EXPLORING THE AUSTRALIAN HOUSE COMPLETION TIME TO IMPROVE HOUSING SUPPLY

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ABSTRACT

The housing undersupply is a current issue in many capital cities in Australia. The relevant statistics to the housing shortage has been reported by the Australian government and housing industry associations. The gaps between demand and supply continuously have increased over the past years. Many factors contribute to the shortage of the Australian housing supply. One of the key factors is the house completion time. To overcome the shortage situation, it is significant to know how completion time can be improved. The completion time guarantees the time of housing delivery to house customers. In this paper, Little's law is used to discuss the physics of the Australian house building. Additionally, capacity and sales and operations planning strategies are the focal aspects to improve the Australian house completion time.

KEYWORDS

Australian house building, house completion time, Little's law, capacity strategies

INTRODUCTION

The Australian residential sector consists of many independent building organisations to construct separate houses, semi-detached houses, townhouses, flats, units and apartments (NHSC 2013). The total values of work commenced in residential building are likely to be less responsive to the growth of other construction activities (ABS 2012). This situation could be influenced by housing supply and demand factors. The housing supply has been found in a shortage to serve the housing demand (NHSC 2012). The previous studies mainly focused on housing demand and affordability rather than housing supply challenges (Liu and London 2011). This paper, therefore, addresses the undersupply of Australian housing from the housing supply perspective. The paper presents a possible relationship between the house completion time and the housing delivery by using Little's Law.

The house completion time is a key factor influence housing supply. It indicates time required to deliver a house to a house customer. The paper additionally provides possible guidelines to improve housing supply situation in Australia through an understanding of capacity management. It involves the adjustment of an

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organisational capacity toward changes in customers demand. Capacity management is related to the sales and operations planning (S&OP) that concerns on utilising the available capacity relative to demand (Olhager and Johansson 2012). S&OP relates the production level to the demand level at different planning horizons. Accordingly, the production plan is based on the sales plan (forecasted demand). Then, the plan is translated into capacity requirements in terms of the total resources. It is acknowledged that increasing the construction capacity contributes to the growth of construction organisation. Developing the construction capacity includes using modern methods of construction such as off-site manufacturing (OSM) (Blismas and Wakefield 2009). Increasing the capacity requires supportive organisational policies in human resources development such as training and incentives, and quality control techniques.

A REVIEW ON AUSTRALIAN HOUSING SUPPLY AND DEMAND

Australian Government and housing alliances recognised that supply of new houses is inadequate especially in the state's capital cities (COAG 2012; NHSC 2013). A report on housing supply produced by NHSC (2012) indicates the gaps between the underlying assumptions of demand and supply in housing from the year 2011-2031 ranging from low, medium, and high growth scenarios as presented in Figure 1.

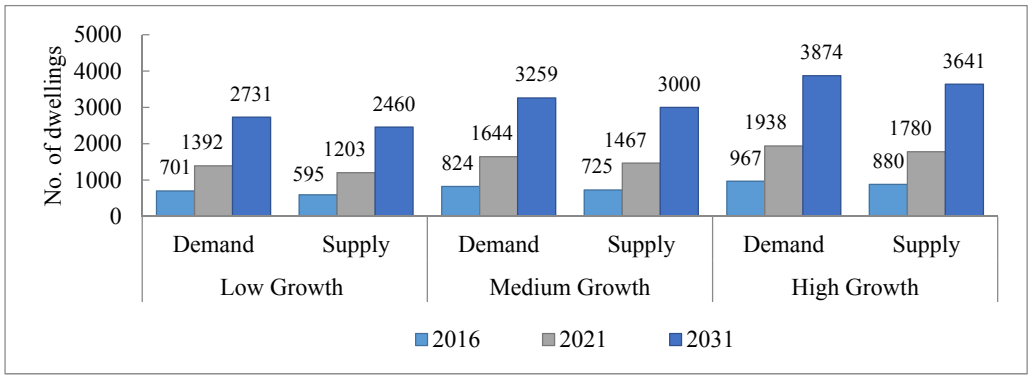

Figure 1: Projected Australian housing demand and supply (in'000 units).

