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A CROSS DISCIPLINE COMPARISON OF RANKINGS FOR E-PROCUREMENT DRIVERS AND BARRIERS WITHIN UK CONSTRUCTION ORGANISATIONS

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SUMMARY: *A defined set of drivers and barriers to construction e-procurement has been identified by Eadie et al (2010). These were ranked from a Quantity Surveyor's perspective. In a similar study, Eadie et al (2007) ranked drivers and barriers to e-procurement from a construction contractor's perspective for the Northern Ireland public sector.*

The current study provides a cross discipline comparison of drivers and barriers to construction e-procurement encompassing the views of quantity surveyors, public sector clients, architects and engineers establishing the level of uptake by different disciplines. A telephone survey of 775 organisations mapped the current practice of e-procurement in construction within the United Kingdom. This telephone survey was followed by a web-based questionnaire survey. The web-based survey gauged the ranking of drivers and barriers to e-procurement of organisations that have implemented e-procurement for construction related activities. The web-based survey produced a ranking for each driver and barrier across the construction industry. The overall ranking for all types of construction organisations (across disciplines) identified "Prevention of Tampering with Documents - changes to documents", followed by "Confidentiality of Information - unauthorised viewing" as the most important barriers for UK construction organisations. The two most important drivers identified are "Process, Transaction and Administration Cost Savings" and "Convenience of archiving completed work". The complete set of rankings will provide an insight in to the effect of different drivers and barriers to construction e-procurement while identifying their relative importance in e-procurement related strategic investment decision making.

KEYWORDS: *Drivers and Barriers to e-procurement, construction e-procurement*

REFERENCE: *Eadie R, Perera S, Heaney G (2010) A cross-discipline comparison of rankings for e-procurement drivers and barriers within UK construction organisations, Journal of Information Technology in Construction (ITcon), Vol. 15, pg. 217-233, http://www.itcon.org/2010/17*

1. INTRODUCTION

Rankin (2006) defines e-procurement as the business to business purchase and sale of products and services by electronic means (today primarily using the internet). Hore et al (1997) showed that tendering is "*a procedure to select a suitable contractor, at a time appropriate to the circumstances, and obtain from him at the proper time, an acceptable offer upon which a contract can be let*." IDEA (2008) defines completing the tendering process electronically (e-procurement) as "*an electronic tendering solution that facilitates the complete tendering process from the advertising of the requirement through to the placing of the contract*".

Eadie et al (2010) reviewed seventeen published works showing the benefits that implementation of e-procurement can achieve. Despite these benefits, Martin (2003, 2008) shows that the uptake has not been as expected within the construction industry. This paper investigates the current status of the uptake of e-procurement across the various disciplines in the construction industry. It presents a further investigation into the aspects of e-procurement that have assisted in its introduction and the barriers that make organisations reluctant to implement it.

The variables which influence the uptake of e-procurement were divided into two groups. Those that supported the implementation of e-procurement are positive determinants that act as *drivers* in promoting e-procurement and were placed in the first group. The second group contained those items which created challenges to the embedding of e-procurement within construction organisations and are classed as *barriers*. Activities which produce a positive result will therefore be denoted by the term drivers and conversely those producing a negative effect as barriers.

Martin (2008) states that implementation of e-procurement in construction has been slow and that less than 20% of construction organisations use e-procurement in the UK. The significance of ranking the importance of the drivers and barriers to e-procurement in construction is imperative to gaining a comprehensive understanding of the reasons for the lack of its implementation. The identification of the driver and barrier importance in e-procurement will also allow the development of a model to embed e-procurement in construction. As a precursor to this current research, Eadie et al (2007) carried out a preliminary study into drivers and barriers in construction. This study used drivers and barriers identified to e-procurement from other industries and determined their applicability and ranking in construction. Eadie et al (2010) reported on a verification process using an expert forum and Delphi methodology to confirm which drivers and barriers were relevant to construction. They further reported the ranking of these drivers and barriers specifically to a sample of Quantity Surveying practices. The current research expands on Eadie et al (2010) by ranking the drivers and barriers to construction e-procurement from the perspective of all relevant disciplines. This produced a combined ranking with input from public and private sector clients, engineers, architects and quantity surveyors.

Martin (2008) indicates that e-procurement is starting to accelerate within the construction industry. However, despite the benefits collated in Eadie et al (2010), Martin (2008) further identifies that this is still not at the level of other sectors. Investigating the drivers and barriers to construction e-procurement will provide a construction industry insight and will assist in embedding electronic solutions within construction. Eadie et al (2010) identified the drivers and barriers to e-procurement in a construction context as construction is different to manufacturing.

Eastern v. EME Developments (1991) 55 BLR 114 defined the differences between construction contracts and general goods and services contracts. The decision stated "*the most important background fact which I should keep in mind is that building construction is not like the manufacture of goods in a factory. The size of the project, site conditions, the use of many materials and the employment of various kinds of operatives make it virtually impossible to achieve the same degree of perfection that a manufacturer can. It must be a rare new building in which every screw and every brush of paint is absolutely correct*".

