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# Improving the Supply Chain of Housing Industrialization from Transaction Costs Perspective: A Literature Review

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## ABSTRACT

Sustainable development has been the focus of all major industries in the world, especially in the construction industry. As one of the sustainable construction modes, housing industrialization (HI) is now absorbing a growing number of attentions that lead the industry to go green. However, the implementation of HI in China is far from satisfactory due to its low economic efficiency. This paper attempts to improve the HI supply chain from a new perspective-transaction costs (TCs). First, it provides an objective understanding of status quo of HI in particular in China. Then, the study outlines the basis of TCs theories and supply chain management theory, compiling literature review of the application of TCs and supply chain management in other fields to states the feasibility of their application in HI area. A theoretical framework is developed to explain the relationships and overlaps among these three areas. Analysis of the state of research in application of TCs in HI supply chain management is expected to help optimized the governance structure of HI supply chain.

**Keywords:** *housing industrialization (HI), supply chain management, transaction costs (TCs)*

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## 1. INTRODUCTION

Nowadays, the sustainable development has been the theme of the world. Building is a resource and labour intensive industry, where takes up 24% of raw materials consumption, and accounting for around 40% of primary energy consumption worldwide (Dong and Ng, 2015, IEA, 2014). It is vital for these aspects to be reformed in order to save energy and resources. There has been much work done in the past to look for optimal solutions to remedy these issues. One of such propositions is to apply industrialization in housing construction. Housing industrialization (HI) is a concept originated from manufacturing industry. As Egan (1998) highlighted, the construction sector necessitates a manufacturing process to be developed within its production which can lead to high performance. With the inspiration of the Egan report, the profile of HI has been increased and its implementation has been significantly expanded both in academia and industry. Many terminologies are associated with HI in the global construction industry. It is often referred to as: 'prefabrication', 'preassembly', 'modularization', and 'offsite fabrication' in the US (Song et al., 2005, Egan, 1998); 'off-site production' in the UK (Pan et al., 2012); 'off-site manufacturing' in Australia (Blismas and Wakefield, 2009); 'prefabrication' in Hong Kong (Jaillon, 2009) and Singapore (Park et al., 2011) and 'industrialized building' in Malaysia (Kamar et al., 2009). In this paper, HI is specifically defined as a business strategy that transforms the traditional construction process into a manufacturing and assembly process in order to reduce cost, time, and improve the quality of the product/ service. This is achieved by engaging people, embracing new technologies, and translating clients' needs into building requirements through new contractual working relationships across the whole supply chain (Nadim and Goulding, 2011).

Over last several decades, HI has been developed as one of the innovative approaches to overcome the traditional site-based construction drawbacks and being widely applied around the world. Today, Japan is the world's largest practitioner of industrialized construction with some companies producing over 70,000 manufactured homes a year (Arif et al., 2012). European countries, such as the UK, Ireland and Scotland, are experiencing a significant boom in industrialized houses. For instance, over 30% of the new homes built today in the UK are prefabricated; in Ireland and Scotland, industrialization rate is projected to rise to nearly 70% in a few years (Blismas and Wakefield, 2009). Leveraging lean management strategies, several Swedish construction companies start to transform their conventional site-based construction workflow into a lean-embedded off-site production and on-site assembly

workflow. Through these measures, the workforce, project design and delivery are envisioned to be benefited from continuous effectiveness and efficiency improvement of HI (Jansson, 2010).

With sustainable development becoming a profound global challenge, exploration has also been made in China to seek for sustainable development goals. The China's National Development and Reform Commission (NDRC), in collaboration with the China's Ministry of Housing and Urban-Rural Development (MHURD) published its Green Building Action Program (2013) with implementation of HI being one of the prominent themes (MOHURD, 2013). This program aims to reform the industrial practices through promoting the application of HI in major cities in China. Driven by the market and policy, HI is increasingly emphasized in China. Nevertheless, it was noted that China had not gained enough momentum to push HI forward due to an incomplete supply chain causing loads of environmental and social problems. HI develops rapid in recent years in China, few research has tried to improve the economic performance from a holistic view. To achieve high benefits and high efficiency within an innovative industry, it is essential that economic aspects are addressed throughout the whole supply chain (Blair et al., 2005). The theory of supply chain management, which takes a systemic view of the production activities of autonomous production units (subcontractors, suppliers in construction, etc.), can help seek for a holistic solution to improve HI (Mao et al., 2013).

Economic efficiency and supply chain management have, in recent years, become two of the most important performance-related issues within the construction industry. This study is an attempt to develop a combined framework, aiming to understand the current state of HI implementation and improve the economic performance of HI supply chain from a Transaction costs (TCs) perspective.

