Explaining the Increase in the Australian Average House Completion Time: Activity-based versus Workflow-based Planning

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Abstract

The Australian house building industry has been facing an increase in the average house completion time in the last decade. This increase in some states is quite dramatic. For instance, Western Australia has faced a 70 percent increase in the average house completion time during this period. This paper uses two planning approaches to explain this; i) the activity-based planning methods and ii) the workflow-based planning methods. In addition, this research investigates the strengths and weaknesses of these two planning approaches in explaining the behaviour of the house building industry. For this purpose, a national case study and five state case studies including Victoria, Western Australia, New South Wales, Queensland and South Australia have been used. The data related to the key parameters have been collected and their correlation with the average house completion time has been investigated. These key parameters include the average house floor area, the number of house completions and the number of houses under construction. The reasons for the increasing trend of the average house completion time have been postulated in all case studies. According to this research, the increase in the average house completion time cannot be explained using activity-based planning methods. In contrast, by using workflow-based planning methods, it has been shown that the average house completion time is correlated with the number of houses under construction. This paper shows that the average completion time is influenced directly by the workflow in the house building industry and that workflow planning should be the basis for the house building industry planning.

Keywords: Average house completion time, Australian house building industry, Activity-based planning, Work-flow-based planning

Introduction

Completion time of a construction project is always a major concern for all stakeholders. For the Australian house building industry, completion time has serious investment implications. Simultaneously housing customers remain financially and emotionally engaged in the process while waiting for their home to be delivered. In this situation, any increase in completion time results in further capital investment, more management effort, and reduced customer satisfaction.

According to the Australian Bureau of Statistics (ABS) (2008) the house building industry in Australia has experienced an increase in the average completion time of houses since 2000. The average completion time for new houses at the beginning of 2000 was 1.8 quarters,

reaching 2.4 quarters by the end of 2008. These figures show that house buyers had to wait 35 percent longer in 2008 than in 2000. The increase in some states is more dramatic. For instance, Western Australia has faced a 70 percent increase during the same period.

Considering that houses are the dominant type of dwelling in Australia, these figures show the criticality of the situation. Finding solutions for this critical situation needs a proper understanding of the house building industry and the major factors affecting house completion time. This paper investigates these factors using different theories of planning.

Two main planning approaches have been considered; namely activity-based planning and work-flow-based planning. The former is the basis for the most of the conventional planning methods used in construction, and the latter forming the foundation for production planning methods common in manufacturing. This research will use both of these approaches to explain the reasons for the increase in the average house completion time.

The case studies in this research comprise five cases at the state level and a case at the national level. The national case mentioned in the title is the Australian house building industry. The state cases are Australia's states namely Victoria, New South Wales, Queensland, Western Australia and South Australia. These states contain about 95 percent of the population of Australia. Therefore, the outcome of this research is robust for the Australian house building industry.

Firstly, the related literature will be reviewed. Then each of the planning approaches will be explained and their recommended effective factors on the completion time will be investigated.

Literature Review

Literature related to this research is divided to two areas. These two areas are the housing and construction management. Generally, housing literature is more focused on housing market demand (Glaeser, 2004). However, since Dipasquale's review (1999) attention towards market supply has increased (Murphy, 2008). The elasticity of supply and the effective factors on supply are the issues covered in these researches. The Australian National Housing Supply Council (2010) in its state of supply report described the factors affecting supply of new dwellings as the construction cost, infrastructure costs, land availability, land release and development processes.

In this approach, the quality of supply and the circumstances within the house building industry are ignored. One of the supply issues which has remained unexplored in the housing literature is the time for the completion of the houses. However, time is one of the focus points in construction management literature.

Time is a critical factor for project success and many planning methods have been developed to address this issue. These methods can generally be categorized into activity-based planning and workflow-based planning methods (Sawhney et al., 2009). The

Gharaie, E et al. (2010) 'Explaining the increase in the Australian average house completion time: activity-based versus workflow-based planning', *Australasian Journal of Construction Economics and Building,* **10** (4) 34-49

35

application of activity-based planning methods such as critical path method (CPM) and project evaluation and reviewing technique (PERT) have been extensively criticized (Harris and Ioannou, 1998, Koskela, 1992, Reda, 1990). The workflow planning method, also known as production planning method, was more popularly introduced to the construction industry by Koskela (1992). More specifically, Willenbrock (1998) and O'Brien et al. (2000) suggest that the production planning can be usefully adopted in the residential construction industry.

According to workflow planning methods in manufacturing, work in process and the throughput of the system are the factors that affect the cycle time of a product (Hopp and Spearman, 2008, Koskela, 1999). In construction industry, Sacks and Partouche (2009) has shown that the completion time of the tall buildings similarly can be affected by the work in process. Bashford et al. (2005) have taken this issue to the housing industry. They conducted research to find reasons for the large variations in the house completion times in the Chandler, Arizona area. They showed that the completion time of the houses in this area was significantly affected by the production system loading. This is a factor neglected by current management tools.

Building on Bashford et al.'s (2005) work, this research seeks reasons behind the increase of the average house completion time in Australia. For this purpose activity-based and workflow-based planning approaches were considered and their respective weaknesses and strengths demonstrated.

Activity-Based Approach

The main focus of most of conventional construction planning methods is on the activities. Network planning (CPM, PERT) and line of balance are two examples of the planning techniques, which are based on activities. With this focus, project planning leads to activity planning and the duration of the project relies directly on the duration of activities. Consequently, any change in activity durations would result in a change to project duration.

