METHODOLOGY FOR DEVELOPING A MODEL FOR THE ANALYSIS OF E-PROCUREMENT CAPABILITY MATURITY OF CONSTRUCTION ORGANISATIONS

Srinath Perera¹, Robert Eadie², George Heaney³, Jim Carlisle⁴
s.perera@ulster.ac.uk¹ eadie-r@ulster.ac.uk²
sg.heaney@ulster.ac.uk³ j.carlisle@ulster.ac.uk⁴
University of Ulster, Jordanstown, Northern Ireland, UK

ABSTRACT

Uptake of e-procurement by construction organisations worldwide has been inadequately researched. E-business successes achieved in other industries indicate the potential for the construction industry to achieve the same or better. There have been many government backed programmes and initiatives to encourage e-procurement within the UK. Since inception in April 1995, the Construction Industry Trading Electronically (CITE) standard has been proclaimed as the way forward for construction e-procurement in the UK. However, the poor usage (less than 2.9%) is indicative of the poor state of e-procurement in the UK construction industry (Martin 2003).

There are many drivers and barriers to e-procurement. Previous studies in the US (Davila et.al. 2003, Minahan & Degan 2001) and Australia (Hawking et.al. 2004) have ranked these for the general procurement of goods and services industry. There is no such analysis provided for the construction industry.

This paper presents details of a wider research project aimed at developing a model to analyse the e-procurement capability of construction organisations. This termed as e-readiness of organisations will indicate the current state of a construction organisation in terms of its readiness to carry out e-procurement. The paper describes in detail the research methodology being employed for the development of this model. It also provides details of preliminary findings (based on a pilot study of the Northern Ireland construction industry) of a research project which ranks drivers and barriers to construction e-procurement. It also evaluates the use of CITE prescribed data exchange format for the construction industry.

The results of the pilot study indicate that 71% of construction organisations receive less than 10% of contact documentation in an electronic form. 80% of organisations have never used CITE approved software for bills of quantities preparation or pricing while 84% of organisations use and prefer spreadsheets over CITE approved format for data exchange. It also identifies ‘improving communication’ and ‘reduced administration costs’ as the two most important drivers with ‘security of transactions’ and ‘being unsure as to the legal position of e-procurement’ as the two most important barriers to construction e-procurement.
Keywords Capability maturity model, CITE, Construction, e-procurement, e-readiness

1. INTRODUCTION

E-Procurement enhances all aspects of the procurement process. (National Institute of Governmental Purchasing 2001, Minahan and Degan 2001, McIntosh and Sloan 2001, Ribeiro 2001). The procurement process is not solely the buying of goods and services but incorporates the strategy behind this as well (Egbu et.al.,2003). The principle of electronic procurement is to provide a faultless system of transmitting the input from the contractor’s tender through to contract management, removing the inefficiencies, delays and cost involved in manually processing a tender and retranscribing for contract management activity. E-Procurement can then be defined as “the use of electronic technologies to streamline and enable procurement activities” (Hawking et al 2004).

In April 1995 ‘Construction Industry Trading Electronically’ (CITE) was instigated to produce a standard system of data interchange for UK construction industry tenders. Original membership included some of the major players in the UK Construction Industry such as the Mansell Plc, Taylor Woodrow and others. CITE describes itself as “a collaborative electronic information exchange initiative for the UK construction industry”. The idea was to enable the industry to move forward as a unit using the same formats and systems. In practice, this research shows the situation to be different. The Royal Institution of Chartered Surveyors (RICS) reported that there is as little as 10% of documentation in CITE format (Martin, 2003). This is further ratified by this research.