## 2. LITERATURE REVIEW

### 2.1 Transaction costs application in HI

The concept of TCs has a broad range of definitions and empirical evidences (Demsetz, 1968, Barzel, 1985, Allen, 1991, North, 1990). TCs refer generally to costs of trade beyond the materials cost of the product, such as the costs of searching for projects, estimating, project partners, negotiation, monitoring, regulatory approval and dealing with any deviations from contract conditions (Antinori and Sathaye, 2007, Li et al., 2015). In other words, TCs are costs beyond the direct costs (market price times volume) but incurred in making a trade (Antinori and Sathaye, 2007). In the theory of TCs, there are three key constructs that reflect the fundamental representation of it: assets specificity, uncertainty, and governance mechanism (Grover and Malhotra, 2003). In this study, we specifically refer to TCs in terms of risk, time delay, uncertainty, and information searching, setting up costs as well as learning costs. Compared with conventional construction, new procurement processes and extra tasks involved in HI require the support of new rules and institutions, and in turn, cause TCs, which are often invisible.

TCs has been around for nearly seven decades, and it has seen a wide application in various disciplines (Mundaca and Neij, 2006, Grover and Malhotra, 2003). Since HI is essentially a kind of innovative construction mode that combing the process of conventional construction into manufacturing, this study will first summary the TCs-relevant researches in manufacture and construction industry to learn experience (see Table 1).

Research fields	Key findings	Reference
Manufacture industry	Asset specificity is related to lower in-firm transaction costs.	Walker and Poppo (1991)
	Supplier-specific investments are negatively related to perceived buyer dependence.	Sriram et al. (1992)
	Transaction costs are positively related to collaboration propensity.	
	Outsourcing alter the configuration and boundary of an organization and change the economic contribution that an organization makes to the economy.	McCarthy and Anagnostou (2004)
Construction industry	Vertical integration by unconnected firms correlates with better economy performance.	Signorini et al. (2015)
	Factors that affect TCs in construction projects are identified.	Qian (2012) Li et al. (2015)
	TCs to the public sector and the winning bidder vary between countries and sectors, and they are significantly higher in small projects.	Dudkin and Väilä (2005)
	Identifying factors that affect partnership performance using a TC framework.	Jobin (2008)
	Transaction costs in transport PPPs depend on the procurement mechanism used in each case.	Soliño and Gago de Santos (2010)

Table 1: Key studies applying TCs theory in manufacture and construction industry

From the perspective of TCs economics, well-designed institutional structures may lower TCs and provide net social benefits (Levine et al., 1995). Williamson (1985) believed that when the economic organizations have selected the appropriate governance structures, the transaction cost will low down; otherwise they need to pay for higher transaction fee, or even lead to transaction failure. The basic concepts of TCs theory applied to the manufacture industry broadly (Table 1) shows a high correlation with vertical integration in the organization, which is the core concept of supply chain management. Besides, some scholars believe that considerable opportunities within the manufacture industry for evaluating supply chain management issues from the TCs perspective (Grover and Malhotra, 2003). Therefore, TCs can also be applied as a new perspective to unearth the hidden rules in the HI industry to update its supply chain.

## 2.2 Supply chain management in the HI industry

Supply chain management has been introduced during the 1990s, which provides a clear statement that it is a question of a whole chain of organizations (Fredrik Olsson, 2000). According to Cooper et al. (1997), this study defines the supply chain management of HI crossing organizational borders as: Supply chain management of HI is the integration of business processes from original suppliers through end users that provides products, services and information that add value for housing customers.

The theory of supply chain management has been extensively researched and applied in the manufacturing industry. However, the application of it is comparatively new in construction field. Since 1990s, there has been an emerging number of people who have been interested in applying supply chain management theory in project organization. They characterized the deficiencies of it and proposed solutions in order to improve the coordination of the often many subcontractors and suppliers in the construction chain (Segerstedt and Olofsson, 2010). The benefits of supply chain in construction and barriers in its implementation, has been very well documented (Ahmed et al., 2002, Tiwari et al., 2014). It has been found that construction industrial chain management offers new approaches to reduce the costs and increase the reliability and the speed of facility construction.

It has been brought out that although supply chain management for an individual organization is an emerging field of research in the construction management discipline, less attention has been devoted to investigate the nature of the HI supply chains and their organizational economic performance (London and Kenley, 2001).

According to the concept of supply chain defined by Christopher (1999), this paper specifically defines HI supply chain as a set of organizations producing activities. It associated with the flow and transformation of HI from raw materials stage, through upstream and downstream linkages, producing value in the form of products and services in the hands of residents. Here we built a normalized supply chain of HI (Figure 1), which looks across the entire supply chain, rather than just at the next entity or level. It consists of numerous stakeholders, and there are some basic components of HI supply chain: (1) Nodes: they are all stakeholders in the HI industry, such as developer, contractor, supplier and government department. (2) Chain: each chain links several stakeholders and represents transaction behaviour among them. The chain in this study contains three kinds of flow: materials, information and capital. During operation process, this supply chain works in a loop state. The materials recycle plant plays as an important role to make this chain restart, which significantly improve the sustainability of HI.