In activity based planning methods, the duration of the activities are indicated by the activity's scope of work and the production rate of resources. Using this approach, any loss of production rate or extension of the scope can result in an extension in the activity duration, and therefore project duration. Therefore, the reasons for the increase in the project duration are the loss of production rate or the extension of the scope of work according to activity based planning methods.

In house building industry, there is no single project but many concurrent projects. However the same principle can be applied. The loss of production rate in the industry can lead to longer completion times and the extension of the scope of work in construction of the houses can increase the completion time. These two parameters can be traced by the quarterly number of house completions as a proxy of the industry's production rate and the average house floor area as a proxy of the scope of work.

Gharaie, E et al. (2010) 'Explaining the increase in the Australian average house completion time: activity-based versus workflow-based planning', *Australasian Journal of Construction Economics and Building,* **10** (4) 34-49

36

Next two sections will investigate the correlation between these two parameters and average house completion time in the Australian house building industry.

Quarterly Number of House Completions

As mentioned above, the activity-based planning methods suggest that the increase of completion time might be because of loss of production rate. The trend of production rate can be found by quarterly number of house completions. Therefore, the increase of the average house completion time is expected to be concurrent with decrease in the number of completions. The trend of the average house completion time and quarterly number of house completions can be derived from the actual data reported by the ABS (2009). Drawing of these trends on the common graph shows the existence of any correlation.

This research has been undertaken on six cases. Five of these cases are Australia's larger states. The final case will be at the national level and will cover the whole Australian house building industry

Victoria: Victoria is the first case in this study. The comparison between the production rate trend and the average house completion time trend is best illustrated on a common graph (figure 1). The graph shows that the minimum average house completion time in this state was in 2002 where it reached 1.9 quarters. After 2002, the completion time has increased to 2.5 quarters in 2008. However, the production rate of the industry remains constant during this period. The average number of completions (illustrated in figure 1) is around 8,000 houses per quarter.

Figure 1 also illustrates that the trend of production rate does not match the trend of completion time. In other words, the construction industry has maintained a more-or-less constant production rate while the completion time has been increasing dramatically. This refutes the proposition suggested by activity-based planning methods, which suggests that the increase of the average house completion time can be the result of the loss in the industry's production rate.
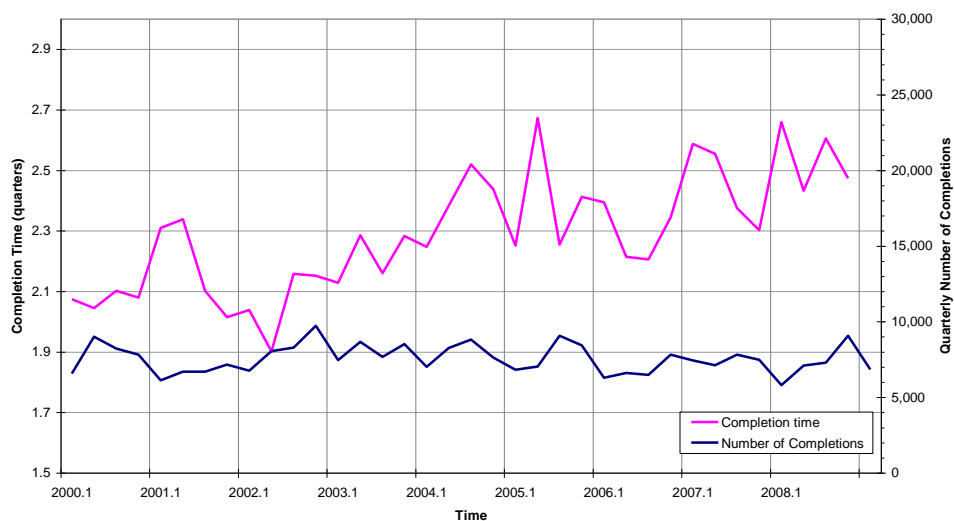

Figure 1: Average house completion time and quarterly number of completions in Victoria

Gharaie, E et al. (2010) 'Explaining the increase in the Australian average house completion time: activity-based versus workflow-based planning', *Australasian Journal of Construction Economics and Building,* **10** (4) 34-49

Western Australia: As mentioned in the introduction, the increase in the average house completion time in Western Australia has been about 70 percent since 2000. This change is the result of the comparison between the average completion time in 2000 and 2008.

However, the main growth in this state did not start until the end of 2001. The average house completion time in the fourth quarter of 2001 was 1.6 quarters. This duration reached 3.2 quarters at the end of 2008, showing an almost 100 percent increase in 7 years. Figure 2 clearly shows this dramatic increase.
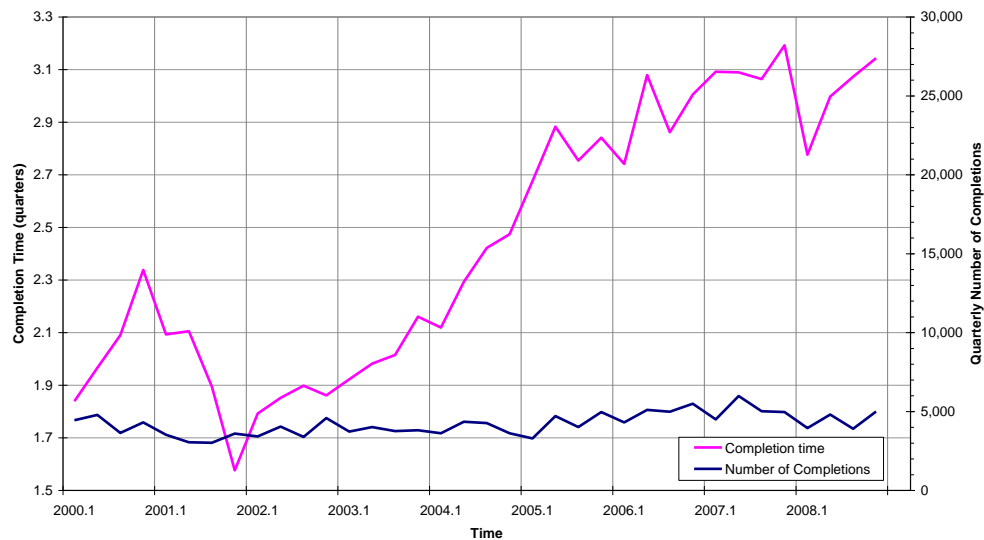