This decision shows that construction is concerned with creating a unique product, built on site and in accordance with a set of drawings and specifications. Manufacturing, on the other hand, is concerned with mass producing an item with minimum unit cost and maximum output. Noting these differences, the ranking, and hence significance, of e-procurement drivers and barriers within the construction industry may be different than the rankings for the procurement of general goods and services. Unlike manufacturing, the construction industry is deeply fragmented with possible variations in the effect of each driver and barrier to construction e-procurement. The differences in the rankings between manufacturing and construction were first investigated by Eadie et al (2010) when an investigation was carried out into the rankings from a quantity surveyor perspective. A knowledge gap therefore exists in the ranking of drivers and barriers from the perspectives of other disciplines. This paper aims to fill this knowledge gap and expand the rankings to other construction disciplines.

2. CONSTRUCTION E-PROCUREMENT DRIVERS AND BARRIERS IDENTIFIED FROM LITERATURE

Eadie et al (2010) reported the following collated set of drivers and barriers to construction e-procurement (TABLE 1 and TABLE 2) and ranked them from the data obtained from Quantity Surveyors. The current research investigates further how these same drivers and barriers are ranked by other disciplines within construction, and compiles the results into a cross disciplinary set of ranked drivers and barriers. It is important to compile drivers and barriers that all disciplines have ranked to enable system developers and strategic decision makers to work on programmes which take all the concerns (barriers and drivers) into account.

Table 1 and Table 2 were constructed as a result of a Delphi process carried out using an expert forum to investigate the applicability to construction organisations of an exhaustive list of drivers and barriers to e-procurement in the goods and services industries identified from literature. A complete list of this literature is provided in Eadie et al (2010). Until the publication of Eadie et al (2010) a defined list of e-procurement drivers and barriers did not exist for the construction industry. In that research, a focus group was established using five domain experts. These represented the various aspects and levels of expertise of construction e-procurement, namely: web-based materials procurement, e-auctions, compact disc write once (CDR) e-tendering, the contractor's perspective and electronic document production. This group produced a comprehensive list of construction-based e-procurement drivers and barriers. The study confirmed that the majority of the drivers and barriers to e-procurement in the goods and services industries applied to construction. It further identified additional drivers and barriers which solely applied to the construction industry and verified a banding suggested by the context of the drivers and barriers mentioned in the identified literature. A detailed questionnaire for a web-based survey was produced from the findings of this focus group to ascertain the importance rankings of these drivers and barriers. Following on from this a telephone survey of all Quantity Surveyors within the United Kingdom, listed on the Royal Institute of Chartered Surveyors (RICS) website, identified those who used e-procurement. This produced a ranking of the identified drivers and barriers from a quantity surveyor perspective. However, this still left a knowledge gap as the remainder of the construction industry had not been studied. This current research subsequently identified rankings from the perspective of other construction organisations. It followed the same methodology where a phone based survey identified organisations using e-procurement in construction. It then used a similar web-based questionnaire survey of the identified organisations using e-procurement in other sections of construction for construction-based activities to allow comparability. The results of this survey are reported within this paper.

For the first time the initial Delphi process provided an exhaustive list of drivers and barriers and confirmed the suggested banding for construction. This list and the categorisation from this process are reproduced in Table 1 and Table 2.

TABLE 1: Final list of Drivers after completing the Verification Process (Eadie et al, 2010)

No	**Drivers from Literature and Delphi Process**	**Banding**
1	Process, Transaction and Administration Cost Savings	Cost
2	Service / Material / Product Cost Savings	Cost
3	Increasing Profit Margins	Cost
4	Strategic Cost Savings	Cost
5	Enhanced Inventory Management	General
6	Shortened Overall Procurement Cycle Times	Time
7	Shortened Internal and External Communication Cycle times	Time
8	Reduction in time through greater transparency (Less objections)	Time
9	Reduction in Evaluation Time	Time
10	Reduction in purchasing order fulfilment time - Contract Completion	Time
11	Reduction in time through increased visibility	Time
12	Increased Quality through increased competition	Time
13	Increased Quality through Benchmarking (Market Intelligence)	Quality
14	Increased Quality through increased visibility in the supply chain	Quality
15	Increased Quality through increased efficiency	Quality
16	Increased Quality through Improved Communication	Quality
17	Gaining Competitive Advantage	General

18	Increased Quality through increased accuracy (Elimination of errors through Computer use)	Quality
19	Convenience of archiving completed work	General
20	Develops the Technical Skills, knowledge and expertise of procurement staff	General

TABLE 2: Final list of Barriers after completion of the Verification process (Eadie et al, 2010)

	Barriers from Literature and Delphi Process	**Banding**
1	Upper Management Support / Lack of Leadership	Cultural
2	Other Competing Initiatives	Cultural
3	Resistance to change	Cultural
4	Lack of a widely accepted e-procurement software solution	Cultural
5	Magnitude of Change	Cultural
6	Lack of a national IT policy relating to e-procurement issues	Cultural
7	Lack of Flexibility	Cultural
8	Bureaucratic dysfunctionalities	Cultural
9	Complicated procedures and extended relationships	Cultural
10	Lack of technical expertise	Cultural
11	Staff turnover	Cultural
12	Company access to the internet	Infrastructure
13	Insufficient assessment of systems prior to installation	Infrastructure
14	Security in the process - Data transmission to the wrong person	Security
15	Confidentiality of information - unauthorised viewing	Security
16	Prevention of tampering with documents - changes to documents	Security
17	Data transmission reassembly - incorrect reassembly of data transmitted in packets	Security
18	Partial Data Display - incomplete documents provided	Security
19	Lack of pertinent case law	Legal
20	Different national approaches to e-procurement	Legal
21	Proof of intent - electronic signatures	Legal
22	Clarity of sender and tenderer information	Legal
23	Enforceability of electronic contracts	Legal
24	Information technology investment costs	Assessment Costs
25	Internal and External interoperability of e-procurement software	Compatibility
26	Investment in compatible systems	Compatibility
27	Reluctance to 'buy-into' one off systems	Compatibility
28	Perception of no Business Benefit Realised	General
29	Lack of publicity / awareness of best practice solutions	Cultural
30	Lack of a forum to exchange ideas	General

