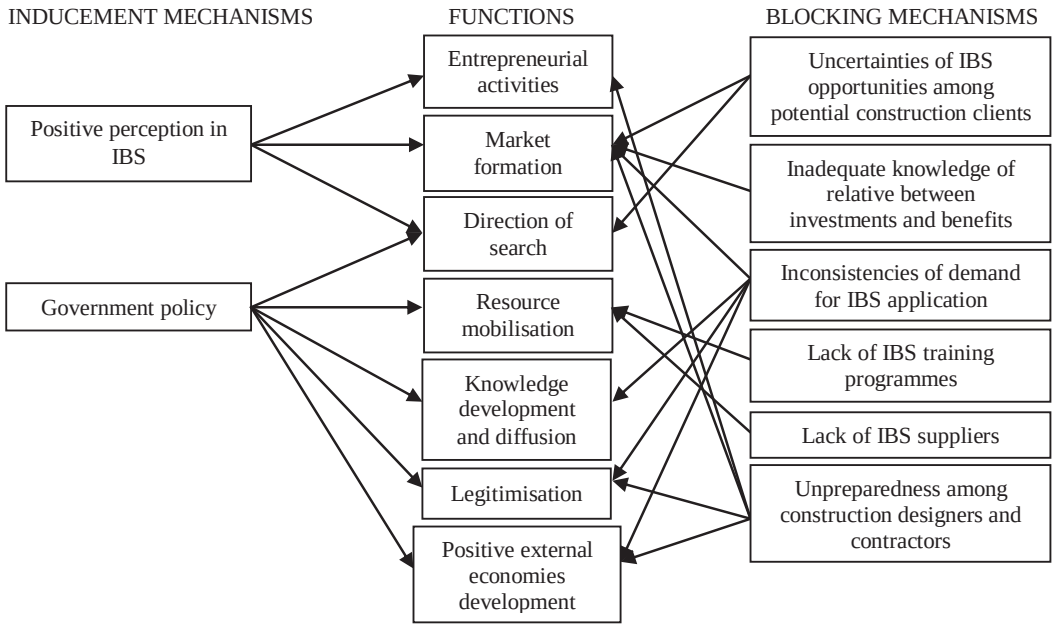

Figure 8: Inducement and blocking mechanisms

Figure 8 indicates that the current functional pattern is shaped by both inducement and blocking mechanisms. There are two significant inducement mechanisms, i.e. positive perception in IBS and government policy. The former is driven by a range of factors, such as IBS in public projects allocation and emerging IBS technological opportunities. This inducement mechanism has influenced the function 'direction of search', 'entrepreneurial activities' and 'positive external economies development'. The latter inducement mechanism strengthens the functional dynamics of 'direction of search', 'resource mobilisation', 'knowledge development and diffusion' and 'legitimisation'. Indirectly, the government policy on IBS has also created market formation and strengthens 'entrepreneurial activities' as a consequence of its positive influence on the system.

The blocking mechanisms are, however, strong and diverse. 'Market formation' is blocked by poor awareness among potential construction clients which leads to inconsistencies of demand for IBS application, unpreparedness among construction designers and contractors, and inadequate knowledge of relative between investments and benefits. Additionally, 'entrepreneurial activities', 'direction of search', 'resource mobilisation', 'negative external economies development' and 'legitimisation', are

each blocked by two mechanisms. These five functions have a common blocking mechanism in the form of a lack of consistencies of IBS demand. This is strengthened by additional but different mechanism in each function.

Some mechanisms block several functions. Moreover, functions are not independent, but rather tend to reinforce each other. A lack of 'market formation' affects negatively on 'entrepreneurial activities', 'direction of search' and 'legitimisation'. This portrays that the impact of blocking mechanisms is magnified by such interdependencies.

CONCLUSIONS

This study investigated the functional patterns of technological innovation system to create insight on the IBS trajectory in Malaysian housing construction. From the findings, the inducement and blocking mechanisms of IBS trajectory in Malaysian housing construction from 1963 to 2010 were identified. The inducement mechanisms identified are: positive perception in IBS and government policy on IBS development. Meanwhile, the blocking mechanisms identified are: uncertainties of IBS opportunities among potential construction clients, inadequate knowledge of ratio between investments and benefits, inconsistencies of demand for IBS application, lack of IBS suppliers, and unpreparedness among construction designers and contractors. Based on this trajectory, the blocking mechanisms identified are stronger vigorous and have decelerated IBS development in Malaysian housing projects. From this paper, the inducement and blocking mechanisms identified in the IBS development could be used as a guide for policy-makers in making better and wiser strategies when dealing with inducing and blocking mechanisms in IBS development. Reducing the strength of the blocking mechanism that have such an extensive effect may lead to a breakthrough for the existing system of construction in Malaysia.

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