

The Rocky Road to BIM Adoption: quantity surveyors perspectives

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Abstract

Quantity take-off has remained the base activity performed for many of the services provided by quantity surveyors. Although many quantity surveying (QS) firms have moved from paper-based quantity take-off to computer screen take-off, quantification process still remains a time consuming process. Part of this tedious task also involves collating and clarifying information from different design consultants, all of which lead to non-productive and inefficient work. Automation of quantities and an integrated information exchange achievable through Building Information Model (hereafter referred as BIM) should enhance the services provided by QS firms. It is not clear how well quantity surveyors are increasing BIM adoption and getting ready for participation in BIM in their professional practice. The research reported in this paper was aimed at understanding the BIM experience of QS firms in Australia. Data collection was a web-based survey of 177 QS firms. Findings of this study shows that BIM is not readily adopted by QS firms due to the incompleteness of information in models, lack of knowledge about new business processes to drive BIM and cost of implementation. It appears that QS firms mostly participate in BIM in the form of computer aided take-off (with 3D drawings – non parametric modelling) in the project's front end tasks such as cost planning and bill of quantities and in the form of one way communication rather than in parametric modelling, quantity automation, collaboration and integration. There seems to be lack of clarity about the 'Time saving' benefits of BIM because QS spent more time checking the accuracy of model. The implications of the findings for technology adoption in construction and especially BIM adoption by QS firms are discussed. Ways of driving adoption of BIM-based working in the construction industry and especially by the QS are also highlighted.

Keywords: adoption, BIM, estimating, quantity take-off, quantity surveying, professional services

1. Introduction

The term “BIM” may be used to refer to the collaborative project delivery process involved in creating and communicating project information into a model by the design team. Thus BIM may be described as a collaborative mechanism (process perspective). From a process perspective, Autodesk (2011) defines Building Information Modelling (BIM) as “an intelligent model-based process that provides insight for creating and managing building and infrastructure projects faster, more economically, and with less environmental impact.” It facilitates simultaneous work by multiple design disciplines. Sometimes BIM is also used to refer to the product that facilitates collaboration in the project delivery process i.e the BIM itself (as a product). From product perspective, a BIM is a digital model of a building in which information about a project is stored. All information related to the physical and functional characteristic of the building are stored in the ‘smart’ objects (Scuderi, 2007).

BIM provides a platform for integrated information exchange through a single model. It reduces design errors and omissions with significant reduction in design time. In addition to its use as visualisation tool of spatial representation of the building components, data enriched model provides extraction of information of each element embedded in it (McCuen, 2009). Depending on the data in the model, it can either be 3D graphical model, 4D time model or 5D cost model and with further information stored it can be modelled to nD. Thus BIM adoption can be at different levels as highlighted by Australian Institute of Architects (2010). In fact in terms of progress towards BIM adoption, firms may be at different levels namely manual 2D, computer aided 2D, 3D drawings (non parametric model), intelligent 3D (parametric model), collaboration which involves sharing of object-based models between two or more disciplines, and integration which involves integration of several multi-disciplinary models using model servers of other network based technologies (the highest level of BIM adoption).

Because of its capabilities BIM-based estimating could transform and revolutionise the way quantity surveyors (QS) work. This study sought to investigate progress towards adoption of BIM by QS in Australia. Drawing from At breakfast seminar titled “Integrated Design and Delivery Solutions: Design Management in an Online Collaborative environment” organized by the Chartered Institute of Building Australia (CIOB) Australia branch at the school of property, construction and project management RMIT University on 21st March 2011, participants’ discussion suggested that quantity surveyors in Australia are somewhat not ready and are very reluctant to participate and adopt BIM. A similar anecdotal evidence of slow or lack of participation of QS in BIM was expressed by some participants at the NATSPEC Implementing BIM seminar on Wednesday 9th of May 2012 in Melbourne, Australia. RICS reported a similar finding in the UK (Building Cost Information Service, 2011). London et al (2008) also suggest that overall BIM adoption is slow in Australia. Thus the research reported in this paper is very important because it investigates the BIM experience of quantity surveying firms in Australia with a view to making recommendations that could facilitate widespread adoption of BIM-based quantity surveying services as well as BIM in general.