3. RESEARCH METHODOLOGY FOR THE IDENTIFICATION AND RANKING OF CONSTRUCTION BASED E-PROCUREMENT DRIVERS AND BARRIERS

A methodology similar to that used in Eadie et al (2010) was employed to achieve a comparable data set to that of the previous studies (Eadie et al 2007). The data for all main professions were evaluated and matched against the previous published results to produce a comparison. Figure 1 presents the breakdown structure of the entire research programme and shows where the various sections of the study have been published.

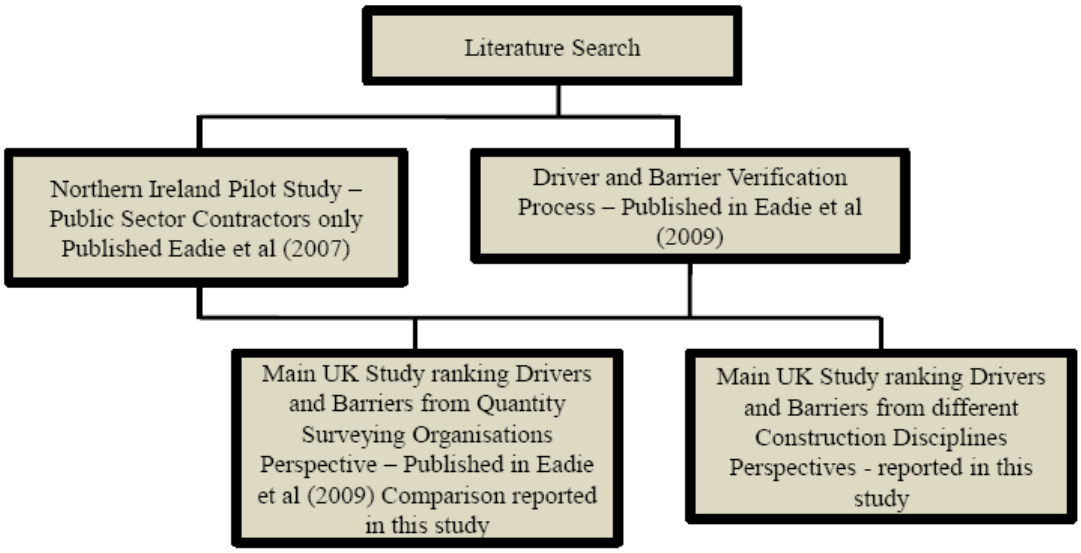

FIG. 1: Methodological Approach to Study

A total of 775 construction organisations were surveyed from January to March 2008; this included 483 surveyors, 42 Public Sector clients, 172 Architects, 35 Private sector clients and 43 Consulting Engineers. A total of 42 Public Sector Clients were identified from published sources such as the "Local gov" website (Local Government UK, 2007) and the yellow pages for Central Government departments (Yell Limited, 2007). A full list of 35 private sector clients were added from a list of clients from the NIFHA database (NIFHA, 2007) who had carried out work related to housing schemes. The study included all 172 architects listed by the Royal Institute of British Architects, Northern Ireland. All 43 current members of the Association of Consulting Engineers, Northern Ireland were also included in the study. All the organisations were contacted by telephone to confirm they had e-procurement experience and were willing to partake in the survey. Once these conditions were established the representatives of the organisations were then asked to complete the web-based survey. The study also provided useful statistics for the level of e-procurement usage within the United Kingdom across the disciplines surveyed.

Table 3 shows the number of organisations contacted during the telephone survey and the percentage of valid responses obtained. These values show the extent of the survey (% valid response) and show that the results are statistically significant and hence can be generalised across the UK industry.

TABLE 3: Sample Valid Response Breakdown by Discipline

Discipline	Total Number of Organisations	Number of Organisations using E-Procurement	Number of Organisations not using E-Procurement	Number of Organisations not contactable, no longer trading or with no one available for comment	% valid response
Quantity Surveyors from Eadie et al (2010)	483	83	247	153	68%
Public Sector Clients	42	29	10	3	93%
Architects	172	12	156	4	98%
Private Sector Clients	35 in sample	0	35	Not applicable	
Consulting Engineers	43	4	25	14	67%
	775	128	473	174	77%

TABLE 4: Comparison of Cross Discipline E-Procurement Usage

Discipline	% using E-Proc.	% not using E-Proc.	% not contactable or with no one available for comment	Number with results	% of contactable sample using E-proc.	% of contactable sample not using E-proc.
Quantity Surveyors from Eadie et al	17%	51%	32%	330	25%	75%
Public Sector Clients	69%	24%	7%	39	74%	26%
Architects	9%	89%	2%	168	9%	91%
Private Sector Clients	0%	0%	0%	35	0%	100%
Engineers	9%	58%	33%	29	14%	86%
Overall	16.5%	61%	22.5%	601	21%	79%