It can be seen from the demonstrated figure that all scenarios show the continuing gaps between the housing demand and supply from 2016 to 2031. The Australian housing undersupply is caused by both housing supply- and demand-related factors. The housing supply factors generally include but not limited to, house price, house completion time, and house customisation. The house price refers to construction material and labour costs, and land price (Liu and London 2011). The house completion time is a key factor indicating the period required to deliver a house to a house customer. There is an increase in the average Australian house completion time reported, while the production rate has found to be relatively stable (Gharaie et al. 2010). On the demand-side, the Australian housing is influenced by other factors such demographic and house customer preferences.

RESEARCH METHODOLOGY

The research aims to explore the Australian housing supply shortage in the context of lengthening house completion time. A review of background studies was conducted

through exploring the opened online databases. The databases include Emerald, Elsevier, Taylor and Francis, Google Scholar and book publications. Moreover, some published reports from Australian government and housing industry alliances were searched. This includes Housing Industry Association (HIA), National Housing Supply Council (NHSC), Coalition of Australian Government (COAG), Department of Education, Employment and Workplace Relations (DEEWR) and Australian Bureau of Statistics (ABS). Data collection from the databases focused on the initiatives employed to explain the housing shortage situation in Australia. The research processes are as follows:

- **Stage 1:** Screening the collected data for house customisation, construction method, skilled labour shortage, number of houses under construction, and coordination between stakeholders.
- **Stage 2:** Applying the Little's law to the categorised data to understand the house building process.
- **Stage 3:** Explaining the capacity management using the Little's law in house completion time context.
- **Stage4:** Developing capacity and S&OP strategies for house building in the Australian context.

AUSTRALIAN AVERAGE HOUSE COMPLETION TIME

The house completion time can be defined as the time period between the first and last physical building activities to produce a house and make it ready for occupation. The house completion time is a major factor indicating the quality of housing delivery to house buyers. Figure 2 illustrates the average completion times of new houses in Australian states, territories, and national level. Using 1995 to 2000 as a base line, all states and territories except Tasmania experienced increased house completion time during the years from 2000 to 2010 (ABS 2012).

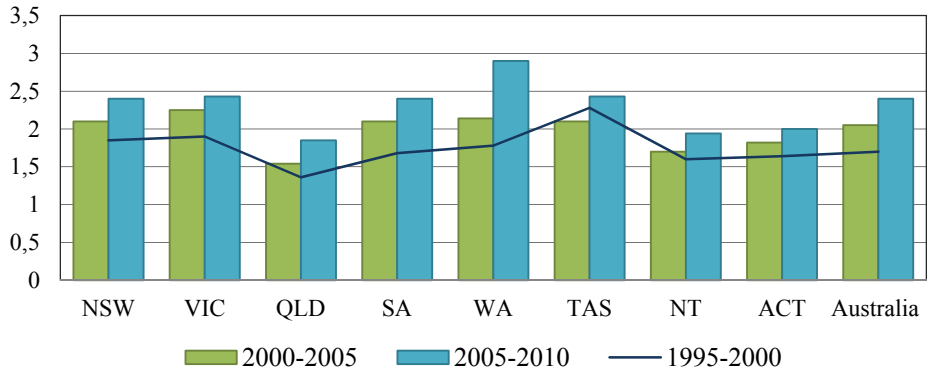

Figure 2: Average completion time of new houses, States, Territories and Australia.

The house completion time is a key factor affecting the housing supply (Gharaie et al. 2010). Nevertheless, their study has not illustrated other related factors to the house completion time. This paper contains an expanded view of factors contributing to time spent in delivering houses. The related factors to the housing capacity and demand are shown in Figure 3. Excess completion time is known to a project

manager as one of the factors that contributes to project delay or even project failure (Nawi et al. 2012). The delay does not impact only on time spending to finish a project, but also on additional costs to complete the project. Therefore, the relationships between completion time, scope, cost and quality in house building can be demonstrated by using quadruple constraint adapted from a fundamental project management as integrated into Figure 3.