2. Quantity Surveying: The Evolved Profession and the Pivotal Role of Quantification

The history of quantity surveying profession should provide a useful context for understanding the development in quantity practice in Australia and elsewhere. It may also provide some useful insight into the widespread adoption or otherwise of new technology by the profession. Broadly speaking, the first reference to quantity surveying activities is found in the Bible (the holy book of the Christians) in the book of Luke 14:28 where the central figure of the Christian faith, Jesus, said: *'For which one of you, when he wants to build a tower, does not first sit down and calculate the cost to see if he has enough to complete it?'* Thus it would appear that the traditional quantity surveying activities dated back to over 2000 years ago. However, the need for an organised form of quantity surveying emerged during the restoration of London after the Great Fire in 1666 (Winch, 2010:37). Quantity Surveyors who were in early days referred to as 'measurer' or 'surveyor', worked for contractors to measure for payment purposes only (Association of South African Quantity Surveyors, 2011). Later years saw the need for accurate estimates widening the role of quantity surveyors and as years passed by, it was considered economical for the owner to have a cost advisor to represent him rather than each builder preparing his own bill of quantities (Drogemuller and Tucker, 2003). According to AIQS's cost management manual (2006), 'Specified Bill of Quantities' are a single integrated statement of the description and quantity of all work and contractual obligations in the one document.' The preparation of bills of quantities as a basis for estimating the cost of works from design drawings and specifications seems to have become established at the beginning of the nineteenth century. While many countries, like Europe and America for a long time did the measurement role through architects, the profession became more popular in England and Scotland (Sanders, 2008). In Australia, the first recorded quantity surveying activity occurs in June 1819 at Hobart Town where a first quantity surveyor was employed to measure in 'standard measurement' the walls of a new county (Leach, 2008). The first quantity surveying firm was in 1853 and the first bill of quantities was prepared by an Architect in 1859. Problems of over/under measurement, material cost and increase in cost of labour in 1800's, particularly after the Great Depression of the 1920's and 1930's led to a call of professionals specialised in the measurement of building quantities (Sanders, 2008). Overtime this profession has had its rise and fall in demand but due to its role played throughout the project lifecycle, it has now attained an importance among the core players in the Australian construction industry as with United Kingdom and other commonwealth countries. In 1971 (41 years ago), a professional body association named 'Australian Institute of Quantity Surveyors' (AIQS) was formed in Australia to represent quantity surveying professionals.

Although the role of a quantity surveyor which was just confined to doing measurements for the sole purpose of making payments in 1600's, the role has changed over time. Quantity surveyors now provide cost plans and prepare bill of quantities, which are now considered as the traditional services of a quantity surveying firm even now. According to a survey in UK in 1998, cost planning and advice services were seen as a leading QS service with potential to growth (Burnside and Westcott, 1999). In Australia, the traditional core services provided by the firms are Estimation, Bills of Quantity (BOQ) and Builders Quantities (BUQ), Contract Administration and specification whereas some firms extend their service to provide non-traditional services such as Facility Management,

Expert Witness, Due Diligence reports and many others (Smith, 2010). To accommodate these new roles, the skills required by quantity surveyors have now extended from just measurement to the ability to read drawings, have knowledge of construction materials and technology, the ability to visualise fitting of components from drawings, the knowledge of occupational health and safety issues, knowledge of relevant legislation and many others (Hodgson et al., 2008). Since quantity surveyors derive income from the construction industry, any changes occurring in the industry will greatly affect the way the profession operates (Frei, 2010). The changes occurring in the construction industry with an emphasis to shift from 'cost' to 'value' and importance of the procurement and management skills has changed the role of current day industry practitioners (Poon et al., 2000). Thus quantity surveying firms have now extended their roles to include many services into their firms to gain a competitive edge. With the declining use of bill of quantities driven by the change in procurement strategies and the higher cost involved in producing a bill of quantity, some quantity surveying firms started to include their services to provide builders quantities for the contractors in their portfolio (Drogemuller and Tucker, 2003). Quantity surveyors are currently considered as Cost Managers or Construction Economists who is one of a team of professional advisers to the construction industry by estimating and monitoring construction costs, from the feasibility stage of a project through to completion (Australian Institute of Quantity Surveyors, 2011). They are also involved after construction in preparing tax depreciation schedules, replacement cost estimation for insurance purposes and, if necessary, mediation and arbitration. With their increasing role in providing advisory services, project management, cost and value management [including life cycle costing analysis], it is apt to call 'quantity surveying' as 'project cost management' (Poon et al., 2000). With the unique and challenging nature of each construction projects, the current role of the quantity surveyor has become more strategic due to the proactive role in the management of costs in all phases of the project rather than just providing cost information for design proposals (Burnside and Westcott, 1999). Quantity surveyors are now well placed in the industry and regarded as major information handlers on construction projects as the majority of information flow has cost implications (Best et al., 1996).