Table 4 indicates that the UK public sector is foremost in using e-procurement, with 74% of organisations involved in e-procurement. Knudsen (2003), Minahan and Degan (2001), and Martin (2008) all show that the introduction of e-procurement produces significant cost savings. It has been suggested that the means of achieving the cost savings is through efficiency savings in the process. Knudsen (2003) points out that e-procurement is a lean channel for communication and a rapid method of connecting sources and clients thus producing these savings in the private sector. Writing about government purchasing Panayiotou et al (2003, p.79) confirm that this applies to the public sector as well stating that *"E-Procurement solutions make corporate purchasing activities more efficient and cost effective"*. With a large number of organisations still to implement e-procurement in construction, the private sector could benefit from these savings after adoption; however, the results also show that less than 25% of all the organisations surveyed use e-procurement.

Martin (2008) shows that less than 20% of the Quantity Surveying organisations reported that they carried out e-procurement in construction. The current research produced a similar result with 25% of Quantity Surveying organisations using e-procurement. To date there have been limited publications on the usage of e-procurement by other disciplines within the construction industry: this research addresses the gap in knowledge. Data was collected in 2008 using Limesurvey™, a system similar to that used by Solomon (2001). This software enables the survey data to be collected through a web-based interface and stored in an online MySQL™ database. Subsequently, data collected was exported directly into SPSS™ for analysis.

Table 5 presents the validity percentages for each of the disciplines.

TABLE 5: Main Survey comparison of validity percentages

Location	Number using E-Proc.	Number not willing to take part in the Web-based survey	% of complete sample From phone survey stating willingness to complete	Number of Organisations that completed the Web-based survey	% valid response
Quantity Surveyors from Eadie et al	83	32	61%	29	57%
Public Sector Clients	29	6	79%	21	91%
Architects	15	6	73%	5	45%
Engineers	4	2	50%	1	50%

Table 5 indicates that an exceptionally high rate of participation has been achieved for the public sector clients (91% valid responses). All other disciplines with the exception of the Architects and Engineers achieved a sample that is high enough to warrant generalisation across the disciplines as they met the 50% criteria stipulated by Rubin and Babbie (2004). This allowed analysis to be carried out on the public sector clients separately in a similar way to that carried for the Quantity Surveyors in Eadie et al (2010). A further separate analysis was carried out on all the combined results obtained from all the disciplines in the construction industry. This produced an overall rank. These results included those from the Quantity Surveyors (Eadie et al 2010), the public sector clients (reported in the current research) and the architects and engineers (who due to lack of adequate quantity of data could not be analysed separately – 5 responses from Architects and 1 from Engineers). The lack of responses from both Engineers and Architects is somewhat explained by the fact that most of tender (bid) procurement activities for construction projects in the UK are carried out by Quantity Surveyors (often working for the Architect or the Engineer). This argument is further supported by Table 2 indicating the low percentage (9%) of e-procurement usage by Architects and Engineers. Therefore, it can be deduced that most of the Private Sector e-procurement activities are undertaken by Quantity Surveyors.

As the RICS web-based list contained Quantity Surveyors from the private sector only and as the remaining private sector submission from the Architects and Engineers amounted to 7% of the sample, the quantity surveying data was deemed as being representative of the private sector. A further analysis was carried out to identify the top three drivers and barriers after the addition of the 5 responses from Architects and 1 from Engineers. The public sector clients carry out all public sector procurement that is not outsourced to the private sector. They are therefore representative of the public sector.

The data for all the disciplines in the private sector (including the architects and engineer) and public sector clients were merged and a separate combined data analysis was carried out to produce the overall rankings considering all members of the construction industry who carry out e-procurement.

In summary, three separate analyses were carried out:-

1. Analysis of the Quantity Surveyors on their own (Eadie et al (2010), representing private sector responses. The method of calculating the private sector rankings (R_{pvt}) is described below.

$$R_{Pvt} = \frac{\sum_{i=1}^{l} R_i}{l}$$

Where: R_{pvt} is the private sector ranking

R_i is the individual rank from the Quantity Surveyors

l is the total number of responses from Quantity Surveyors

2. Analysis of the Public Sector Clients on their own (reported in this paper), representing public sector responses. The method of calculating the public sector rankings (R_{pub}) is described below.

$$R_{Pub} = \frac{\sum_{i=1}^{m} R_i}{m}$$

Where: R_{pub} is the public sector ranking

R_i is the individual rank from public sector clients

m is the total number of responses from public sector clients

3. A combined analysis of the Construction Industry which included all disciplines: Quantity Surveyors, Public Sector Clients, Architects, and Engineers (reported in this paper in the 'Construction Industry Rank' Column.) The method of calculating the construction industry rankings (R_{ci}) is described below.

$$R_{CI} = \frac{\sum_{i=1}^{n} R_i}{n}$$

Where: R_{CI} is the construction industry ranking

R_i is the individual rank from all responses

n is the total number of responses calculated by $n = l + m + x$

l is the total number of responses from Quantity Surveyors

m is the total number of responses from public sector clients

x is the number of responses from engineers and architects

4. RESULTS OF THE SURVEY

4.1 Driver Results of the Web-based Survey

TABLE 6 shows a cross discipline comparison of how the Private and Public Sector across the UK ranked the drivers for e-procurement.

