

# Improving affordable housing delivery through the reduction of rework in the supply chain

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## Abstract

The housing sector has been experiencing inadequate supply which is exacerbated by a strong growth in demand. Several factors have contributed to the shortage of affordable housing including lack of investment from the public and private sectors, market prices, financial volatility and economic fluctuations, land and regulatory regime. The cost of production also affected the quantity of affordable housing. The aim of this study is to explore the causes of rework and the application of lean thinking as an alternative approach to minimise the cost of production necessary to increase both the quantity and quality of affordable housing. A qualitative research approach based on semi-structured interviews with experts in the housing construction industry is adopted to investigate the root causes and barriers to eliminating rework within the entire housing supply chain. Preliminary findings suggest that housing can benefit significantly from lean thinking and the exponential growth of technologies applied in other sectors, particularly in manufacturing to increase the production and quality of affordable housing units. Reduction of rework through improved managerial practices and communication can significantly reduce project time and cost overruns. Collaboration with a support of new technologies between various contributors and stakeholders in the entire housing supply chain can significantly reduce the production cost through innovation and adaptation of lean thinking and innovative strategies to eliminate rework within the entire housing supply chain.

*Keywords: Affordable housing, Supply and Demand, housing supply chain, Elimination of Rework.*

## 1. Introduction

UK housing market has been experiencing inadequate housing supply and a strong growth in demand for the past few decades. A report authored by Pennington et al. (2012) in the Institute for Public Policy Research (IPPR), projected that by 2020 England alone will face a shortage of housing around 750,000 units. A problem which will have an adverse effect particularly on young generation and other low-income groups, who are experiencing difficulties to get into the housing ladder. In the general election of 2015 and 2017 respectively, the main political parties pledged to address affordable housing— and recently, Prime Minister, Theresa May proposed several new programmes and approaches to address the unaffordability of housing (May, 2018). There is a plethora of research on the precise definition of affordable housing. For example, the Department of Environment (1977) has defined affordable housing as “a decent home for all families at a price within their means”. The Mayor of London defined affordable housing as “social rented, affordable rented, and intermediate housing, provided to eligible households whose needs are not met by the market with eligibility determined based on local incomes and local house prices” (Greater London Authority, 2017). Local authorities have played a significant role in building affordable housing since the 1920s. From 1950 to 1980, around 150,000 dwellings were built per annum by local authorities in comparison to housing associations, which only built 14,000 (Chandler and Disney, 2014).

Several factors have contributed to the shortage of housing, and particularly affordable housing. Such factors include lack of investment from the public and private sectors, market prices, financial volatility and economic fluctuations, land and regulatory regime, and special schemes such as ‘Help to Buy’ and ‘New Homes Bonus’. However, the underlying problem is mainly related to the supply of housing (Barker, 2004; Bramley and Leishman 2005; Cladera and Johnsson, 2013; and Hilber, 2015 and Anacker, 2019). Investment and housing prices are key factors afflicting the supply of affordable housing. Since the 1990s, and particularly after the 2008 financial crisis

investment in housing stock has accelerated, where many people's capital has plunged as a result of inflation (Cheshire, 2014). This has led people to invest in housing stock as a preferred secure long-term investment. Housing constitute a large portion of household wealth, fluctuations in house prices can have a significant impact on private consumption through a wealth and a liquidity effect (Andre, 2010). Lower mortgage rates also played an important role to higher housing price in the UK. In 2011, 65% of total circulated money in the economy was invested in housing market, with only 20% of that invested in financial institutions, and 15% into the rest of the economy (Andre, 2010 and Cheshire, 2014). This resulted in rising house prices and created problems of affordability among households. Furthermore, housing has always been vulnerable to financial volatility and economic fluctuations and a combination of these factors with the shortage of housing supply over a time has led to the increase of housing prices with significant negative impact on the level of affordability. The Office National Statistics (ONS) noted in 2018 that house price is 7.8 times annual workplace-based earnings on average.