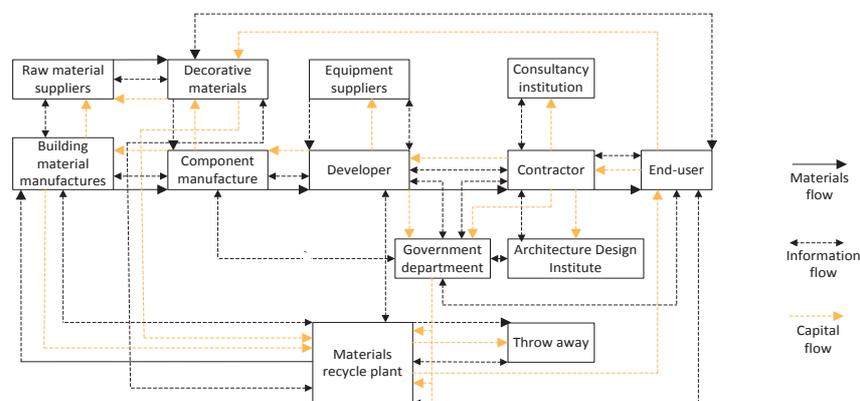


Figure 1: The normalised supply chain of HI (by the authors)

### 2.3 The framework to improve the HI supply chain using TCs

Under the theme of this programme, there are three major theories connected as the research basis, housing industrialization, transaction costs and supply chain management. The research question of this program is in the intersection among the three fields. Although this is quite a vacant field that is worth working on, studies on the supply chain of HI project from TCs perspective is still very limited. To fill this gap, we can first build the theoretical framework (Figure 2) using the overlap area between each two theories as the starting point.

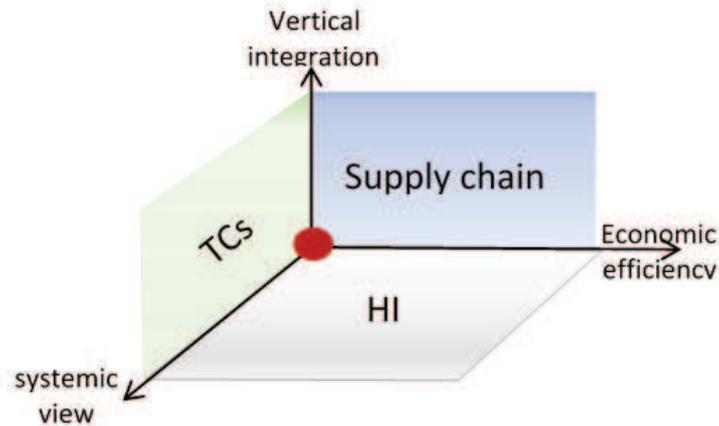


Figure 2: A theoretical framework combining HI, TCs and supply chain management

## 3. DISCUSSIONS

From Figure 2, we could find that there are common topics existing as the link between each two areas:

### HI & supply chain management

HI is a research area that attracted loads of attention recent years. In the transforming period of China's construction industry from conventional construction to industrialization, a systemic view is needed. Supply chain, a vertical integration of constructors, end-users, the government and the market, which can provide a more objective view to achieve global optimization of HI (Mao et al., 2013).

### TCs & supply chain management

Transaction costs are important because they affect the organization of economic activity or "vertical integration". Vertical integration, viewed as a continuum, is exactly the core of supply chain management (Hobbs, 1996). According to the TCs theory, one of the determinants of vertical integration is the nature and level of TCs. A change in the TCs arising from the exchange of a product may lead to a change in the management of that supply chain (Hobbs J E, 1996). Therefore, there is a correlation between TCs and supply chain management (Grover and Malhotra, 2003). Nevertheless, the combined application of TCs and supply chain in HI even the whole construction industry is very limited.

### HI & TCs

Profits are the key motivation to maintain the operation of market, HI is no exception. Most researchers in this area prefer to study on the cost control to help enterprises boost profits in HI implementation. However, the actual cost of a construction project consists not only the production cost. There are also hidden costs, transaction costs (TCs), are often obscure, but they may affect the final decisions (Qian et al., 2015). The transaction paradigm has indeed received considerable attention by academics and has been applied to a variety of construction-related topics including project organization and governance. However, in the field of HI, only a few have given the attention to the importance in regards to the economic efficiency of HI projects. Most studies fail to systematically measure the TCs in the HI supply chain. Such knowledge gap is significant and it relates to the challenges faced by Chinese enterprises in producing more buildings, delivering higher quality, providing better affordability and improved economic efficiency.

#### 4. CONCLUSIONS

TCs is chose in this paper as a new angle to understand and improve the supply chain of HI. It aims to summarize the literature of supply chain management in HI area from TCs perspective to propose a framework. The constructs of TCs and the feasibility of its application in both manufacture and construction industry is introduced. TCs is emphasised to evaluate HI supply chain integration mechanisms for the efficiency of the project economic performance. The results are expected to build a framework for scholars and managers who are working in HI field to rethink about the direction of this industry. This study also goes further exploring the key links where redundant TCs occurred on HI supply chain, which provides a guidance of HI supply chain optimization. The need to meet customers' needs and create value while organizing HI supply chain in high level will provide challenges and opportunities, so issues discussed here will remain on the agenda.

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