TABLE 6: Rank Order comparisons for Drivers for e-procurement

Drivers in rank order	Private Sector Rank R_{pvt}	Public Sector Rank R_{pub}	Construction Industry Rank R_{CI}
Process, Transaction and Administration Cost Savings	1	1	1
Convenience of archiving completed work	2	1	2
Increased Quality through increased accuracy (Elimination of errors through Computer use)	2	6	3
Shortened Internal and External Communication Cycle times	6	5	4
Increased Quality through increased efficiency	4	7	5
Shortened Overall Procurement Cycle Times	9	3	6
Increased Quality through Improved Communication	5	10	7
Strategic Cost Savings	13	3	8
Service / Material / Product Cost Savings	8	10	9
Reduction in Evaluation Time	10	7	10
Develops the Technical Skills, knowledge and expertise of procurement staff	14	16	11
Increasing Profit Margins	7	19	12
Increased Quality through Benchmarking (Market	17	9	12

Intelligence)			
Reduction in purchasing order fulfilment time - Contract Completion	11	13	14
Enhanced Inventory Management	17	14	15
Reduction in time through greater transparency (Less objections)	16	12	16
Reduction in time through increased visibility	14	18	17
Increased Quality through increased visibility in the supply chain	19	17	18
Increased Quality through increased competition	20	14	19
Gaining Competitive Advantage	11	20	20

This shows, in overall terms, the two most important drivers identified by the Construction Industry Rank (Table 6) for UK construction organisations are "*Process, Transaction and Administration Cost Savings*" and "*Convenience of archiving completed work*".

4.2 Barrier Results of the Web-based Survey

Table *7* shows a cross discipline comparison of how the Private and Public Sector across the UK ranked the barriers to e-procurement.

TABLE 7: Rank Order comparisons for Barriers for e-procurement

Barriers in rank order	Private Sector Rank R_{pvt}	Public Sector Rank R_{pub}	Construction Industry Rank R_{CI}
Prevention of Tampering with Documents - changes to documents	1	2	1
Confidentiality of Information - unauthorised viewing	6	3	2
Resistance to change	6	1	3
Reluctance to "Buy-into" one off systems	2	23	4
Proof of intent - electronic signatures	3	4	4
Lack of a widely accepted e-procurement software solution	6	4	6
Security in the process - Data transmission to the wrong person	10	4	6
Insufficient assessment of systems prior to installation	3	17	8
Lack of a national IT policy relating to E-Procurement Issues	6	10	9
Data Transmission reassembly - incorrect reassembly of data transmitted in packets	14	17	10
Partial Data Display - incomplete documents provided	15	13	10
Bureaucratic dysfunctionalities	18	7	12
Lack of technical expertise	15	10	13
Internal and External interoperability of e-procurement software	11	13	13
Investment in compatible systems	11	19	15
Lack of Flexibility	17	13	16
Lack of publicity / awareness of best practice solutions	13	10	17
Enforceability of Electronic Contracts	3	22	18

Upper Management Support / Lack of Leadership	21	9	19
Magnitude of Change	18	13	20
Other Competing Initiatives	23	7	21
Complicated procedures and extended relationships	26	19	21
Clarity of Sender and Tenderer Information	23	19	21
Lack of a forum to exchange ideas	25	26	24
Information Technology Investment Costs	18	29	25
Lack of Pertinent case law	22	25	25
Perception of no Business Benefit Realised	26	26	27
Different national approaches to e-procurement	26	26	28
Staff Turnover	30	23	29
Company Access to the Internet	30	30	30

This highlights, in overall terms, the two most important barriers identified by the Construction Industry Rank (Table 7) are "*Prevention of Tampering with Documents - changes to documents*", followed by "*Confidentiality of Information - unauthorised viewing*".

5. ANALYSIS OF DRIVERS AND BARRIERS TO E-PROCUREMENT

This section analyses the top five drivers and barriers for the construction industry and compares the public and private sector ranking of the drivers and barriers using the results shown in Table 6 and Table 7.

5.1 Analysing the Drivers for e-procurement

5.1.1 Process, Transaction and Administration Cost Savings

Process, Transaction and Administration Cost Savings was the driver ranked highest by both the public and private sectors. This ensured that it was ranked highest in the 'Construction Industry Ranking'. This driver was a combination of the "*Reduced Administration Costs"* and "*Price Reduction in Tendering*" drivers ranked by Eadie et al (2007) for the Northern Ireland public sector contractor's organisations where they were ranked second and third overall, respectively. These two drivers were combined during the driver and barrier verification process by a forum of experts using a Delphi technique (Eadie et al, 2010). Quantity Surveying organisations ranked this combined driver in first place. Therefore, the construction industry ranking shows that this is the most important overall driver for e-procurement in construction. This agrees with the findings of McIntosh & Sloan (2001) and Ribeiro (2001) in their assessment of the goods and services industries as they support this assessment of e-procurement suggesting that industry wide adoption of e-procurement initiatives could significantly streamline the material procurement processes and bring speed, flexibility, efficiency and increased profit margins to organisations. Any proposed e-procurement model that wishes to increase the performance of the construction industry should therefore focus on the reduction of costs.

Ranking cost savings as the top driver is similar to the results from other industries. "*Price Reduction in Tendering*" was ranked first for the goods and services industry in Australia by Hawking et al (2004). In a similar study Davila et al (2003) ranked "*Purchasing Transaction Costs*" in first position for USA.