This highlighted that there were still barriers to be overcome in construction e-procurement. The literature review further revealed that most of the studies relating to drivers and barriers to e-procurement dealt with the general goods and services supply industry (Hawking et.al. 2004, Davila et.al. 2003, Minahan & Degan 2001). The only study that reports on the status of the construction industry was recently reported from Canada (Rankin et.al, 2006). This research in Northern Ireland identified and ranked the drivers and barriers for e-procurement in the construction industry and will form part of a broader study to analyse the e-readiness of construction organisations. The research aims to develop an e-procurement capability maturity model to establish the state of readiness of construction organisations to adopt e-procurement (e-readiness). This paper describes the research methodology used to develop the capability maturity model for e-procurement and presents the initial findings of the research related to drivers and barriers to e-procurement in construction. It also reviews the use of CITE as a protocol for e-procurement in construction.
2. METHODOLOGY FOR DEVELOPING AN E-PROCUREMENT CAPABILITY MATURITY MODEL

The development of the e-procurement capability maturity model can be broken down into three main phases, namely; theoretical, empirical and the modelling and development phase. These are shown by the different types of shading in Figure 1.

2.1 The Theoretical Phase
This phase of the study involves carrying out a detailed literature search into procurement. This is divided into three stages: procurement, electronic procurement and electronic tendering. Each of these stages involves a critical review of traditional methods, the use of electronic technologies in procurement and electronic tendering in construction procurement.

There are studies in the general goods and services sectors, analysing drivers and barriers to e-procurement in the USA and Australia (Davila et. al.,2003, Hawking et. al., 2004), the Northern Ireland study applied these identified drivers and barriers to construction e-procurement. In another recent study reported from Canada, Rankin et.al.(2006) attempts to identify the drivers and barriers to construction e-procurement. The Northern Ireland research reviews both sets of data and applies the drivers and barriers to e-procurement identified by these studies to the construction industry in Northern Ireland.

2.2 The Empirical Phase
This phase involves carrying out a pilot study primarily aimed at identifying the drivers and barriers to construction e-procurement. It also attempts to explore the existing e-procurement initiative CITE as a standard system or data exchange in construction. The survey was limited to the Northern Ireland construction industry. The pilot study is now completed and the main findings are presented in this paper.

There are two further UK wide detailed surveys planned to be executed as a part of this research. Both these surveys aim to capture drivers and barriers to construction e-procurement in the UK. One survey will examine the status at organisation level while the other will explore drivers and barriers at project level. A representative group of ‘Industry’ specialists who can supply the necessary information will be selected. This group will include representatives from all sections of the construction industry such as; architects, engineers, quantity surveyors and contractors from across the UK. These parties will be required to rank the drivers and barriers to construction e-procurement at both organisational and project levels. The survey will also focus on the particular difficulties which an electronic system of tendering encounters at project level and will investigate why there is a lack of uptake on the Construction Industry Trading Electronically (CITE) approved programmes.

The detailed surveys will be carried out using both traditional and electronic means. The information collected by surveys will mainly be quantitative although a number of qualitative questions will also be included. Empirical data gained from the surveys will be used to create a theoretical structure for ranking drivers and barriers. The web-based surveys will be carried out using PHPSurveyor™ a web-based survey tool mounted on a website. This will allow collection of data in a SQL database that facilitates the export to programmes such as SPSSTM, Sphinx™ and Nvivo™ for
quantitative and qualitative data analysis. A series of semi-structured interviews with industry experts with e-procurement experience will be used to interpret data analysed from the surveys.

2.3 The Modelling and Development Phase
The key deliverables of this stage are the object oriented classification hierarchy of drivers and barriers to construction e-procurement and the generic e-readiness capability maturity model. Each of these outputs are developed using object oriented modelling techniques, tested using industry case studies and evaluated using the Focus Group of experts as indicated in Figure 1.

Figure 1 Methodology for the development of an e-procurement capability maturity model

The information gathered from the detailed surveys will be used to develop a driver and barrier hierarchical classification model using Object-Oriented modelling techniques. Many of the drivers and barriers identified in the literature are polymorphic (having many forms) and therefore may be inherited by more than one class (multiple inheritance). It is intended to categorize each object (driver or barrier) into its class and show its inheritance to identify the status of e-readiness of
construction organisations to carry out e-procurement. This classification hierarchy will be further developed into a model to analyse the e-procurement capability maturity of construction organizations (e-readiness).