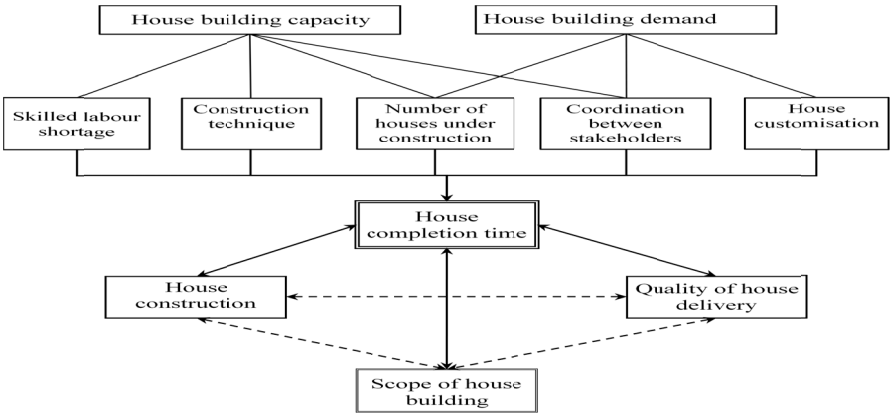

Figure 3: Quadruple constraints of house building.

HOUSE CUSTOMIZATION

House customization refers to design and build a house to suit the customer requirements. Chang and Lee (2004) identified that ambiguous demand from customers is one of the main issues in any construction project. Any change in the house customer demand requires time from the house builder to respond. Therefore, dynamic changes of house customer demand expand the house completion time. The house customer preferences may vary from person to person based on the residential desirability and acceptability. The preferences are influenced by some factors including household income, family size, and cultural background. It includes the design, quality and location of the house (NHSC 2013). The house design is a main factor which includes the size, type, internal and external design of the house. The average floor area of the Australian dwellings has been increased from 162.4 square meters to 248.0 square meters from 1984 to 2009 (HIA 2011). A mass customization strategy is suggested as a solution to reduce the impact of customization variation (Barlow and Ozaki 2005). This strategy, in turn, could help to reduce the excess completion time.

CONSTRUCTION TECHNIQUE (METHOD)

Some builders are anticipating the potentials of using cheaper materials to deliver more affordable dwellings (NHSC 2012). Those builders were buying housing materials from overseas, although there were challenges noted in establishing regular supply chains. Other builders remain a sense of national loyalty to organization that source house materials locally. On the other hand, other builders are looking for employing new house building materials and new construction methods. One example of new material is using light-weight bricks in preference to traditional clay bricks. A new method is such as employing off-site manufacturing (OSM) with pre-

cast concrete walls and building façades (NHSC 2013). OSM is an innovative construction method that has the capabilities to improve the performance of the Australian house building (Blismas and Wakefield 2009).

SKILLED LABOR SHORTAGE

The house building is labour intensive industry with its main product of new dwellings or renovated dwellings. The skilled labour is an important element for a house building organisation. The skilled labours are considered as enablers for an organisation to work in the competitive environment and overcome any challenges. The challenges include new working relationships such as partnering and virtual enterprise. The challenges are also include changing the construction technologies and adopting modern methods of construction. According to DEEWR (2012), there are shortages in some construction occupations such as roof tiller, glazier, plumbers and cabinetmaker from 2008 to 2012. The skills shortages contribute to the undersupply of housing (NHSC 2012).

NUMBER OF HOUSES UNDER CONSTRUCTION

The house construction activity in Australia can be interpreted using the number of dwelling commencements and completions, and dwelling units under construction. The quarterly published data from ABS (2013) indicate that the gap between the number of dwellings under construction and completed every quarter has been increased from March 2000 to March 2013. The gap could be explained by the increasing in the time to complete a house. As a result, the number of completed houses per quarter has continuously decreased.