In 2003, the Office of Government Commerce (OGC) recognised reduced costs as being a result of e-procurement within the public sector (BravoSolution, 2008). The OGC advertised a framework contract for the provision of an e-procurement system in the Official Journal of the European Union (BravoSolution, 2008). BravoSolutions™ won this competition in December 2003. The implementation of BravoSolution's e-procurement system within both the public sector, through the OGC, and the private sector, through the Royal Institution of Chartered Surveyors (RICS), resulted in cost savings: BravoSolution (2008) have reported savings of £15million in staff productivity. Martin (2008), reporting for the RICS (predominantly for private sector organisations), also considers the BravoSolution™ system and highlights cost savings achieved as an important driver.

5.1.2 Convenience of archiving completed work

Public Sector clients rank "*Convenience of archiving completed work*" in joint first place along with the "*Process, transaction and administration cost savings*". The importance of this driver was validated by Islington Council (2008) when it decided to store all documents electronically including all contract documents: digital archiving will enable the removal of 250,000 pages, or 12 square metres of archive space, thereby saving £2,400 annually. This substantial saving becomes even more impressive as some councils, for example Blaby District Council (2004, pg. 23) have requested that documents are retained for six years after they become non-current and twelve years if they are contracts under seal. In the case of contract documents where building and engineering work is carried out, some government organisations such as the Scottish Office retain the documents indefinitely (Gray, 2006). The savings that electronic storage can bring are therefore rightly identified as being one of the most important drivers for e-procurement within the public sector. This driver was also ranked joint second by the private sector organisations indicating that it also recognised as being an important issue in the private sector. The applicability of this driver to construction e-procurement was first identified during the application of the knowledge elicitation process using Delphi technique on the Expert Forum (described in Eadie et al, 2010). It has not been identified or rigorously ranked in other industry studies hence there are no other comparisons available.

5.1.3 Increased Quality through increased accuracy

"*Increased Quality through increased accuracy (Elimination of errors through Computer use)*" was ranked third in the overall construction industry. This supports the findings of Minahan & Degan (2001) who suggest that the use of e-procurement produces improved contract compliance. It was ranked second by the private sector organisations but only sixth by the public sector clients. Rigorous internal checking procedures adopted by public sector organisations as part of the Gateway Process have already produced high quality contract documents (OGC, 2009, 2006). In addition, many public sector organisations in other fields such as healthcare and housing have already moved to electronic systems to increase the accuracy of documentation (Scalde et al, 2006). This would have created a perception of lesser importance in the public sector in comparison to the private sector. The benefit of increased accuracy is not lost on the private sector where there are additional perceived pressures as a result of being more disciplined by market forces and high competition (Cartlidge, 2006). This would have resulted in the private sector ranking it as the second most important driver for e-procurement in construction. Similar to the previous driver, it was identified as being applicable to construction e-procurement during the knowledge elicitation process using the Delphi technique on the Expert Forum (Eadie et. al., 2010). As such, there are no comparisons available for this driver from other industries.

5.1.4 Shortened Internal and External Communication Cycle times

Time reduction is also regarded as an important issue with "*Shortened Internal and External Communication Cycle times"* being ranked highly. "*Shortened Internal and External Communication Cycle times*" ranks as the fourth highest driver overall, with the private sector ranking it sixth and the public sector ranking it fifth. This follows the findings in the goods and services industries where Panayiotou et al (2003) divide the time savings into four categories: lead time savings, reduction in time taken to resolve objections through greater transparency, reduction in evaluation time, and reduction in time through improved internal workflow. Davila et al (2003) identify purchasing order fulfilment time and purchasing cycle time as drivers for e-procurement. Kalakota et al (2001) investigates the increase in visibility showing how e-procurement decreases time by allowing procurement activities 7days a week, 24 hours a day. However, these studies do not provide a ranking. Davila et al (2003) ranked "*Purchasing Cycle time*" as third for the goods and services industry in USA. Hawking et al (2004) analysed different aspects of this driver considering "*Supply Chain Management*" which is much broader than just communication times and therefore a direct comparison with the Australian goods and services industry is not possible.

Within this study, the aspect of improved communication was seen as more important in the public sector where the constraints of European contract timescales apply to the large scale projects that these organisations are often involved. The timescales can be reduced by the adoption of e-procurement as per the Public Contracts Regulations 2006 (OPSI, 2006). For example, the reduction in time can be achieved through the use of e-mail "*reducing the overall time by 7 days"* (Williams, 2007, pg. 48), It is seen as somewhat less important to private organisations where these constraints do not strictly apply for the majority of their procurement.

5.1.5 Increased Quality through increased efficiency

Martin (2008), in emphasising the efficiency gains relating to the removal of rekeying of information by the implementation of e-procurement, states "*The role of the scribe, thought to have died out within 100 years of the*

invention of printing in the 15th Century is alive and well in construction in the 21st Century". Not having to retype the information and rates two or three times brings savings in the accuracy and speed of results for the final product. The quality and efficiency improvements e-procurement brings is also emphasised by Tindsley and Stephenson (2008). The overall ranking of fifth position in this study corroborates the findings of these two other studies. Quantity Surveying organisations that carry out this work on a day-to-day basis recognise the impact the efficiency gains can have on a practice and therefore rank it higher than the public sector organisations -- fourth and seven place, respectively. Although McIntosh and Sloan (2001), Ribeiro (2001), and Martin (2008) identify this driver they do not rank it. Therefore it is not possible to compare its relevance to other industries.