'Help to Buy' initiative in 2010, led number of local authority new build schemes declined to 1,500 per year in England (Wilcox and Perry, 2014). Wilcox et al. (2015) suggested housing demand from the 'Help to Buy' scheme was announced in March 2013 to help first-time home buyers to minimise the required deposit for buying new properties. There is an argument insufficient supply and surging demand can drive housing prices up to 25% and create a bubble in the housing market (Hilber, 2015). International Monetary Fund (IMF) argued that "this measure may temporarily boost confidence in the housing market, but there is a risk that, in the absence of an adequate supply response, the result would ultimately be significant increases in house prices that would work against the aim of boosting access to affordable housing. Land and regulatory regimes also affect the supply of housing. To mitigate this risk and stimulate a supply response, the government considered various fiscal disincentives for holding land without development" (Oxlade, 2013; Anacker, 2019).

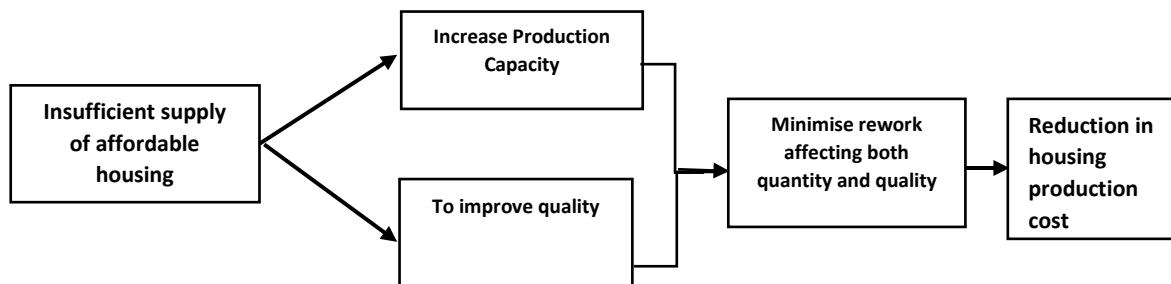
In 2011, the government introduced 'New Homes Bonus' strategy to encourage local authorities to grant planning permissions for the building of new housing in return for extra revenue (Wilson, 2015). However, The National Audit Office (NAO) stated that 'little evidence that the Bonus had not made significant impact to local authorities' behaviour to increase the supply of housing' (NAO, 2013).

The cost of production also affected the production of affordable housing due to highly fragmentation of the housing supply chain resulting in significant occurrence of rework. Housing supply chain plays a critical role to deliver a successful affordable housing unit.

Housing has a certain peculiarity and uniqueness such as temporary organisation, the heterogeneous nature of housing supply chain, the length of the production cycle and, an uncertainty around housing market, has contributed to higher production costs. However, housing supply chain has often been criticised for being wasteful, having low productivity, poor quality and high risk with a very tiny profit margins (Egan 1998; Rooke et al., 2004; Zeng et al., 2007; Pan et al., 2008; Fulford and Standing, 2014; Arashpour et al., 2014). Addressing these challenges, can significantly reduce the cost of producing housing units and increase the production level of affordable housing across the UK.

However, reduction of rework has not been a dominant strategy with regard to improving productivity in the construction industry (Bolviken and Koskela, 2016). The elimination of rework is a key driver for improvement in manufacturing such as automobile production. However, despite the great achievement, it has not been prevalent in housing construction practices (Koskela et al., 2012). One way to address the inefficient cost of production in housing is to eliminate rework within the entire housing supply chain. Rework has a direct effect on both the cost and schedule of projects. For example, the cost of rework has been projected to almost 12% of the contract value. Love and Edwards (2004) argued that elimination of rework can prevent projects from higher cost of rework and result in significant reduction of total cost of projects ranging from 3% to 15% of a projects contract value (Shahparvari and Fong, 2018).

The research focus on eliminating rework in the housing supply chain to reduce its impact on the cost of housing production. The aim of this study is to explore the causes of rework to minimising the cost of production which can contribute to improve the quantity of affordable housing. The flowchart in Figure 1 schematically illustrates the focus of this research.