With external factors playing a part in the roles performed by quantity surveyors, recent impact of the global financial crisis (GFC) has highlighted the need for quantity surveyors to pursue diversification of services and sectors. Leading edge QS firms which offered diversified services have withstood the impact of the crisis during the downturn times (Frei, 2010). With clients seeking value for money and collaborative relationships, there is a need for the profession to provide services with broader engagement, specialist insight and focus on value by adapting to innovative technology and to new socio cultural, political, legal and environmental exposures (Frei, 2010). While the role of quantity surveying professionals has changed over time, the quantity take-off (QTO) (also referred to as quantification) for the purpose of cost estimation and material ordering remains one of the core aspects of the quantity surveying practice. It still remains a basic skill leading to a competent quantity surveyor (AIQS, 2005; PAQS, 2001) and upon which whole life project financial management rests. Thus any technology that facilitates the quantification process has the potential to change and revolutionise the operation of the quantity surveying practice.

3. The Case for BIM-based Quantity Surveying Services

Traditionally, when estimating project cost, estimators do manual take-off or alternatively digitize architects paper drawing or import CAD drawings into a cost estimating software package to enable quantity takeoff. These methods are fraught with human errors and often lead to inaccuracies in estimates. Quantification errors may arise in the form of mistakes, arithmetic errors, processing errors, data extraction errors from drawings and data bases, and double or multiple counting (Olatunji, 2011). Inaccurate estimates have been identified as one of the major underlying sources of project failure in construction (Aibinu and Pasco, 2008). Many statistical/mathematical and intelligent models using historical data from completed projects have been developed to reduce inaccuracies in estimates (for example, Aibinu, *et al.* 2011). However, these mathematical models are inadequate due to the uniqueness of building. They are useful only at the early stage of projects development when the client is interested in indicative projects cost. With its computable information and single information-sharing model driven by a collaborative environment, theoretically BIM can offer many benefits to the quantity surveyor because of its quantity automation capabilities – important because when preparing cost estimates, quantity surveyors perhaps spend 50-80% of their time on quantity take-off (Autodesk, 2012). Other potential benefits include: help provide cost information consistent with the design, better visualization of design for costing purposes and overall time savings, to mention a few. Cost is one of the most important elements in a project development. Cost information is a feature of most of the role played by QS. Meanwhile, accurate cost estimating depends on accurate quantification. Thus technology (such as BIM) that potentially improves accuracy in quantification would impact cost estimating in a significant way and would impact all other services provided by the quantity surveyor and in turn would have positive implications for a project as a whole in terms of better outcome and value for money. Though BIM is said to have been in the industry for many years, the past few years have seen an increase in the use of BIM worldwide. While BIM is yet to be used in all construction projects worldwide, a study by McGraw Hill Construction in 2009 has indicated a significant increase in the use of BIM. A recent Australian study conducted in 2010 has indicated that use of BIM by the construction industry would provide potential economic benefits to the country and that it is being used by various industry players. However, it is not clear whether or not quantity surveyors find BIM a useful concept and whether they perceive a great benefit in the adoption of BIM-based quantity surveying services. It is also not clear what is the BIM experiences and perceptions of the quantity surveying profession in Australia and how much has BIM been adopted or how much are they ready for BIM adoption. Perception is important since culture, attitude and ultimately practice are driven by perceptions.

4. Australian Quantity Surveying Practice and Technology Adoption

In seeking to understand barriers to progress towards BIM or drivers of progress towards BIM, a brief overview of how Australia QS practice has been influenced by ICT in the past would be helpful. Australia has already made a significant contribution to the development and dissemination quantity surveying software. Estimator II was created in Melbourne in 1978 and was widely used by 500

clients across Australia, Southeast Asia and New Zealand. RIPAC software was sold in 1985. Development of Buildsoft software started in 1986 and has become popular across the industry with capabilities in the area of estimating, digitizer take off, palm pilot sight manager and progress claim, electronic tendering system, price guide to mention a few. ROSS software was developed by Rider Hunt in 1987 while CostX was released in 2003-2006 (Hemmett, 2008, in Sanders, 2008 page 324-333). In terms of widespread adoption of technology, according a survey (Smith, 2006) which studied the trends in the utilisation of automated quantities by the quantity surveying firms in Australia, non-user QS firms of electronic drawing, was reduced from 85% to 69% in 2005. This indicates that there are still QS firms which have not changed over to new technologies and still do the traditional quantification. Anecdotal evidence suggests that the advent of CAD has been received with mixed feelings. Some perceive CAD as a challenge to the QS profession and it could lead to the demise of the quantity surveyors (Sanders, 2008). Others offered a more optimistic view proposing that CAD as a tool that could offer QS a good opportunity at the early stage of design but if those opportunities are missed, and taken instead by other professions, there is the real danger that the growth of CAD will signal the demise of quantity surveying as distinct profession (Atkin, et al, 1987). There is no doubt the QS profession need to embrace the use CAD and or advanced way of working and tool such as BIM. They need to explore the opportunities inherent in BIM to deliver value in their areas of professional services. To make progress in this area, it would be useful to understand the BIM experiences and perceptions of quantity surveyors.