5.2 Analysing the Barriers for e-procurement

5.2.1 Prevention of Tampering with Documents - changes to documents

The most important barrier identified in Table 7, to e-procurement from a construction industry perspective is the "*Prevention of tampering with documents - changes to documents*". This barrier was investigated in Eadie et al (2007) under the title of '*Security of Transactions'*. The different aspects of this barrier relating to security were broken down to allow them to be assessed separately within the current study. In other industries, Davila et al (2003) shows that security and control mechanisms are necessary to ensure appropriate e-procurement usage by investigating the barrier "*Lack of faith in transaction and data integrity*". However, they found it to be ranked ninth, identifying that it is a greater barrier in construction owing to the level of security required in this industry and the magnitude of transaction. "*Security of Transactions*" is also ranked ninth by Hawking et al (2004) in the Australian goods and services industry. This shows a clear disparity in the requirements of the two industries. Others such as Gebauer et al (1988) and Feniosky and Choudary (2001) further emphasise the security related difficulties with e-procurement, showing the necessity to overcome this barrier but without actually ranking it. Min and Galle (1999) stated that they rate the "*severity of security*" as a barrier in relation to other problems that hinder effective Internet-based cyber-purchasing. They state that the lack of security when using Internet transactions is the most important obstacle to be overcome. Chaffey (2004) supports this, quoting a Pricewaterhouse Coopers survey of 400 senior European business leaders indicating that security concerns and lack of faith in trading partners are the most important factors holding back e-procurement. Reilly (1999) shows Secure Electronic Transactions (SET) developed by VISA and MasterCard from 1996 onwards may apply to e-procurement. Despite having security measures in place, banking institutions are still experiencing increasing levels of fraud (Hawser, 2008). This study shows that this is one of the most significant barriers to e-procurement in the construction sector.

5.2.2 Confidentiality of Information – unauthorised viewing

This is overall the second highest ranked barrier to e-procurement in construction. Pena-Mora and Choudary (2001) express their fears over tampering with contract documentation. A fully Internet based system will require security systems and encryption to preserve confidentiality. It was ranked in third place by the public sector as most public sector organisations have in-house security experts who deal with these aspects of the IT infrastructure. The adverse publicity attracted by the recent breaches of security in public sector data management activities have exacerbated the security concerns related to e-procurement; thereby, making it an absolute priority to overcome this barrier if e-procurement is to succeed within the construction industry (Jones, 2009). In the private sector where often the contract sizes are smaller and the impact of security breaches is diminished it can be seen that the importance of this barrier is reduced to sixth place. A comparison with other industries shows that Davila et al (2003) investigated the topic of "*Proprietary and confidential purchasing data will end up in competitors hands*" in the USA goods and services industry but shows it ranked twelfth. Others such as Gebauer et al (1988) and Feniosky and Choudary (2001) further emphasise the security difficulties with e-procurement in the goods and services industries, showing the necessity of overcoming this barrier without ranking it. Min and Galle (1999) stated that they rate the severity of security and hence confidentiality as a more severe barrier relative to other problems that hinder effective Internet-based cyber-purchasing. They consider that the lack security of Internet transactions is the most important obstacle to be overcome. This is more in line with the findings of this study. The rankings of this study may be due to the uniqueness of the construction activity attracting high turnover, limited transactions as opposed to high volume of low value transactions in the goods and services industry.

5.2.3 Resistance to change

"*Resistance to change*" is considered in overall terms to be the third most important barrier. The difference in ranking between the public sector and the private sector is also striking here. It was ranked first by the public

sector while the private sector ranked it in sixth place. This could be attributed to the cultural differences between the public and private sectors. The public sector is more cautious in its attempts to change and often found to be slow to respond to changing working practices (Brookfield, 2000). They are very concerned with spending public money and wish to ensure that all the necessary systemic practices, procedures and other safeguards are in place prior to its adoption. The private sector is more ready for change and is often under severe economic pressure to improve efficiency by cutting costs and seeking competitive advantage over others in order to improve their industry position (Silverman, 1992). Martin (2008) shows that construction companies in both the public and private sectors exhibit a natural inertia in relation to procurement practices. The Information Society Commission (ISC) (2003) suggests that careful marketing of the benefits of e-procurement would be a means to overcome this barrier. This could be coupled with the establishment of standard practice and procedure for the use of e-procurement to develop path ways to eradicate or minimise the effects of this barrier.

Davila et al (2003) identify this as an important barrier and investigate it under the title "*A lack of enthusiasm for e-procurement among company officials and/or stakeholders*". As a barrier it is ranked fifteenth in the goods and services industry. In contrast it is found to be much more important in the more traditionally driven construction industry. The high value nature of transactions attracts greater caution in contracts with case-law dictating more traditional form of contractual behaviour. Therefore, the construction industry is naturally more cautious towards change and slow to adopt new technology. However, the private sector has seen the benefits that e-procurement systems within construction can provide and have been less opposed to its introduction because the control systems in place are generally less onerous than those in the public sector.