*Fig. 1. The focus of the current research*

## 2. Literature Review

There is a considerable shortfall in the number of dwelling available in the UK which puts house builders under pressure to deliver upward 200,000 housing units a year to meet increasing demand (Holmans 2013, Hopkin 2016; Hashemi, 2017). In the last 8 years, an average of 134,000 houses was built per annum. However, the supply of houses has been declining since 2007 from 188,450 to 114,670 (Hopkin, 2016; NHBC 2011). According to ONS (Office for National Statistics), housing demand is projected to grow by each year due to population increase, demographic changes while the supply has been performing quite poorly (RTPI, 2013). In addition, house prices in the UK have increased at a fast rate since the 1980s (RTPI, 2013). About three quarters (77%) of people in the UK felt that it is harder for them to rent or to buy than for previous generations and 90% felt it will be harder still for the next generation. The experience of the last two decades suggests that the level of demand for new houses over the next 10 years will not be met by piecemeal incremental developments (RTPI, 2013). The UK faces a serious challenge in providing affordable houses that is needed now and in the near future. A fundamental shift and innovative ideas towards affordable and quality dwellings is essential in meeting this challenge (Rodionova 2016; Kollewe, 2017).

### 2.1 Planning and Regulations

Governments have different type of mechanisms for intervention in housing supply. Planning restriction has been a major obstacle for developers. Bramley (1992) identified that planning has caused housing price to increase, and creates barriers for households to put their feed on the housing ladder. Several authors such as Evans (1991); Cheshire and Sheppard, (2003) and Glasser et al., (2008) argued that the overall restriction of land supply regulation will lead to higher prices and densities as a result of growth controls and general planning restriction. Whitehead and Williams (2011) discussed that number of proposed planning have been abandoned as a consequence of the removal of output targets for local authorities. They also noted the implications of global economic uncertainties on the number of housing starts together with the change in the national planning policy framework and approaching towards localised community planning control regime. The Barker Review pinpointed planning as the primary cause of housing supply (Baker, 2004). Since 2003, housing policy changed the trajectory of its emphasis to housing supply and affordability issues as encapsulated in the Barker review. Despite the government approval of the proposed plan, it has not been addressed the supply and affordability of housing. Setting regulations is one of the ways that governments can control housing supply. This can set the limitations of action to private companies and individuals and can institutionalise social practice in the housing market. An example of such practice includes the regulations set for the private rented sector that can control rents, constrain the activities of letting agents and provide securities tenure to tenants (Campbell et al., 2000; Clapham, 2015;2018). The inherent pressure of housing supply, including the multiplicity of government objectives with an increase of local political tensions, have made regulatory systems complex and uncertain. However, regulatory systems can be used to support the provision of affordable housing by shifting away from public sector ownership and allocation towards more market-based systems (Whitehead, 2007).

The impact of housing policies may differ between individuals and groups. For instance, a policy may provide financial support to house builder and increase their profits, but it may not result in more houses being built, and so may not be a help for those who are willing to purchase a house. Some policies may lead to an increase in the price of existing houses, which helps those already living in, but may hinder those who are looking to buy (Clapham, 2018). Housing supply has been a ‘prominent part of the devolution story’ and a site of much policy innovation in the UK context (Gibb, 2015). Chancellor Gordon Brown in 2003, tried to understand UK housing supply by setting up two enquires; one into housing finance and the other one into housing supply, with emphasis on the role of planning system.

## **2.2 Cost of rework in housing production**

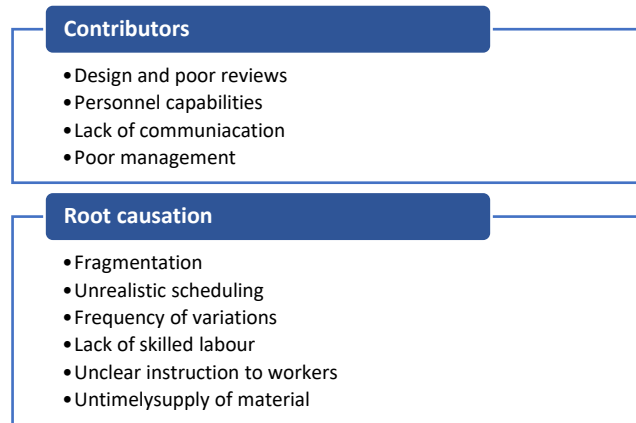
The cost of production in housing supply chain can affect the quantity of housing produced and this could be seen as a result of both cost and time overrun of housing projects. Housing construction is one of the major sectors worldwide that is commonly recognised as having high level of ‘rework’ (Aziz and Hafez, 2013) which has a direct impact on the cost of production. However, reduction of rework has not been a dominant strategy with regards to improving the productivity of housing. The elimination of rework is a key driver for improvement in manufacturing industries such as automobile manufacturing. However, despite this great achievement, it has not been prevalent in housing production (Koskela et al., 2012). The problem of poor supply and production cost has been successfully tackled by automobile manufacturing industries. The industrialized housing can be compared with automobile manufacturing regarding similarities existing in their production strategies, as suggested by Gann (1996), Barlow et al. (2003) and Woudhuysen and Abely (2004). Its distinctive features, including controllable production flow, high production volume (in the case of mass housing production) and large inventory of work in process, which makes industrialised housing favourable for the housing supply chain (Yu et al., 2009).