COORDINATION BETWEEN STAKEHOLDERS

The supply chain of house building in Australia includes various stakeholders. It includes the sub-contractors, supply and installs contractors, building material suppliers, and house customers. The stakeholders are involved in the house building process through delivering the materials and information to process the material. Dalton et al. (2011) emphasized on the coordination among stakeholders to deliver the work on site in a right sequence. Their study comprised various interviews with the supply and install contractors including plastering and plumper's. It was concluded that during the inspection of the building supervisor, some jobs were not ready for undertaking on the construction site. Therefore, it required a considerable rescheduling that resulted in increasing the amount of time to complete the house building.

LITTLE'S LAW FOR HOUSE BUILDING

Capacity of a house building organization could be explained by using Little's law. The house building physics is a systematic description of the underlying behavior of the house building system. A thorough understanding of the system may lead to improvement of house building capacity. Little's law has been applied to a single production station, production line, or an entire production plant with or without variability. Applying Little's law results in the lead time control. Bashford et al. (2005) examined the applicability of Little's law in the residential production system.

Their study showed a predictable relationship between cycle time (CT), work-in-process (WIP), and throughput (TH). Gharaie et al. (2012) investigated the applicability of Little's law in predicting the house completion time. However, their study was conducted within the US housing industry which may be driven by different factors from the Australian housing environment. As seen in Equation 1, Little's law describes relationships among three critical measures of a production system.

$$CT=WIP/TH \qquad \text{Equation 1}$$

The construction works are characterised with increasing uncertainties i.e. design, processes, stakeholders and site conditions which resulting in unpredictable delays of buildings added to the construction WIP (Daneshgari 2010). In house building, Gharaie et al. (2010) defined CT as time required to complete a house. Components of CT include WIP as number of houses under construction (NHUC) and TH as the production and construction rate. The study showed that there is a positive correlation between NHUC and CT. It is possible that CT can be reduced by controlling NHUC. However, the study did not convince that when the NHUC may not be an absolute solution for reducing house completion time. To understand CT regardless the number of houses being built, a concept from house building system physics can be applied. This paper represents the Australian house building as single system as shown in Figure 4. The system inputs are the number of unit dwellings commenced based on customer demand. The system outputs are the number of unit dwellings completed and ready for occupation or TH. The systems' process is to transfer all the construction materials and information into finished houses. The process includes the number of unit dwellings being constructed or WIP.

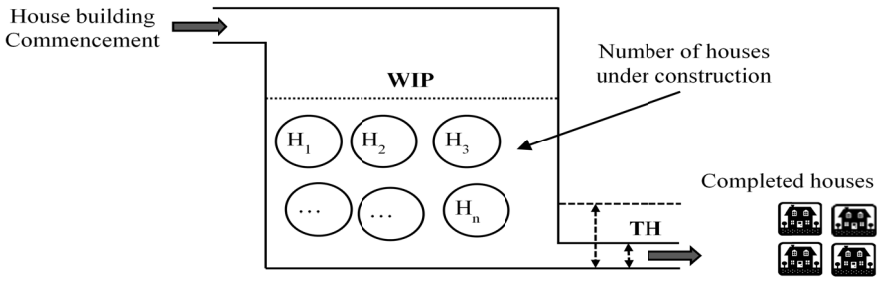

Figure 4: House building systems.

As demonstrated in Figure 4, TH is, to some degree, a function of WIP as TH can become worsened if we reduce the WIP to some point (Hopp and Spearman 2011). WIP represents the number of unfinished houses. The lesser the WIP shortens the completion time. However, it may mean low housing outputs being constructed. This scenario will not satisfy the increased housing demand. On the other hand, if WIP is carried out to the optimum capacity with the increased production rate, it is likely to result in higher finished houses. WIP may be considered as unfinished units between operations which occupy space and generate handling costs. The benefits of maintaining WIP can be found when operation independence, breakdown impact absorption, setup changes, and spatial decomposition are taken into account. The throughput of a production system is presented in Hopp and Spearman (2011) as:

$$TH = \text{Bottleneck utilization} \times \text{bottleneck rate} \quad \text{Equation 2}$$

The bottleneck in a system is located at the resource that has the smallest capacity. It is suggested that to maximise the bottleneck utilisation, reduction of blocking and starvation of the bottleneck resource must be implemented. This can be achieved by maintaining a sufficient amount of WIP before the bottleneck resource as a safety buffer (Gautam and Miyashita 2007). To expand the bottleneck utilisation, additional equipment, staff, and training are typically required. Moreover, house building organisations must ensure the flexibility of their labours, quality improvements, and effective product design. To improve TH, CT, and bottleneck utilisation, the concept of capacity needs to be integrated. Capacity of a system is a major determinant of TH, WIP and CT. System's capacity is a maximum level of TH. Therefore, it is a functional capacity of each process in the system (Hopp and Spearman 2011).