5. Research Method

This study investigates the BIM experience of quantity surveying firms in Australia and progress made by firms towards BIM adoption. A web survey was sent to 180 Quantity Surveying firms on the Australia Institute of Quantity Surveying business registry. 10 firms opted out of the survey and 3 email invitations bounced back. The effective surveys sent out are 177. Forty out of the 177 firms responded to the survey representing 23% response rate. 30% of the responses were received from New South Wales; 22.5% were from Queensland; 20% from Victoria while 12.5%, 7.5%, 5%, and 2.5% were from Western Australia, the Australian Capital Territory, South Australia and Tasmania respectively. The respondents are from diverse firm sizes, small, medium to large firms (35% employed 6-25 staff while 50% employed 0-5 staff, 5% employed 26 to 50 staff; 5% employed 51 to 100 staff and another 5% employed over 100 staff. Majority of the respondents were Partners or Company directors. 10% were Associate directors while 17% and 5% were Senior quantity surveyor and Quantity surveyor respectively. Also 45% of the firms have been in quantity surveying practice for more than 26 years while 47.5% have been in practice from between 6 to 25 years. Around 40% have annual turnover of over \$10million. Of the 40 respondents, 75% of them have more than 15 years of experience. When put together, the data comes from firms with significant years of experience and respondents who are at top management level. Hence their responses can be confidently relied upon. Estimating and Cost planning is a core activity of the majority of the firms. 62.5% are involved in non-traditional services such as construction planning project management, dispute resolution and feasibilities studies. 5% are involved in the development of estimating software.

The survey was designed to capture quantitative and qualitative data. Drawing from an illustration by Mr Carl Agar – the BIM Director of Sterling Group, Melbourne Area, at the ‘NATSPEC Implementing BIM’ seminar on Wednesday 9th of May 2012 in Melbourne, Australia we believed that BIM train has left the station worldwide and so this study wanted to know from QS perspective whether they are on board the BIM train, and whether they have the right people (skills) on board, and whether they are on the right seat in the BIM train. Additionally, we seek to explore whether or not the BIM train is heading in the right direction in Australia. Thus the survey contains open-ended and closed ended questions. Questions were directed at issues relating to progress towards BIM adoption, impact on staff/skills of progress towards BIM, difficulties with BIM, benefits of progress towards BIM, challenges/drivers of progress towards BIM adoption.

6. Findings and Discussion

6.1 Progress towards BIM adoption

In order to identity the progress of firms towards BIM adoption, respondents were asked to provide information about the current method of quantification used in the preparation of cost plan/estimates, bill of quantities and other services. The results show that 35% of the firms use only electronic measurement, 50% use both manual and electronic measurement while 15% of the firms still do paper based manual takeoff. The results suggest that 85% of the firms engaged in some form electronic take off indicating that a large number of firms are making use of the technology to follow the market trend and to make their services efficient. The finding also suggests that as new technologies evolve, most of the firms follow the industry in order to remain competitive in the market. Even though 85% use electronic measurement, 50% of them still combine electronic measurement with the use of traditional paper based measurement. This indicates that technologies have not completely eliminated the traditional ways of working. The findings showed that the majority of the respondents work with 2D drawings (around 94%) for performing professional tasks. Only 22% work with 3D drawings while 20% have worked with intelligent 3D models (parametric models). None of them have experience working with 4D and 5D models. CostX estimating software is the most dominant software used (67%). Some use Buildsoft (23%). CostX is an Australia based software but now sold in over 40 countries including the UK, Ireland, USA, UAE, Malaysia, Singapore, Hong Kong, New Zealand and across Africa. Costx has a 3D quantity automation capability. Buildsoft is also Australian based software with 3D viewing capabilities for walls and openings. There are other softwares such as CATO CAD/BIM Measure (used by 17% of the respondents), On-screen take off (by OnCentre) (used by 11%). Another question ask the respondents to indicate their involvement with BIM-based projects. 37% of the respondents have been directly involved in a BIM-based project in Australia (hereinafter referred to as BIM users). 63% have not been involved in any (hereinafter referred to as non-BIM users). A respondent indicated that they have just been appointed to their first BIM-based project. 19% of the BIM users have been involved in the past 3-5years while 36% of the BIM users became involved in the past 2 years another 36% in the past 1 year. Hence it appears that QS involvement in BIM projects has increased in the past 2 years. Only few 9% have been involved for more than 5 years.