A study by Love (2002) suggested that, cost increase of housing production and schedule overrun have a direct correlation with costs of rework, which has an adverse impact on overall cost of production (Palaneeswaran et al., 2007). Josephson and Hammarlund (1999) projected the costs of rework on housing, industrial and commercial building projects, on average around 2% to 6% of the contract value. Love and Ki and Li (2000) noted the direct cost of rework as an average of 3.15% of the contract value in housing projects. Another study conducted by Oyewobi et al. (2011) noted that rework cost is estimated to be almost 5% of the completion cost of new built housing and, 2.3% of the completion cost of refurbished buildings. Love and Edwards (2004) showed that earlier engagement and practices to avoid rework can result in reduction of cost production with savings of between 3% and 15% of a projects contract value. Barber et al. (2000) also noted that rework can escalate the cost of production to as high as 23% of a contract value (Shahparvari and Fong, 2018).

## **2.3 Causes of Rework in housing production**

Rework is a chronic issue in housing and, often times have a negative impact on the cost of production, and finished products (Love et al., 2009;2010;2015; Wanberg et al., 2013). According to Love et al. (2010) rework contributes almost up to 52% of increases in costs and around 22% of time overrun (Love 2002). However, data on rework are usually hard to obtain, and lack of precise interpretation and definition of rework have led vague data collection and quantification in housing supply chain (Love and Smith 2003; Young and Yip 2010). Love et al., (1999); and several other authors such as Josephson et al., (2004); Love and Edwards (2004); Palaneesaran et al., (2008) and Ye et al., (2014) suggested that managerial aspects are the most significant factor causing rework. Client’s change requirement leads to design error and is considered to have a relatively greater cost impact compared to other factors (Hwang et al., 2009; 2014; Love and Edwards 2013).

Based on a comprehensive review of literature, Fayek et al. (2004); Mossman, (2009); Love et al., (2010); and Arashpour et al., 2014) identified the contributors and root causes of rework as shown in Fig. 2.



*Fig.2 Root causes of rework and contributors*

The level of rework generated in projects is inevitably influenced by the attitude of key players (Faniran and Caban 1998). As client set the standards of quality to which the project team must comply, it has been argued that clients normally have the greatest influence over minimisation of rework. However, efforts for elimination of rework will not be successful if those downstream the supply chain do not buy into strategies for effective reduction of rework (Dainty and Brooke, 2004). The fragmented nature of the construction industry is seen as a significant barrier to embed the culture of minimising rework to improve the cost of production in housing supply chain.

#### **2.4 Fragmentation of the UK housing supply chain**

The housing sector comprise of a large supply chain characterised by highly fragmented activities (Shahparvari and Fong, 2018). Harris (2013) identified that for a typical large housing project (within a range of £20 to £25 million) the main contractor is usually engaged directly in managing around 70 different subcontracts. This illustrates the scale of fragmentation in housing supply chain and the need for integration of small medium enterprise (SMEs) in housing supply chain (Shahparvari and Fong, 2018). In fact, subcontractor's employ ratios are fewer than 5 people in each entity often with insufficient resources to invest into new technologies, education and training.