Figure 2: Average house completion time and quarterly number of completions in Western Australia

In the same period, the production rate of the industry was around 4,000 houses per quarter. The industry even had a slight growth in production rate in 2006 and 2007. But this increase could not help the industry finish houses in a shorter time. Therefore, the growth of the average house completion time cannot be the result of production rate loss. Western Australia is the second case whose behavior cannot be explained by activity based planning methods.

Queensland: The average house completion time in Queensland has a similar trend to the first two cases. This state has been facing an increase in completion time since the end of 2001 and reached 2 quarters at the end of 2008. This increase has taken place whilst the production rate has remained constant. Figure 3 shows that the number of completions in Queensland has remained around 7,000 houses per quarter.

Beside the existence of different trends for the completion time and production rate in this state, it can be seen in figure 3 that there were peaks and dips in the completion time in this period but these extremum can not be seen in the production rate. Therefore, it can be concluded that the increase in the completion time in Queensland is not correlated with the loss of production rate. Hence, Queensland will be the third case in which the activity based planning method could not explain the increase in the completion time.
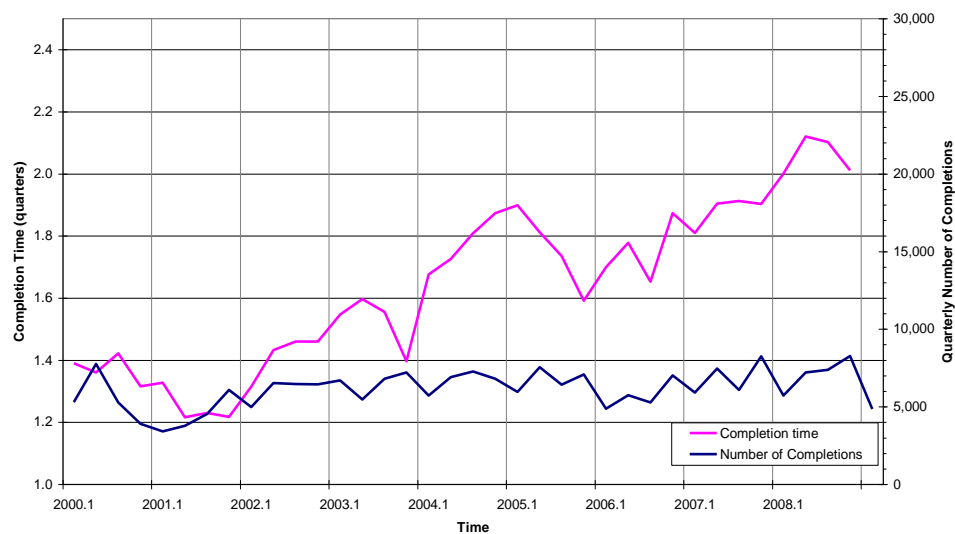
Figure 3: Average house completion time and quarterly number of completions in Queensland

New South Wales: The average house completion time in New South Wales follows the same trend as previous cases. However, this state has a different production rate trend compared to other states. In this state, the production rate has been declining since 2000. The production rate has become half in this period and the completion time has been affected by this reduction. The trends in NSW can be explained by activity-based planning methods, the decline being the reason for the increase in completion time. New South Wales is the only case that supports this theory, and provides a valuable comparative case (Yin, 1994).

South Australia: South Australia is the last case at the state level. This state has also been facing an increasing average house completion time since 2000. The production rate in South Australia has been almost constant. There is no loss in the production rate that can be considered as a reason for the increase in the completion time. Further, there are variations in the completion time that cannot be seen in the production rate.

So far four of five cases at the state level rejected the idea suggested by the activity-bases planning methods. The final case will be the whole Australian house building industry.