CAPACITY MANAGEMENT FOR HOUSE COMPLETION TIME REDUCTION

Capacity can be defined as the maximum output over a specified period of time. Capacity management is regarded as the adjustment of capacity to meet the changes in demand. Expanding the construction capacity is a strategy directed towards the growth of construction organizations. Developing the construction capacity requires developing of the construction methods such as using industrialized and prefabricated concepts. Moreover, it urges for human resource development in the construction industry including human resource training and incentive schemes, and the implementation of quality control techniques. Capacity management generally is found within the operations management domain. The appropriate strategies used in managing the capacity of an organization include leading and lagging the demand for capacity (Olhager and Johansson 2012). Leading demand strategy creates a high cost but it maintains high delivery and flexibility. Lagging demand creates a high utilization of the resources. Therefore, it enables low cost profile, but there is a long deliver time.

Capacity strategies are associated with the sales and operations planning (S&OP). The S&OP contains sales plan which based on the forecasted demand and production plan which constrained by the existing capacity. S&OP relates the production output to achieve the demand level at different planning horizons. Accordingly, S&OP process generates a balance between the sales plan and the production plan. Then, the production plan is translated into capacity requirements in terms of the total resources including production output rate, employment levels, inventory levels, backlogs, and subcontracting. The process of S&OP includes two alternatives: modifying the demand to match with the production constraints or modifying the supply to match with the demand (Olhager and Johansson 2012). Modifying the demand is employing some marketing tools to influence the demand to be achievable within the production capacity. The tools including pricing mechanisms, new product information and product consultancy. Modifying the supply is achieved through three strategies: level the production, chase the sales or mix of levelling and chasing (Choudhari et al. 2011).

Levelling production strategy refers to fixing the output at a constant rate over the planning period. Levelling the production output achieves a uniform and high utilisation of the available resources. Therefore, it reduces the costs associated with

changes in production rates. Chasing strategy adjusts the production output to match demand. Chasing the demand reduces the investment in inventories and/or backlogs. It also achieves flexibility at low utilisation of available resources. Mix strategy is a combination of level and chase strategies. In this strategy, the production rate is levelled for some periods according to the stable demand level and then it is changed to chase any dynamic changes on the demand. Any difference between the sales plan and the production plan results in a corresponding inventory or backlog.

Focusing on increasing the housing supply by expanding the capacity may not be suitable for the long term as the housing demand in Australia always exceed the supply (shown in Figure 1). Moreover, the capital cost of additional assets must be considered in the limited resources organisations as the Australian houses are produced by small to large organisations. In 2012, 66% of all Australian residential dwellings are built by small builders or in the form of self-build houses (HIA 2013). Therefore, this paper suggested that demand management should be employed collaboratively with capacity management as shown in Figure 5.