UK housing supply chain has often been criticised for poor quality of its products (Pan et al., 2008). While other countries such as Germany have had significant progress in producing large scale green buildings and zero carbon emission buildings, the UK is struggling to deploy sustainable and energy efficient practices in housing projects (Gröndahl and Gates, 2010). Almost in all industries, supply chain plays a significant role to deliver a product, and that is critical particularly in housing sector. Housing has a certain peculiarity such as the temporary organisation of teams in the supply chain. Almost on every project between 70% to 90% of construction work is subcontracted to small and specialist firms. Up to 90% of the construction work by value is distributed between different subcontractors with less attention paid to the nature of the supply chain (Dainty et al., 2001; Karim et al., 2006). In housing projects, client plays the most crucial role in achieving integration of supply chain (Brisco et al., 2004). For instance, in infrastructure development projects, clients are service providers to the public with great influence over a project and are able to exercise considerable change upon the supply chain.

#### **2.4 Philosophy of Lean Thinking in housing industry**

In early 1990s Toyota developed a systematic method entitled 'lean' for minimization of waste in their manufacturing system to improve the productivity and quality of their products (Koskela 1992). Lean implementation emphasizes the importance of optimizing work flow through strategic operational procedures while minimizing waste and being adaptable. The 'Lean' concept has been transferred to the construction industry from manufacturing principles, first by Koskela 1992. He termed the concept as 'Lean Construction (LC)'. Lean thinking aims to increase value at every stage of the production process. Although the construction industry is very different from manufacturing, industrialized housing construction, as a unique sector in construction, provides the closest analogy to automobile production (Winch 2003). Manufactured housing can be compared

with automobile manufacturing regarding similarities existing in their production strategies, as suggested by Gann (1996), Barlow et al. (2003) and Woudhuysen and Abely (2004). Its distinctive features, including controllable production flow, high production volume (in the case of mass housing production) and large inventory of work in process, make the application of lean thinking favourable for the housing supply chain (Yu et al. 2009).

After introducing the lean concept to the construction industry, there were many attempts and practices to implement Lean Construction (LC) across the industry to eliminate 'wastes' and add 'values' to projects. There was an indication from Lean Institute UK that lean operation in construction can really revolutionise construction to build more affordable housing units with high quality. Ogunbiyi et al (2013) highlighted several benefits associated with implementation of lean construction in their study on UK construction industry. They showed that benefits such as improved corporate image and sustainable competitive advantage, improved process flow and productivity, improvement in environmental quality and increased compliance with customer's expectations can be achieved following integration of principles of lean construction within construction industry. Their study also identified several areas of linkage between lean and sustainability such as waste reduction, environmental management, value maximisation, and health and safety improvement among others. However, during the last two decades, there has been lack of clarity within the construction sector surrounding the concept of lean construction. The majority of the industry has failed to implement LC, and despite some great achievements, it has not been as prevalent in construction practice and literature (Koskela et al. 2012, Bolviken and Koskela, 2016).

Salem et al (2006) compared manufacturing and construction housing to find out why lean production theories and practices do not fully fit the construction industry. They highlighted three main features of construction industry which distinguish it from manufacturing: Onsite production, one-of-a-kind projects, and complexity. However, they concluded that, although many lean construction tools and elements are still in an embryonic state, lean construction techniques are gaining popularity because they can affect the bottom line of projects. More specifically, Mossman (2009) mentioned that one of the main reasons why lean thinking has not been successfully implemented in the UK, is fragmentation. Sub-contracting and fragmentation in housing means that there is little motivation for project teams to learn together as it is highly unlikely that they will work together again. Subcontracting strategies are widely used by many companies in the construction industry to reduce some activities in the construction process, to eliminate part of the costs with welfare taxes and to reduce costs due to competitiveness among construction companies (Ohnuma et al., 2000). However, fragmentation in construction industry can work as a barrier for LC deployment (Mossman 2009). There have been attempts by some clients to create opportunities of lean implementation for SMEs as subcontractors through partnering agreements, but these generally only involve the major players (Mossman 2009). To conduct a LC deployment research beyond some specific LC techniques, Texel et al. (2017) suggested taking the entire supply chain into account as well as sector context and project governance structure.

Housing supply chain has a tendency to generate immense of data to share information with other players in site, which contribute to multitude of barriers and challenges such as design errors and mistakes, document control, poor communication and scheduling, and result in high cost of production. As a result of rework, productivity and cost of production in housing supply chain has been affected. Automation in construction supply chain with novel technological innovation such as manufactured housing has a potential to improve housing productivity and change the trajectory of traditional way of onsite production.