The BIM-users were asked to indicate the number of BIM-based projects they have been involved. 8 firms responded. Overall 42 BIM-based projects were listed by the BIM users. On the average there are about 5 BIM-based projects per BIM user. It should be noted that one BIM user accounted for 19 (around 45%) of the BIM projects. This implies that the frequency of involvement in BIM by the QS is very low and only occurs in the past 2 years. A RICS survey of QS members in UK and US show a similar result (BCIS, 2011). On the nature of BIM-based projects in which the respondents have involved, more projects are located in Queensland when compared to the other states. Most are institutional projects by government projects. The projects ranged from less than \$10million to \$500 million. Majority are based on traditional procurement (around 60%), followed by Design and Build (40%). The problem is that full benefit of BIM cannot be realised in a traditional procurement method because the traditional procurement does not support collaboration and integration of disciplines within the project development process. It is likely that on the projects listed by respondent as BIM based projects, BIM was only used as a tool to facilitate the technical tasks of individual participants rather than as a collaborative or integration tool. Thus the full benefit of BIM cannot be realised and so maturity and progress toward BIM adoption is expected to be slow.

The data shows that in about 66 projects BIM was created by the design consultants, but was not issued to the QS. Majority of the projects in which BIM was used for providing QS services are traditionally procured institutional projects by government in Queensland, Victoria and Northern Territory. This is followed by commercial projects by private clients. Again because of the dominance of traditional procurement it is likely that for most of the projects QS used the BIM as a tool only for the technical tasks i.e. facilitate visualisation during quantification, rather than as a full collaborative platform and integration. The data shows that measurement and quantification for cost estimating was done using 2D drawings. It is consistent with previous result which shows that many of the firm still use 2D drawings with onscreen take-off.

On the project where QS used BIM, the data shows that QS used the BIM mostly at the tender documentation stage followed by conceptual design, sketch design and detailed design stage. This is not surprising since QS used BIM in traditionally procured project where there is a limited opportunity for the use of BIM as a collaborative tool. BIM in such instances are only used to prepared tender estimate based on completed design and the advantage might be that it offers QS a good visualisation of the design thereby facilitating quantification and so cost estimating. Only one firm reported that they have used BIM from the concept stage to construction stage.

When asked how BIM was used for their services, majority stated that it was used predominantly for cost planning and for preparing Bill of Quantities. Two respondents indicated they have used BIM for contract administration. None mention facility management. Thus BIM involvement of QS is only limited to design stage and especially when design is completed. In one of the 6 case studies reported by CRC (Corporate Research Centres) in Australia, 4D BIM was used for checking the claims by the quantity surveyor by comparing with the base program of the model. Overall, it would appear that overall BIM has only been used as a tool for specific tasks of QS especially at the design stage rather than a collaborative platform or for team integration involving QS.

6.2 Impact of progress towards BIM

The effect of changeover process from traditional working to BIM-based working on staffs' attitude was investigated. Respondents were also asked to state the investment needed to adopt BIM-based working as well as difficulties encountered. The respondents' years of experience in BIM, total number of staff in the firm, staff skilled in BIM-based working, and the number of BIM projects in which respondents firm have been involved were also investigated. Seven respondents answer this question. The results show that firms who have been involved in more BIM projects have more staff skilled to work with BIM. This is not unexpected because firms BIM capability would increase as BIM-based project workload increases. 57% of the respondents reported that their staff were enthusiastic with BIM-based working while 15% stated that their staffs were resistant. 14% indicated that their staff showed mixed reaction - resistant and enthusiastic. 14% reported that their staff were very cautious in learning to work with BIM. It is likely that staff attitude would change over time as firms' BIM-based work load increases and staff get used to working with new software and a new way. Not all take-off and estimating software has the same level of BIM capability. Thus the respondents were asked to name the software implemented prior and during their involvement in BIM. The results show that 57% of the firm have been working with BIM compatible software for quantification using 2D OR 3D drawings before working on their first BIM-based projects. 87% of the respondents now use CostX after their first BIM-based project. To work with BIM additional investment is required only if firms current software are not compatible with BIM models. Being a new technology with many uncertainties and more capabilities to be explored by software providers, the cost of implementing BIM may grow over time because most of the software undergo frequently improvement with new capabilities and new versions released within few years. For example since 2003 Exactal have realised numerous versions of CostX estimating software. This is true of most software and most technologies. The challenge is that firm working with a version would need to upgrade when new version is released. Sometimes, projects documented in old version cannot be imported into new versions. Thus firm have to maintain the old version to enable them continue work on ongoing project already set up in the older version. Still yet firm may need to subscribe to the newer version if clients demands require the use of some of the capabilities in the new version. This brings added cost and uncertainties for firms.