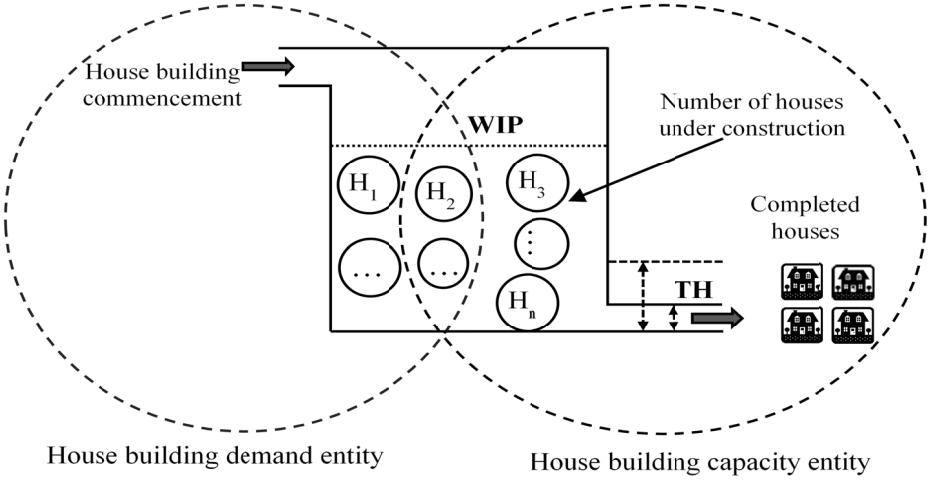

Figure 5: House building capacity and demand entities.

Demand management is the process of balancing the customers' requirements with the supply chain capabilities. The process includes using the customer demand and providing efficient flows throughout the supply chain. Reading, sensing, shaping and synchronising customer demand will reduce demand variability and improve operational flexibility. According to Mendes (2011), demand management comprises of four components including statistical forecast, sales and operations planning (S&OP), collective planning and forecasting replenishment (CPFR), and vendor managed inventory (VMI). For housing organisations, the following capacity and demand management criteria can be applied to facilitate house completion time deduction (Figure 6). The key enablers to improve house completion time can be categorised into housing capacity and demand management. Housing capacity management provides two approaches to enhance housing supply capacity including process-based and resource-based approaches. Housing demand management focuses on pricing, sales and innovation aspects as well as inventory management.