Australia: the Australian average house completion time has gone up from 1.8 quarters at the beginning of 2000 to 2.44 quarters at the end of 2008. The linear regression on the quarterly number of completions shows that the production rate in the Australian house building industry has been swinging around 27,000 houses. This regression is almost horizontal in this period, which shows the consistency in the production rate between 2000 and 2008. It means that while the industry has maintained its production, the average house completion time has grown. Once more, the production rate trend does not match the completion time trend. Activity-based planning methods do not adequately explain the increase in completion time.
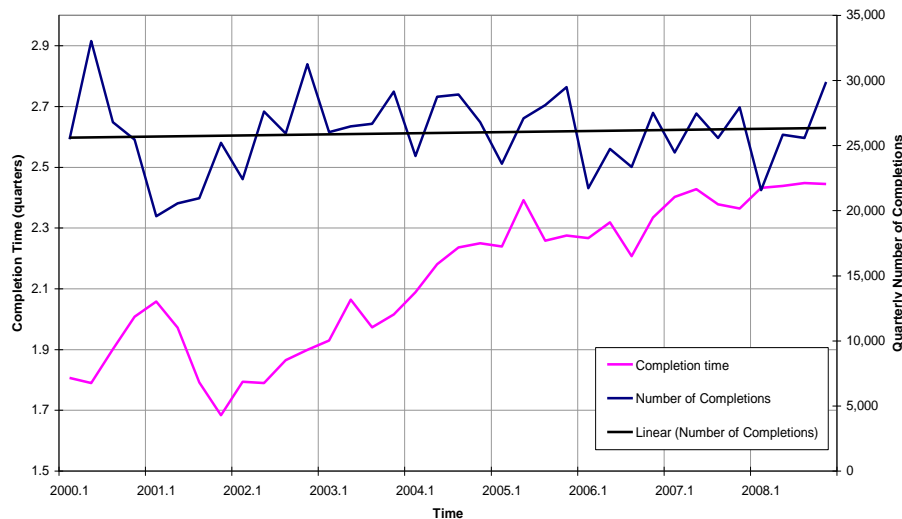
Figure 4: Average house completion time trend and quarterly number of completions in Australia

Summary: This part of the research investigated the reason for the increase in the Australian average house completion time using a suggestion theorized by activity based planning methods. Based on this suggestion the loss of production rate lengthens the activities and consequently the project's duration. Therefore, the increase in the average house completion time might be because of a loss in production rate. This suggestion has been investigated in six case studies. In five of the cases, no production loss was observed in last decade. It has been argued that according to the trend of the industry's production rate and the average completion time, the increase in the completion time of the houses cannot be the result of the production loss and the suggestion has not been supported. In the next section another suggestion proposed by activity based planning methods is examined, namely the effect of scope of work on the completion time.

Average House Floor Area

Activity-based planning methods suggest that a reason for the extension in the completion time is a change in project scope. To investigate this hypothesis in the Australian house building industry, the average house floor area was analysed and compared with the trend of the average house completion time. Average house floor area was derived from ABS (2010) data. Since the focus is on the Australian house building industry, the same six cases were utilized; one case at the national level and five at the state level. Following shows the result of the investigation on the effect of the average house floor area on the average house completion time in these cases.

Victoria: Victoria shows inconsistency between the trend of the average house floor area and the average house completion time (figure 5). The completion time in this state experienced a 35 percent increase between 2002 and 2007, yet the average house floor area grew by only 10 percent.

The trend of both parameters in this state is increasing but these increases do not match each other. For example, the completion time in Victoria fluctuates even though the average floor size does not show any fluctuation. Based on activity-based planning suggestion of the correlation between the completion time and the scope of work, an increase in the scope should cause the completion time increase; and its decrease should have the opposite effect. In the case of Victoria however, the completion time both increases and decreases without apparent correlation to the increasing average floor area. Subsequent cases on the other states further emphasises this.
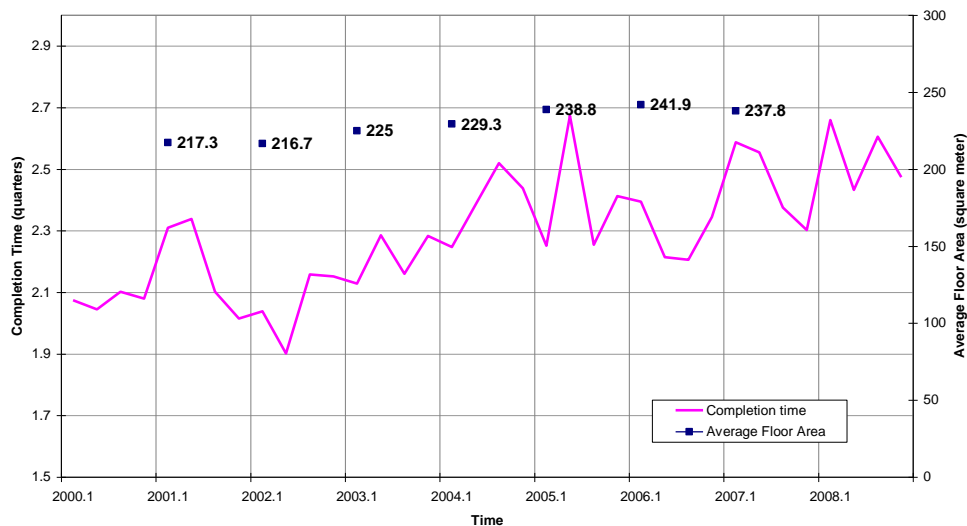