Expert evaluation of the results from the above two models will be carried out by a series of interviews with those involved with e-procurement. A focus group will be formed from the members of the E-Procurement working group established in the Northern Ireland Civil Service. Qualitative data analysis tools such as NVIVO™ will be used to analyse the data gathered.

A series of industry case studies will be used to test and validate the e-readiness model developed. An iterative process of testing and modification of the model is intended with a final validation.

3. THE PILOT STUDY

This section of the paper presents the details and results of the pilot study. The main aim of the pilot study was to test the methodology of carrying out a survey to identify and rank drivers and barriers to construction e-procurement. It also investigated the use of electronic contracts and the existing e-procurement initiative CITE.

Road Service Northern Ireland (RSNI) was selected as the case study organisation for the pilot study. As one of the largest public sector organisations involved in construction with an existing e-procurement system approved by the Office of Government Commerce, RSNI was well qualified as the organisation that is most suitable for the research. Utilising the RSNI’s register of contractors, a list of 70 Contractors who had registered an interest in road works over the past four years was compiled. 50 contractors responded to the survey. This sample by its nature included an even distribution of all sizes of companies as indicated in Figure 2.

![Figure 2 Breakdown of Responding Organisations by Company Size](image)

A short telephone briefing was used by the author’s to act as an initial contact pre-notification for the web-based survey to follow. The web-based survey achieved a 73% response rate surpassing the representativeness and bias levels indicated in Eysenbach (2004). This study used PHPsurveyor™, a web-based survey tool similar to that described in Solomon (2001) for the conduct of the survey.

3.1 Construction e-Procurement in Northern Ireland

Understanding the factors that influence e-procurement and the degree of influence each factor generates is fundamental to any study on e-procurement. Most of the
previous studies on e-procurement are reported from the US goods and service industry (Minahan & Degan, 2001 and Davila et.al, 2003). These studies were then followed by the work of Hawking et. al.(2004) who attempted to rank drivers and barriers to e-procurement. However, with a static product and a moving production line, greater economic significance and a complex product, the construction industry is fundamentally different to most other industries. The consequence is that the drivers and barriers to construction e-procurement could be performing differently to the general goods and service industry. Until recently (Rankin et.al, 2006) there was no study that reported the state of drivers and barriers to construction e-procurement. Therefore this research filled the gap in knowledge with respect to construction e-procurement, by applying the drivers and barriers for e-procurement identified for the goods and services industries to the construction industry. It allowed respondents to rank the drivers and barriers identified by the research and propose any additional ones. Although respondents successfully ranked drivers and barriers no new ones were identified. The Rankin et.al. (2006) study which evaluated drivers and barriers to construction e-procurement in the Canadian construction industry, verifies and validates most of the findings of this study. However, drawing direct comparisons between these two studies is difficult due to the nature and the difference of methodology used. Rankin et.al. (2006) merely verifies the previously identified drivers and barriers from the goods and services industries could be applied to construction, however, ranking and application may be different.

The pilot study investigated drivers and barriers to construction e-procurement in Northern Ireland. The key findings of the survey indicate the following ranked drivers to construction e-procurement (Table 1) and barriers (Table 2):

<table>
<thead>
<tr>
<th>Driver</th>
<th>Rank Order for Construction e-Procurement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Improving Communication</td>
<td>1</td>
</tr>
<tr>
<td>Reduced Administration Costs</td>
<td>2</td>
</tr>
<tr>
<td>Price reduction in Tendering</td>
<td>3</td>
</tr>
<tr>
<td>Gaining Competitive Advantage</td>
<td>4</td>
</tr>
<tr>
<td>Reduction in time to Source Materials</td>
<td>5</td>
</tr>
<tr>
<td>Reduced Operating and Inventory Costs</td>
<td>5</td>
</tr>
<tr>
<td>Reduced Staffing Levels in Procurement</td>
<td>6</td>
</tr>
<tr>
<td>Enhanced Decision Making and Market Intelligence</td>
<td>7</td>
</tr>
</tbody>
</table>