### **3. Research Method**

A two-stage approach was selected to address the research issues as part of an on-going research project. First, a literature review was conducted focusing on the problems of inadequate supply of housing, nature of rework and associated cost on housing production; causes of rework, and the application of lean thinking and technologies to eliminate rework from entire housing supply chain. Second, a qualitative approach was adopted using semi-structured interviews to explore the root causes of rework in housing supply chain. In-depth interviews were conducted with two experts in construction housing projects. The first participant has been working for 10 years in housing development projects as a construction project manager. He is currently working on a project valued at £5 million, comprise of 5 flats. The second participant works as a site engineer with 7 years' experience. He is

currently working on a project that valued more than £200 million, consisting of 700 housing units located in central London.

### **3.1 Preliminary findings and discussion**

The preliminary findings from the research are summarised as follows:

#### **3.1.1 Managerial Issues among stakeholders**

Managerial aspects are one of the key factors leading to rework in the housing supply chain. Early engagement of stakeholders in projects can improve the decision-making process and eliminate bias from misinterpretation of exchanged data. This can result in less change as project continue to progress forward. Often times lack of sufficient experience, precise information of design and construction procedure leads to rework that causes project time and cost overrun. One of experts identified that *“Management set-up is key for success of delivering project from both clients’ and contractors’ perspective, which requires a strong communication and collaboration for the progress of projects”*. Also, the expert noted that *“Informed decision-making among stakeholders are crucial to the progress of projects”*.

#### **3.1.2 Lack of communication**

Communication exchange among different actors from early stage of construction process increase the awareness of each undertaken tasks. This can help to reduce design and production errors that affecting time and cost overrun in projects, and enhance the learning process to overcome some of the negative culture of the housing industry. One of the experts argue that: *“lack of communication among different actors from design team to subcontractors often leads to unintended changes and rework, which requires a lot of new resources and materials, sometimes finding new supplier with the need for new materials that often leads projects ‘to overrun”*.

#### **3.1.3 Lack of co-ordination and collaboration**

Poor coordination between various contributors are one of the main obstacles for elimination of rework in practice. The experts interviewed believe that efficient coordination among subcontractors is indispensable in eliminating rework within entire housing supply chain. Trust and transparency are the bedrock to collaboration where stakeholders’ express different concerns and disparity in perceptions. This could increase the transparency in construction site effortlessly improve the collaboration. Collaboration is a key factor in reducing rework. As one of the experts noted *“often times subcontractors view contractors as their client than part of a chain. Means that subcontractors usually try to keep the cost down to maximise their profit, result in defects which sometimes are not detected until some later stage resulting in multiple cost – this usually affects the level of collaboration among different actors who are working in construction site”*.

#### **3.1.4 Lack of innovative approach**

The productivity improvement in housing industry has lagged compared to those in other industries. The culture of resistance to change has been identified as one of the crucial factors affecting the adoption of new technologies and innovative strategies to improve the overall cost of production through minimisation of rework in housing supply chain. One of the reasons for apparent sluggish innovation in housing supply chain is limited access to finance among small medium enterprise (SMEs).

One of the experts discussed that *“Record of data and information is still based on hard copies for weekly update – where some part of information sometimes gets lost or forgotten to comply as a lack of collaboration”*. Another expert also stated that *“although sometimes Building Information Modelling (BIM) is employed in construction site, some contributors particularly subcontractors still prefer co-ordinate on hardcopies, because of cultural resistance to change in construction and lack of resources to invest in”*.

Digitisation has a potential to facilitate continuous improvement of workflow in manufacturing process and that can be implemented extensively in housing supply chain to eliminate rework. Emerging technologies such as

Artificial Intelligence (AI), Robotics and manufactured housing could minimise errors that are caused by humans in highly pressured and complex design and construction environment.

#### 4. Conclusion

Issues around housing supply has always been a concern for the UK government to address the affordability of housing. Strategies and policies proposed to make housing more affordable. However, none of proposed strategies appear to be transformative in tackling the supply side of affordable housing in the long term. The proposed perspective of addressing the issue by reducing rework within housing supply chain, supported by appropriate use of emerging technologies, should improve the robustness and timeliness of affordable housing production, as well as ensuring value in its delivery.

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