On the question difficulties encountered when working with BIM, 'information included in BIM not enough to enable automation of QS tasks' was rated the most difficult issue followed 'scarcity of skilled employee who can work with BIM'. When information assigned to objects in BIM model is not sufficient, quantity surveyors will have to revert to onscreen or manual take-off. 'Employee disengagement' and 'Employee turnover' rated lowest. Respondents indicated some strategies they are using to address these difficulties. Firms who indicated that information in BIM is often not sufficient to enable quantity automation are working with design consultants to embed quantification data in the model. One respondent stated: *'discussing with consultants and requesting changes to know how they set up the model'*. Another respondent who has used BIM for quantification/estimation in 3 projects in the past 2 years stated that they reverted back to traditional measurement method as a result of this difficulty. Though employee disengagement was rated low as one of the difficulties encountered, one firm having difficulties with staff attitude and training stated: *'we engage more*

employees with flexibility to use new software. We work with architects and engineers to ensure quality data is embedded in the model’.

6.3 Benefits of progress towards BIM

We investigated the experiences of respondents regarding the benefit of BIM for QS services. 6 respondents answered this question. Time savings (80%), visualisation (40%) and increased productivity (20%) were the benefits listed. However, one respondent stated that the time saved as a result of using BIM provides them with more time to analyse design options, reduction in intensive take-off, and ability to advise design team on areas of cost overspend. However, one other firm stated *‘[BIM] will be quicker for take-off but not until the consultants get up to speed with drawing the model correctly’*. Another respondent stated that benefits are *‘very little. BIM models are created with a different end goal to what QSs have. The information is not easily reconciled to QS measurement – in our experience’*. The benefits of BIM in a project cannot be realised by the quantity surveyors until the model issued to them are embedded with the required information needed for automating QS tasks. With insufficient and incorrect information, QSs may end up spending more time taking-off quantities manually. Another implication is that QS may spend more time checking the correctness and accuracy of the model and so the time savings may not be realised in the short run. This was expressed by one of respondents during the follow up interview.

6.4 Barriers to the adoption of BIM and Drivers

It is expected that BIM being a smart technology that facilitate collaboration and reduces complexity by providing better visualisation should be adopted widely by quantity surveyors to enhance their role in the project development process. However, findings from this study showed that there are certain barriers to the adoption of BIM by QSs.

Respondents in this study reported that in about 66 projects, BIM was created but was not made available to the quantity surveyors. It is possible that a project is BIM-based but the BIM may not applicable to QS services. Requirement for BIM-based QS services would depend on BIM brief for each project and would depend on the objective and the goals of BIM for the project. For example, some clients may request for BIM to facilitate post construction facility management purposes or operations rather than for containing cost within a limit. Thus clients demand can play a vital role in driving practices to make progress towards BIM. Low clients demand may also be as a result of uncertainties regarding BIM for certain tasks and in turn may be occasioned by a perceived lack of industry capability by clients. In that regards the role of public sector clients as facilitators of BIM adoption would be crucial.

BIM users were asked to state the initiator of BIM concept in BIM-based projects where they used BIM for QS professional services. The results show that in 40.6% of the projects BIM was initiated by the consultants, 25% - by client, and 25% by contractor and in 3 cases (9.4%) BIM was used for research. It appears that the clients demand for BIM-based services is generally low in Australia.

Consultants (engineers and architects) appear to be the parties driving BIM. This is consistent with historical development of the professions. BIM process is mostly driven by parametric models which is a core domain of the designers (Architects and Engineers). It is therefore not surprising that consultants are the dominant initiators of BIM. It has been said that the most effective way to make professionals embrace 3D design is through procurement contracts for projects (Teo and Cheng, 2011). While the activities of the public sector in some other countries are significant in driving BIM, the same cannot be said of the Australia public sector. Most of the BIM development in Australia has been driven by NATSPEC and BuildingSMART Australasia. There has been little support for driving BIM by Australian public agencies. Probably these agencies lack in-house capabilities to deal with digital files. Although the Built Environment Industry Innovation Council (BEIIC) set up by the Department of Industry, Innovation Science Research and Tertiary Education has produced a number of reports about the economic benefits of BIM and issues surrounding BIM there is been little or no concrete commitment and activities to realise some key outputs that could drive adoption of BIM in Australia when compared with other countries. One government agency taking the lead in BIM is the Queensland project Services. It is no surprise that the finding of this study shows majority of the projects in which BIM was used for providing QS services are traditionally procured institutional projects by government in Queensland.