Figure 5: Average floor area and completion time in Victoria

Western Australia: The same phenomenon can be seen in Western Australia (figure 6). In this state, the average house completion time also increased dramatically without any dramatic increase in the average house floor area. In fact, the completion time doubled between 2002 and 2007 with houses having only grown by 5 percent in area. This is the third case that demonstrates the activity-based planning weakness in the explanation of the increase in the completion time.
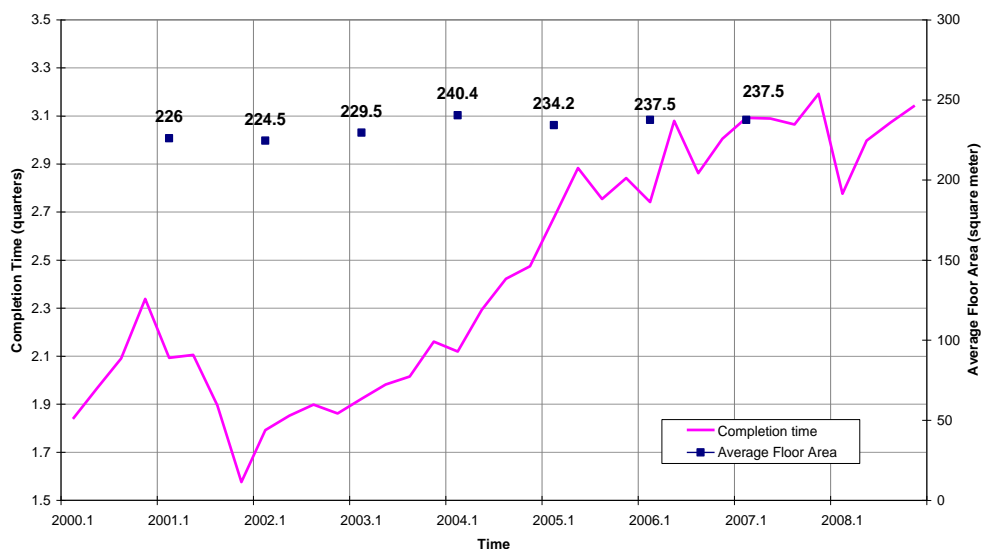

Figure 6: Average floor area and completion time in Western Australia

Gharaie, E et al. (2010) 'Explaining the increase in the Australian average house completion time: activity-based versus workflow-based planning', *Australasian Journal of Construction Economics and Building,* **10** (4) 34-49

41

New South Wales and Queensland: In these two states, the completion times grew dramatically, with only modest average house floor area growth. According to the ABS, the average floor area in NSW has increased by 10 percent while the completion time has been facing a 35 percent increase. Queensland also followed the same trend where the increasing trend of completion time does not match the trend of the average floor area.

South Australia: South Australia is the state that strongly refutes the hypothesis of the impact of the average house floor area on the average house completion time. The average floor area in this state dropped from 206m^2 to 191.5m^2 (figure 7), while at the same time the completion time climbed from 1.7 to 2.4 quarters. This 40 percent increase in completion time when the average size of houses reduced, strongly contradicts the activity based planning methods for explaining the increase in the average house completion time.
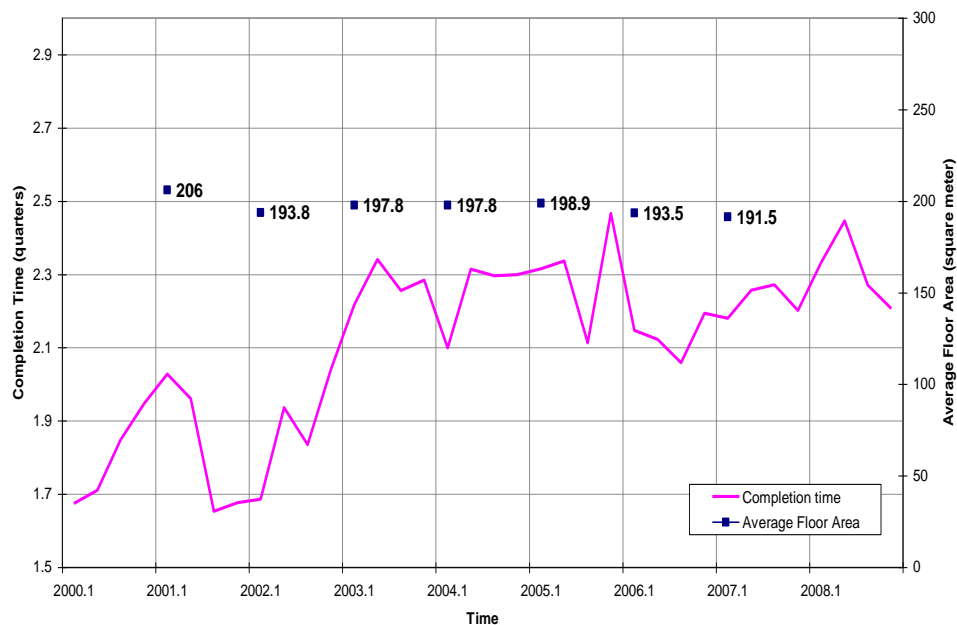

Figure 7: Average floor area and completion time in South Australia

Australia: the average house completion time was explained in section 3.1, which demonstrated that it had increased, by 35 percent in Australia since 2000. In the same period, the average floor area for houses had gone up by 5 percent. This percentage does not match the increase in the completion time. Figure 8 shows this inconsistency.