5.2.4 Reluctance to "Buy-into" one off systems

"*Reluctance to 'Buy-into' one off systems*" is ranked fourth overall but has the biggest divergence between the results from the private and public sectors. Private Sector organisations rank its importance in second place whereas the public sector organisations position it in twenty-third place. This could be due to the fact that the private sector businesses are more profit oriented and therefore continual changing of systems may erode the profitability of the operation. This makes companies in the private sector more reluctant to adopt a volatile and frequently changing system for contracts, especially if they work on smaller schemes. In the public sector this is viewed as a smaller problem because of their service orientation and engagement in larger public funded schemes which have systems adopted for large one-off schemes on a regular basis. Although Irani and Love (2002) identified this as a barrier in the goods and services industry it was not ranked by then, therefore a comparison of the level of ranking with other industries is not possible.

5.2.5 Proof of intent - electronic signatures

Ranked joint fourth overall is "*Proof of intent - electronic signatures*". It was ranked third by the private sector organisations and fourth by the public sector organisations. While legislation has moved to give Electronic Signatures status within law over the past number of years, the issues raised by Wright (1999) still define the difference between Public Key Infrastructure signatures (PKI) and those handwritten. Wright (1999) points out "*The PKI proponents are therefore wrong to equate PKI signatures with handwritten legal signatures. The purpose of a PKI signature is not to ensure that the signer was warned of the gravity of the document being signed or that the signer had a fair opportunity to review the words of the document. The sole purpose of a PKI signature (as it is classically understood) is to identify a person"*. Identification and intent are different in law as the following quote also from Wright (1999) shows *"If a signature technology fails to express the signer's intent, in a way that fairly apprises the signer that the signature is being attached and what the signature means, then the signature cannot be valid. Handwritten signatures do so express a signer's intent because they are physical events that derive their meaning from culture, tradition and emotions. However, a signature based on nothing more than a mathematical key (which the signer cannot see) and a certificate is not fair to the typical signer because it involves no ceremony*". These difficulties have not yet had substantial case law to define the standing of such signatures. Only once the validity of electronic signatures have been fully tested, in relation to construction contracts under United Kingdom (UK) and European law as a means of proving intent, will this barrier be fully overcome. Signatures are treated differently under UK law than German and other European law which is proving a difficult obstacle to overcome (Wang, 2007). This barrier was ranked eighth in Hawking et al (2004) for Australia under "*Legal Issues*". It was not separated under the "*Proof of Intent*" heading and is therefore not open to direct comparison but shows that the issues around the "*legality*" of contract documentation have not been fully addressed in the goods and services industry also.

6. CONCLUSIONS

This study completed the first comprehensively evaluated overall ranking of drivers and barriers to e-procurement across all major construction disciplines within UK. Most of the previous analysis of drivers and barriers for e-procurement were in the goods and services industries (Davila et al, 2003; Minahan and Degan, 2001; Hawking et al, 2004). The key benefit of this evaluation is that it provides a comprehensive and detailed account of the different drivers and barriers to e-procurement in construction, enabling decision makers and organisational strategists a platform to work on further developments required in adopting e-procurement. It provides researchers with a detailed account of where further developments are required in e-procurement to make it more user friendly, industry related and adoptable for organisations. The study also provides the foundation for the development of an e-capability maturity model to assess the e-procurement maturity of construction organisations.

The analysis of the views of different construction industry sectors reveal that both the public and private sectors rank the top two drivers in a similar manner. "*Process, Transaction and Administration Cost Savings"* was identified as the top most driver. On the barrier side there is a difference, with *"Resistance to change"* being the most important in the public sector whereas "*Prevention of tampering with documents - changes to documents*" ranks highest in the private sector.

The overall ranking and a comparison with individual disciplines within construction was provided in Table 6 and Table 7. These tables indicate that the two most important drivers for UK construction organisations in both public and private sectors are "*Process, Transaction and Administration Cost Savings*" and "*Convenience of archiving completed work*". The most important barriers for UK construction organisations are "*Prevention of Tampering with Documents - changes to documents*", followed by "*Confidentiality of Information - unauthorised viewing*". The detailed analysis of the findings showed that resistance to change was the most acute barrier from a public sector perspective.

Due to a larger number of organisations using e-procurement within construction "*Gaining Competitive Advantage*" through e-procurement use is no longer seen as a major driver from a client and design team perspective. This was evident through it achieved the lowest rank of all the drivers that applied to construction. This indicates a degree of maturity of the concept and the perception that e-procurement is no longer a new process that can provide a competitive advantage for the organisation. On the barrier side, barriers such as company access to the internet were ranked lowest showing that this barrier had in the main been overcome with the improved level of data communication technologies and availability of increasing levels of bandwidth and broadband capabilities.

This paper, combined with the findings of Eadie et al (2010), presents a ranking of the drivers and barriers for e-procurement within the Construction Industry in the UK and fills the knowledge gap that existed as to the level and degree of relevance of different drivers and barriers to e-procurement in construction.

This will further allow the development of an e-capability maturity model for construction organisations. A capability maturity model is a means of ascertaining how mature an organisation is in relation to the implementation and use of a process. The e-capability maturity model for construction organisations will be based on the rankings and therefore the importance of the drivers and barriers. Overcoming the most important barriers and incorporating the most important drivers within the e-procurement system adopted will achieve a higher level of maturity. It is envisaged that this will be a strategic information technology management tool that aids construction organisations in the implementation of e-procurement within a construction organisation and therefore improve the uptake, investment and strategic use of e-procurement in construction.

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