We asked the users of BIM and the non-users to list the barriers and factors that would drive the use of BIM by QS. 27 respondents answer this question. The Responses were analysed using content analysis. 'Quality Information in Models' was most frequently cited by respondents followed by 'Case studies to demonstrate the benefits of BIM', 'Cost benefit analysis', 'Client's requirement', 'Ease of use', 'industry wide use'. One respondent cited 'Scenario training'. 'Insufficient or lack of information' by the design consultant is a common problem with the traditional take-off process (where QS measure from 2D or 3D drawings). Thus the cost of switching to BIM tool cannot be justified unless BIM overcome this problem. In fact during the follow-up interview one respondent stated that there is marginal time savings with BIM because they have to spend a significant proportion of the time checking the accuracy of the model prior to quantity automation.

Apparently, problems inherent in BIM can hinder its adoption. In fact one respondent stated that on one project they reverted to the traditional measurement and quantification because of the difficulties they encountered with the BIM. It is surprising that only 2 respondents cited 'Integration with current software' as a driver because one of the widely identified barriers to use of BIM is data interoperability of different software applications with BIM software. This is likely to be a reflection of the fact that non-BIM users accounted for 55% of the respondents. It is likely that non-users of BIM may not fully understand the 'data interoperability' challenges involved in BIM since they lack experience working with BIM. Also, this may reflect the level of experience of BIM users experience with BIM. Most of the BIM users have only used BIM as tool for front end project services such as cost planning and cost estimating at the design and tender documentation stage. Data interoperability becomes a more serious barrier when BIM is used as a collaboration tool as well as where firms have to use BIM for providing services such as financial analysis, contract administration, life cycle cost analysis and Facilities management. The problem is there are now many tools available for different tasks and processes in the project development process (design, construction, operation). In many cases, players use different tools for doing the same task. So, firms existing software may not be

compatible with BIM software or with other players' applications thereby making it difficult to use the BIM as collaborative tool or to integrate disciplines. Also, data created in some applications may be digital but may not be computable thereby constitute a barrier to the full adoption of BIM.

It appears that model progression specification – how to produce models that is useful for quantity estimating is a big issue that need to be addressed if QS must progress quickly toward BIM adoption. This is beyond the QS profession alone but the industry at large especially the designers. When respondent were asked to list barriers to adoption of BIM, cost of implementation was the most frequently cited, followed by incomplete model lack of knowledge, learning time, consultant attitude and change aversion. Cost items includes: software licensing and server capacity in relating to storage of data as QSs are not used to having such a high IT requirements. However, cost of implementing new software would depend on the firms existing IT facility. One respondent is concerned that where models are inaccurate the accuracy of estimate still remains the responsibility of the QS. This flags a legal issue that BIM need to address. One respondent states: *We have reviewed the BIM systems, but in our opinion it does not provide accuracy in measurement. Remember the quantities are only part of the BOQ, descriptions are more important than quantities. Quantity Surveying in the production of BOQs is about communicating in words what is on a two dimensional drawings into words that a sub-contractor can understand and price to reflect the scope of work. Computers cannot communicate the nuances of construction.*

A significant number of respondents stated 'lack of knowledge' of what needs to be done in the implementation/ change over from the traditional working to BIM working as a barrier to its adoption. Some are concern that the time needed to learn the new way of working, studying of projects in BIM would affect their business. Few respondents also claimed that design consultants are reluctant to share their model. Some cited aversion to change and the need for cultural change as well as resistance by older QS to new technology. Some of these barriers are consistent with previous studies.

Broadly speaking, it appears (or it may be deduced) that the barriers to the adoption of BIM by Australia QS are related to lack of demand by clients, contract/legal issues and uncertainties, information and communication issue about BIM, lack of standards and lack of information on need for business process changes and how to change those processes, skills transformation and adaptation issues, technology change and ability of firms to adapt to the change from cultural perspective and financial perspective. A review of BIM development in other countries suggests that the role of the public section agencies in driving adaption BIM is critical (Teo and Cheng, 2011). Based on national and government initiatives countries such as Singapore, Norway, US, and UK are now increasing the uptake of BIM. By 2016 it is a required that all UK government projects valued GBP5million and over must be procured with collaborative 3D BIM incorporating all projects and asset information, documentation and data transfer in electronic format. Similarly, in the US government agencies such as the US Department of Veteran affairs (VA) have been at the forefront of driving BIM. VA is committed to moving both the organisation and its services providers to BIM as effectively and efficiently as possible to integrating BIM process requirement and Integrated Project Delivery methodologies into its delivery requirements (VA BIM Vision). All projects (major construction and renovation) at over \$10million are now required in BIM as design platform starting from 2009. VA have developed VA BIM guide and BIM object/element matrix manual which may be used for