While the completion time grew, the average floor area remained around 235m^2. There was not any dramatic change in the average floor area over this period that might explain the increased completion time. Therefore, the reason for the dramatic increase in the average house completion time cannot be attributed to an increase in scope and therefore length of activities. This further demonstrates the weakness of activity-based planning systems at explaining the housing industry's behavior.
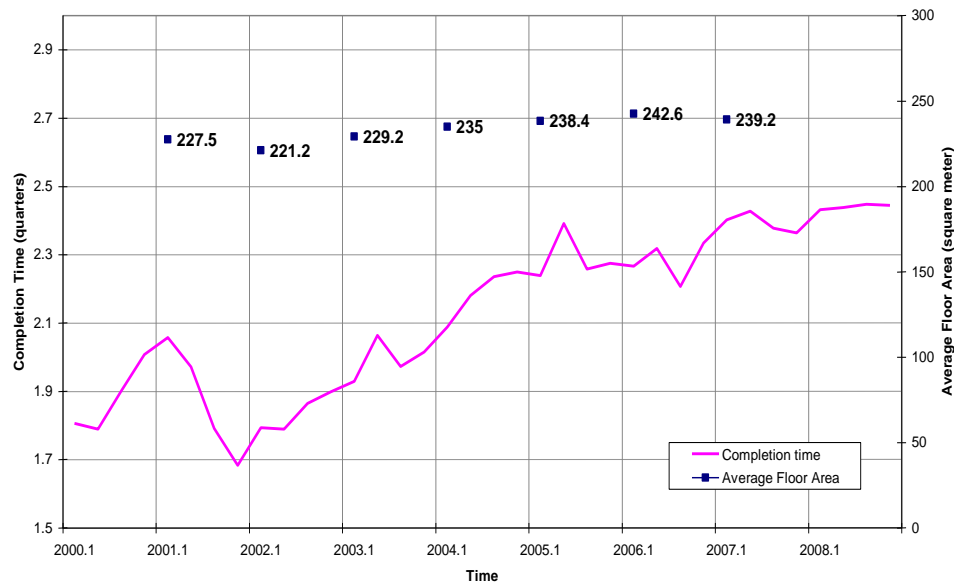
Gharaie, E et al. (2010) 'Explaining the increase in the Australian average house completion time: activity-based versus workflow-based planning', *Australasian Journal of Construction Economics and Building,* **10** (4) 34-49

42

Figure 8: Average floor area and completion time in Australia

Summary: In all states, house size has had limited impact on completion time. The size of houses has grown during last 8 years but without any correlation to the increase in the average house completion time. In fact, South Australia has shown a contradictory trend in which while the average house floor area decreased the completion time rose dramatically. The growth of completion time is an undeniable fact in the Australian house building industry. It has been shown that this fact cannot be explained by the activity-based planning methods where the main focus is on the scope of work and production rate of resources. Therefore, another paradigm affecting the average house completion time is required. The following section uses the alternate method to explain the reason behind this increase.

Workflow Planning Approach

The other method of planning which has been suggested as a planning tool in residential construction is production planning. Production planning focuses on the flow of work. In this method of planning variables such as work in process, cycle time and throughput are considered as the interrelated variables (Koskela, 1999).

In the house building industry, houses are the products. The cycle time of these products represents house completion time and the work in process, houses under construction. With these definitions and knowing that the cycle time is influenced by the work in process, it can be concluded that according to the workflow planning method the completion time is influenced by the number of houses under construction. This idea has been proven true in Chandler, Arizona by Bashford (2005) and this research attempts to study its validity in the Australian house building industry.

Number of houses under construction (NHUC)

Previous sections were dedicated to the investigation of the possible effects of the production rate and average house floor area on the average house completion time in Australia. This section investigates the correlation between the average house completion

Gharaie, E et al. (2010) 'Explaining the increase in the Australian average house completion time: activity-based versus workflow-based planning', *Australasian Journal of Construction Economics and Building,* **10** (4) 34-49

43

time and the number of houses under construction. The actual data for these variables was collected quarterly by the ABS (2009).

For this purpose, the same method of monitoring and comparison of the two parameter trends will be used. Further, this part of research will adopt the correlation coefficient to indicate the level of correlation (Hogg and Craig, 1995). This coefficient has a value between -1 and 1 and shows the association between two variables (Kottegoda and Rosso, 2008). The values closer to 1 indicate high positive correlation and values closer to -1 demonstrate high negative correlation. 0 shows no correlation. The same six case studies as the previous section will be considered.

Victoria: According to figure 9, Victorian house building industry shows correlation between the number of houses under construction and the average house completion time. In this state, the growth of house completion time starts from mid 2002. This growth is the result of the increase in the number of houses under construction in mid 2001. The overall trend of these two parameters is similar and the correlation coefficient between them is 0.623, which is a positive correlation.
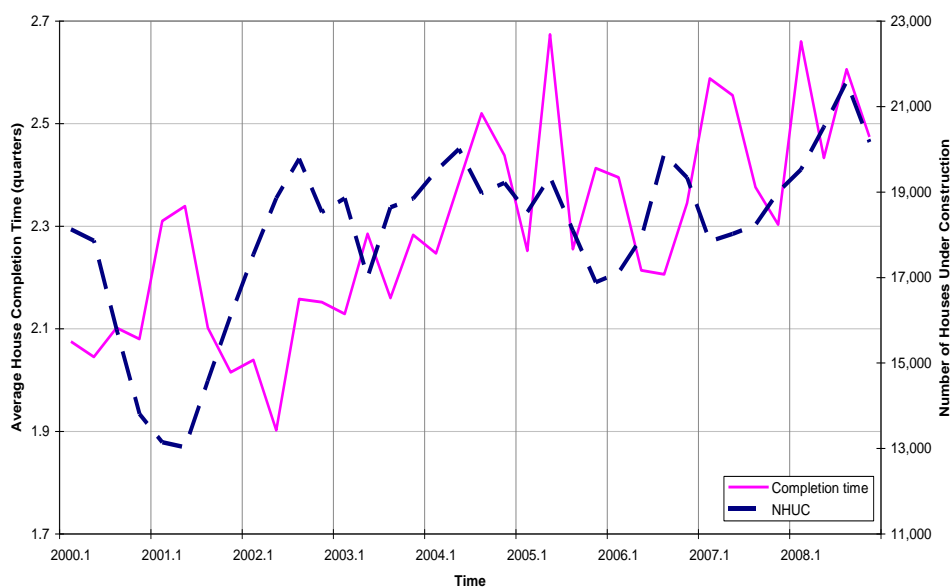