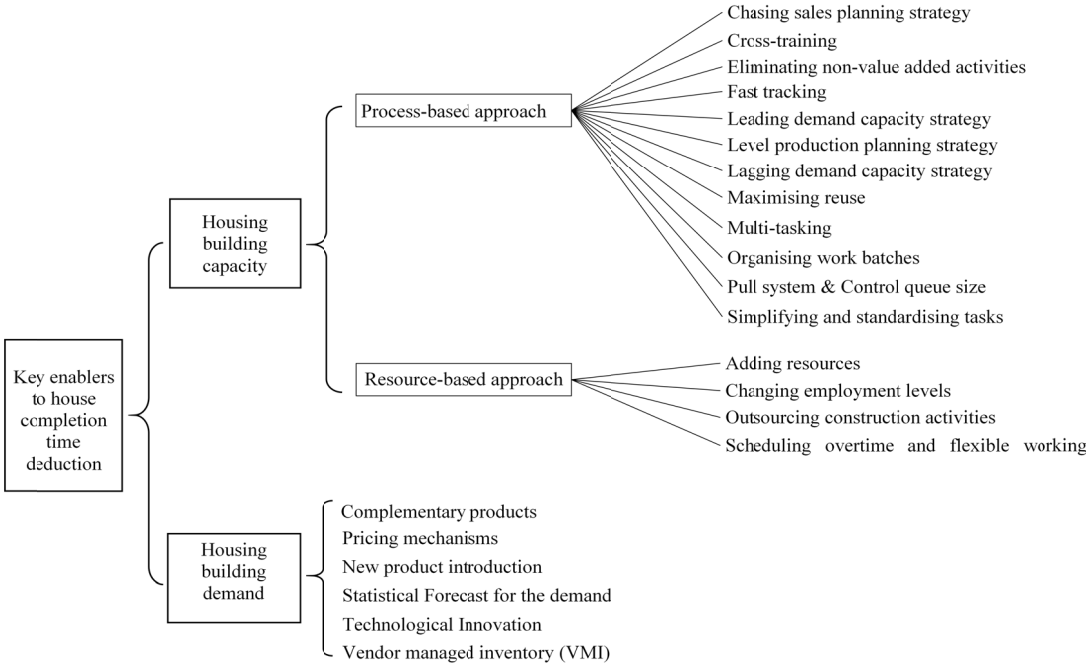

Figure 6: Suggested key enablers to house completion time reduction

CAPACITY AND S&OP STRATEGIES FOR HOUSE BUILDING

Capacity strategies focus on the timing of the capacity changes, while S&OP strategies include both production and sales plans. Both strategies are dealing with the long term capacity management (Olhager and Johansson 2012). It is urged that employing automation, agility or flexibility, leanness, or product modularity facilitates the use of S&OP and capacity strategies. Selecting the S&OP strategies depends on understanding the market environment. Therefore, it is important to understand the different house building strategies in Australia. Mostafa and Dumrak (2013) developed four strategies for prefabricated house building in Australia. The strategies are make-to-stock (MTS), build-to-order (BTO), design-to-order (DTO), and outsourcing to suppliers (OTS). This paper will consider those four strategies within the capacity and S&OP combination. There are five scenarios as presented in Table 1. Selecting any scenario is based on the house building organisation resources and the market environment. This paper develops a combination of the capacity strategies and the S&OP strategies for prefabricated house building.

Table 1: Combination of capacity and S&OP strategies for house building.

	Leading demand	Tracking demand	Lagging demand
Chase demand	• Customised house design • DTO • High availability of resources • Low volume demand • Low capacity utilisation		• Limitation to chase • Rely on subcontracting • Overload and delivery problems • High capacity utilisation
Mix		• Possibility to satisfy the demand from the own resources • BTO and DTO • Low/high volume demand	
Level production	• Possibility to change the production rate • Delay new capacity acquisitions • Steady flow of demand		• Competitive house pricing • High capacity utilisation • High housing demand • MTS

RESEARCH IMPLICATIONS

The house building system is seen through Little's law. This paper proposes dimensions from the lens of Little's law, capacity management and demand strategy in addition to the previous studies to solve the housing shortage situation in Australia. Understanding Little's law concept does not allow only WIP to be drawn to attention, but also allows the production rate or TH to be emphasized as another key factor that impacts on house-building completion time. When the shortage of housing supply occurs, selecting the appropriate capacity and S&OP strategy for house building organizations should be based on market demand and product characteristics (Olhager & Johansson 2012). The attributes existing in house-building organizations such as stakeholders, size, and employment level should be included in strategy selection. Capacity and S&OP strategies can be decoupled within the house building supply chain. The idea refers decoupling as physical or organizational separate activities of an organization which provide organizational unit integration, support change adaptation, optimize usage of productive facilities, and mitigate deviation within the organization (Fowler et al. 2000). Moreover, the decoupling capacity and planning strategies allow house-building organizations to attain competitive advantage in dynamic environments. Demand management is one of the main capacity strategies (Betts et al. 2000). Modifying the housing demand should be aligned with adjusting the housing supply. Levelling the sales pattern to production rate and using marketing methods such as pricing mechanisms and introducing new products can be included in the modifying process.

With regard to S&OP, the current Australian housing supply is as in chasing and levelling scenario. This depends on the size of the house building organization. It can be proved from the number of houses completed and house customization available

from each organization. Therefore, this research suggests decreasing the house completion time by adopting lead and chase scenario. House building organizations could be achieved this through two stages. The first stage is to move from lag-chase and lag-level to employ mix-track scenario. This intermediate scenario could be achieved by using OSM through employing lean and agile concepts. House building organizations level prebuilt or speculative houses using MTS. likewise, chasing improve the house design flexibility by using BTO and DTO. House customers have limited flexibility to change some certain house components from the builders catalogues as in BTO. House customers have a high flexibility in DTO. They can change the whole house design according to their needs. It increases the cost and time to build the house. Afterwards, chasing and leading scenario is the most likely capacity strategies for reducing the house completion time and achieves a high degree of customization for house customers.

CONCLUSIONS

Australian house building sector has continuously experienced shortage in housing supply. House completion time is considered as a key factor contributing to the shortage. This paper has discussed the shortage problem under the lens of capacity and demand management. A combination of tracking and mix strategy is suggested to produce a balance between capacity and housing demand. No single method can guarantee to solve the shortage. Using decoupling practice within the house-building organizations can elevate supply performance. More research is encouraged to explore other dimensions relevant to the situation of housing shortage.

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