identifying and tracking BIM information during project. BIM element matrix depicts Building Information typologies/types. It attempts to standardise information necessary to include in BIM models at the creation and at various stages of development. In Singapore, the role of public sector client is also significant in driving BIM.

As far back as 1995, Singapore launched a strategic initiative - the Construction and Real Estate Network (CORENET), spearheaded by the Ministry of National development. The aim was to drive the construction industry through IT and especially BIM (Teo and Cheng, 2011). Through CORENET, e-plan check system was developed which is an automatic plan checking system for building permissions. The Singapore building and construction authority (BCA) implemented e-submission system as far back as 2001. It is an expert system that allows consultants to check their design for compliance with the regulation through the internet. It has been described as the largest projects ever undertaken by a government agency in support of BIM technology (Teo and Cheng, 2011). Singapore building and construction authority (BCA) has now set a goal to have BIM implemented into public construction by 2015. Also, Singapore has set up a centre for construction IT by the BCA as a means of educating industry in ICT research and development and help pioneering companies to kick-start the adoption of new technology and to build-up industry wide ICT adoption roadmap for the rest of companies (Centre for Construction IT, 2010). In Australia, the role of the public sector in driving BIM adoption is very minimal.

It is however important to note despite the little role being played by government agencies, in Australia there is now a National BIM guide developed by NATSPEC – a not-for-profit organisation owned by professional associations. The guide was adapted from US VA BIM guide. NATSPEC has also conducted study towards the development of construction information classification system for Australia as well as a series of seminar and workshop around the country. Despite the activities of NATSPEC, it is inconceivable how BIM adoption can increase and progress significantly across the industry without a more serious involvement of the public sector.

7. Conclusion

Automation of quantities and an integrated information exchange achievable through Building Information Model has the potential to enhance the services provided by QS firms. As a result of the potential for time savings, BIM with computable data should be readily adopted by QS firms. This study has investigated the progress towards BIM of QS firms in Australia. It appears that BIM is not readily adopted by QS firms due to the incompleteness of the model, lack of knowledge and cost of implementation. QS firms mostly use BIM in the form of computer aided take-off in the project's front end tasks of cost planning and bill of quantities and cost estimating rather than in quantity automation, collaboration and as integration platform. If the quality of information embedded in BIM is not improved, QS would not benefit from the potential advantage that BIM can offer because QSS would need to spent time checking the accuracy of BIM. As a result time savings promised by BIM may not be realised. On top of that the information embedded in BIM need to be digital and computable and in the format that would make it useful for QS services. This can only be achieved if QS work closely with design consultants to define the information need to make BIM useful for QS

tasks and services. BIM may be able to generate quantities however BIM tool at the moment cannot provide automated description of items. Can BIM tool communicate the nuances of construction to enable QS price a project? This is yet to be seen. Thus the ability of BIM tool to store digital and computable information is crucial to make QS realise the automation capacity of BIM. Some QSs still lack the knowledge of what business processes to implement and changes in order to switch from traditional working to BIM based working. Some are unsure whether or not the initial cost outlay to switch to BIM is justified. There is need for documented case studies to show how BIM can bring savings to QS work. There is also need for more awareness about BIM, cost and benefit, challenges, and how the challenges can be addressed. Some respondents have stated that they will use BIM if there is a requirement from client, whereas few have responded that the wide spread use of BIM by the industry which includes other consultants would drive the use by quantity surveyors. Finding ways of integrating BIM software with existing tools would reduce initial cost of change over as well as would increase adoption. Scenario based training can provide an actual hands on experience for the user with the ability to venture into the real project with confidence. On projects where BIM is required by the client quantity surveyors should not wait till the model is created but put effort on their side and liaise with the designs consultants early in the project to set their requirement in the model. Overall, there is need for a more serious involvement of the Australia public sector client if we must see a significant adoption of BIM across the industry ad by QS. It more likely that or firms would adapted quickly when BIM become a procurement requirement in government contracts and supported by government initiatives to help firms adapt to the change. Because of the various dimension involved, maturity and progress toward BIM adoption would also depend on coordinated effort of the various stakeholders across the industry.

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