Figure 9: Number of houses under construction and the average house completion time in Victoria

Western Australia: Western Australia also shows the same correlation between number of houses under construction and the average house completion time. The NHUC in this state has an increasing trend in the last decade. This increase starts in mid 2001 with around 4,600 houses under construction and it reaches more than 16,500 houses by the end of 2006. Figure 10 clearly demonstrates that the growing trend of NHUC complies with the growing trend of average house completion time. The correlation coefficient measured for this state in this period is 0.95 that suggests a high positive correlation. This state is the second case that shows the strength of workflow planning methods in the explanation of the house building industry's behavior.
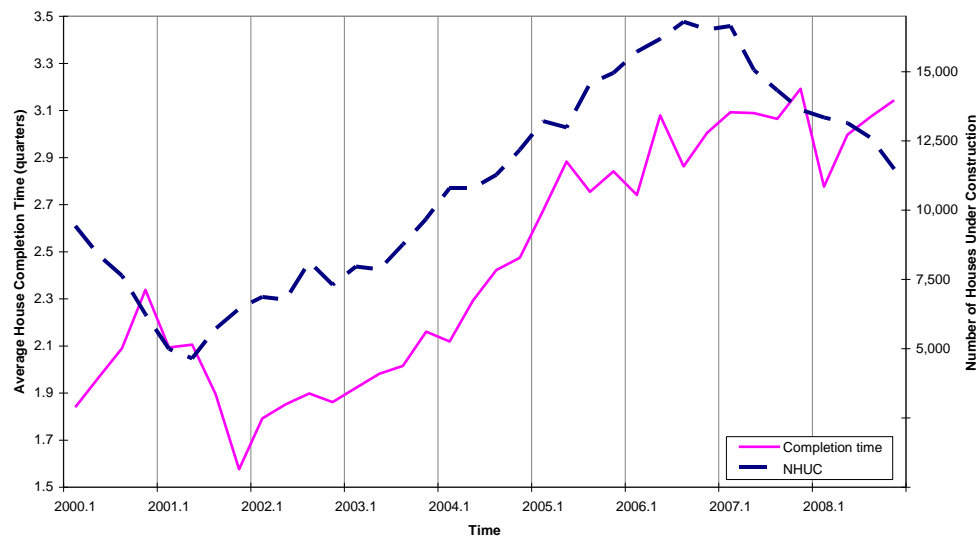
Figure 10: Number of houses under construction and the average house completion time in Western Australia

New South Wales: It has been shown in previous section that New South Wales is the only state in which the increase in the average house completion time can be explained by activity-based planning methods. In this state, the loss of production rate has been considered as the reason for the increase in the completion time. The influence of the production rate on the completion time is also suggested by the workflow planning methods. These methods argue that as long as the production rate is consistent, the completion time is affected by the number of houses under construction. But when the industry faces a loss in the production rate, this parameter also comes to the account and affects the completion time. This phenomenon can be clearly seen in NSW where the loss of production rate makes the average house completion time grow. Therefore, NSW is the case, which shows the comprehensiveness of the workflow planning methods in the explanation of the house building industry's behavior.

Queensland: The correlation between the average house completion time and NHUC can be clearly seen after 2001 in this state. The NHUC peak points in mid 2004 and 2008 are followed by the completion time peak points. The overall increasing trend of NHUC can be seen in the average house completion time too. Comparison of figure 11 with figure 3 shows the strength of workflow planning method against activity based planning methods in explanation of the reasons for the increase in the average house completion time after 2000. It has been mentioned before that the maximum value for the correlation coefficient is 1 that indicates the absolute correlation. This coefficient between number of houses under construction and the average house completion time is 0.97 that shows the strength of correlation in this state.
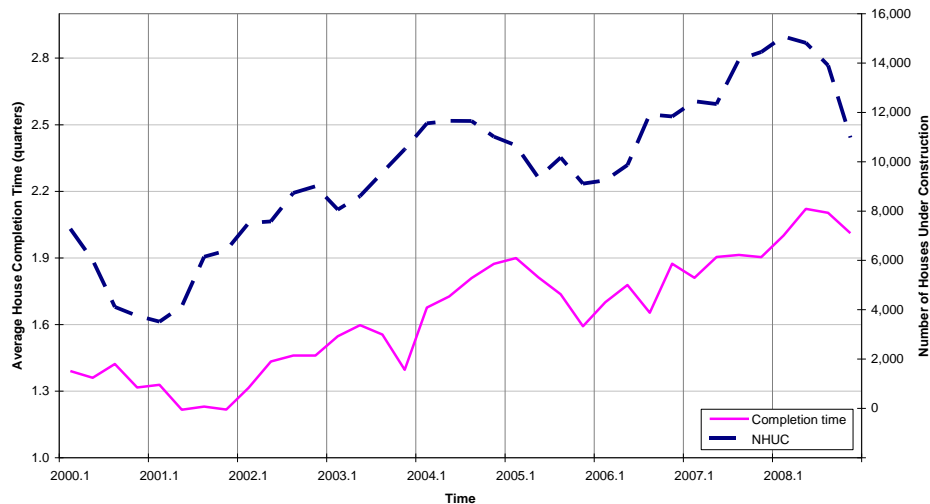
Figure 11: the trend of number of houses under construction and the average house completion time in Queensland

South Australia: In this state, the number of houses under construction has had an increasing trend since 2001 that matches the increasing trend of the average house completion time. The correlation coefficient between these two parameters is 0.85. It means the correlation suggested by the workflow planning methods between the completion time and NHUC is valid in this state too.

Australia: Contrary to the production rate and the average house floor area, the number of houses under construction shows a strong consistency with the average house completion time. The correlation coefficient has been measured for this case too. This coefficient has a value of 0.88, which indicates a high positive correlation. As can be clearly seen in figure 12, the average house completion time and NHUC follow a similar trend. The rise in NHUC is followed by a rise in completion time and a fall is followed by a fall in completion time. Therefore, as is suggested by workflow planning methods, there is a strong correlation between these two parameters in Australian house building industry.

Summary: This part of the research has been dedicated to the investigation of the probable correlation between the average house completion time and the number of houses under construction. This correlation is suggested by workflow planning method. In this regard, the two parameters of the average house completion time and number of houses under construction have been drawn against each other and compared. Further, the correlation coefficient between these two parameters has been measured. This analysis has been undertaken for Australia and five of its states including Victoria, Western Australia, New South Wales, Queensland and South Australia. As a result, a strong correlation between the average house completion time and number of houses under construction was found using the correlation coefficient. This correlation has been also appeared in the graphs and the validity of workflow planning methods in the house building industry has been proven.
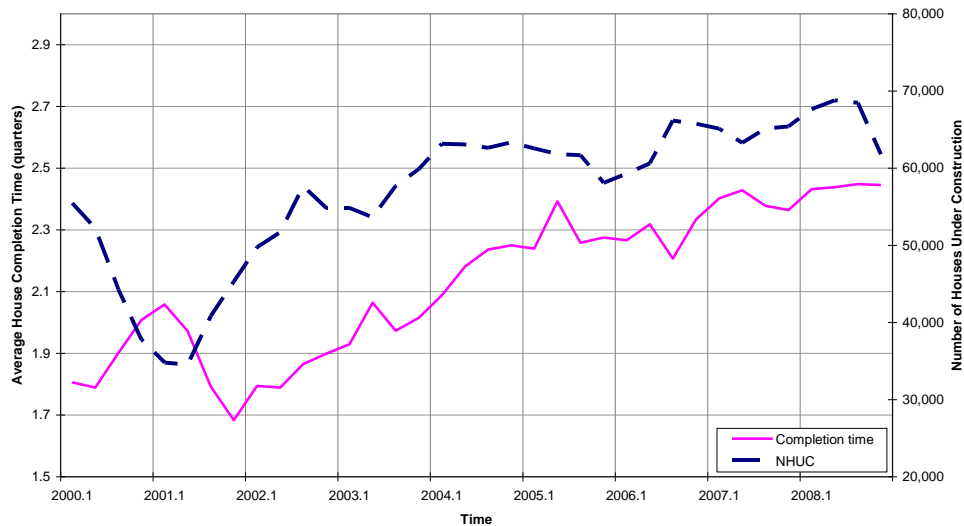
Figure 12: the trend of number of houses under construction and the average house completion time in Australia

Conclusions

The Australian house building industry has been facing an increase in the average house completion time since 2000. This research has used two planning approaches to explain this; i) the activity based planning methods and ii) the workflow planning methods. Further, it has tried to investigate the strengths and weaknesses of these two planning approaches particularly in reasoning the increase of the average house completion time and generally in the explanation of the house building industry behavior.

In this regard, the effect of production rate, project's scope and the number of houses under construction on the average house completion time have been studied. The first two are proposed by the activity-based methods as the effective parameters on completion time and the last one is the parameter proposed by the workflow planning approaches.
Quarterly number of completions has been used as the representative of production rate of the industry. The analysis has shown no apparent correlation between production rate and the average house completion time since 2000 in Australia, Victoria, Western Australia, Queensland and South Australia. The only state that has shown the correlation was New South Wales. In this state, the production rate has been declining since 2000. This decline made the completion time longer during this period.

In case of Australia and other states, because the increasing trend of completion time has happened during the time that production rate has been constant, it can be concluded that this increase has not been caused by the loss in production rate as it is suggested by activity based planning approaches.

The other parameter suggested by these methods is project's scope. For finding the effect of this parameter on the completion time, the trend of the average house floor area has been studied. This trend also has shown that the reason for the increase in the average house completion time is not the increase in project's scope. South Australia is the strong refuting

Gharaie, E et al. (2010) 'Explaining the increase in the Australian average house completion time: activity-based versus workflow-based planning', *Australasian Journal of Construction Economics and Building,* **10** (4) 34-49

47

case in this matter where the average house floor area has been declining since 2000 while the completion time has been consistently increasing.

The next parameter that has been investigated in this research was the number of houses under construction. This parameter is proposed by the workflow planning approach as an effective factor on completion time. The study of the trend of this parameter has shown a strong correlation between the average house completion time and this parameter. This correlation has been verified in Australia and its states.

It has been also shown that the correlation between the number of houses under construction and the average house completion time is positive. Whenever the NHUC increases, the completion time would increase and whenever it decreases the completion time would decrease.

This paper began by discussing a concern over the recent increase in the house completion time in Australia. The research has described that the main reason for this increase is the growth of the number of houses under construction. This research has also demonstrated that the workflow planning approach is able to explain the house building industry's behavior in relation to house building completion times. Therefore, we suggest that this approach should be used by the industry's policy makers and practitioners to better understand the dynamics of the housing construction process.

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49