**Table 1 Ranked list of Drivers in construction e-procurement**

<table>
<thead>
<tr>
<th>Barrier</th>
<th>Rank Order for Construction e-Procurement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Security of Transactions</td>
<td>1</td>
</tr>
<tr>
<td>Unsure as to the legal position of e-procurement</td>
<td>1</td>
</tr>
<tr>
<td>Lack of a business relationship with suppliers providing e-tendering</td>
<td>3</td>
</tr>
<tr>
<td>Lack of e-procurement knowledge/Skilled Personnel</td>
<td>4</td>
</tr>
<tr>
<td>Interoperability Concerns</td>
<td>5</td>
</tr>
<tr>
<td>Lack of Technical Expertise</td>
<td>5</td>
</tr>
<tr>
<td>No business benefit realised</td>
<td>7</td>
</tr>
<tr>
<td>Company Culture</td>
<td>8</td>
</tr>
<tr>
<td>Upper Management Support</td>
<td>9</td>
</tr>
<tr>
<td>IT systems too costly</td>
<td>10</td>
</tr>
<tr>
<td>Do not have the IT infrastructure</td>
<td>11</td>
</tr>
</tbody>
</table>

**Table 2 Ranked list of Barriers to construction e-procurement**
In comparison to the drivers and barriers identified in the previous general goods and services industry studies, it can be concluded that the same type of drivers and barriers generally apply to the construction industry. However, the importance of each of the drivers and barriers for the construction industry differ from the goods and services industry. There are some factors peculiar to the construction industry as explained earlier.

3.2 Use of Electronic Contract’s and CITE
The RICS carried out a major survey of the UK Construction industry on the use of electronic contracts (Martin, 2003). The results showed that only 10% of the electronic documentation was sent out in CITE format. Only 29% of the Bills of Quantities (BOQ) / Schedules of Rates and Prices (SORP) produced were sent to the contractor in electronic form. This equates to only 2.9% of the UK Construction Industry utilising the CITE format to convey contract documents.

![Figure 3 Percentage of BOQ received in Electronic Form by Contractors in Northern Ireland](image)

This research investigated the use of CITE format to convey contract documents within the Northern Ireland construction industry. It first established the quantum of documents conveyed electronically and then the use of CITE format as a percentage of documents electronically conveyed. Figure 3 shows that within the sample of contractors surveyed 71% of contractors receive 1-10% of their BOQ / SORP in electronic form i.e. the overwhelming majority do not use electronic BOQ/SORP. The three smaller Contractors which work solely for RSNI recorded 91-100% of their documentation in electronic format as RSNI convey all their contract documentation electronically.

The study also investigated how many times Contractors used CITE approved programmes during the past 10 years. There are four CITE approved software packages noted on the CITE website [www.cite.org.uk](http://www.cite.org.uk) (Jan 2005) which can be used to produce BOQ’s in electronic format. These are Icepac / Ripac, Qumic, Cato Pro and Causeway Estimating. BRIDGE is a freeware package provided by CITE to transmit data into any CITE approved programme without the necessity to purchase the complete package.
It can be seen from the responses in Figure 4 that Icepac / Ripac software has been more widely used than the other three and yet over 80% have never used it. 96% have never used BRIDGE. The conclusion that can be drawn from this is that CITE’s strategy of providing the programme free of charge in order to promote the common format of data exchange introduced by CITE has not achieved its aim within the Northern Ireland construction industry as few companies have used it.

On detailed investigation it was evident that the widespread usage of spreadsheet programmes such as Microsoft Excel™ was creating a major impact on low usage of CITE approved formats. The CITE website states “Alternatively, a text editor, word processor or spreadsheet could be used to add prices to the unpriced BOQ, provided the file is then saved in the CITE format to be returned electronically”. This is to provide an industry standard common format for data exchange. However, the fact that client and consultant organisations are issuing contract documents using spreadsheet programmes, and the widespread usage and availability of spreadsheet programmes, has eliminated the need of conversion to a standard format such as the one prescribed by CITE. For example the RSNI procurement system on CD uses a Microsoft Excel™ spreadsheet as the medium on which to price documents. This could be brought into CITE format with the use of a macro.

Figure 5 represents the overwhelming popularity of Microsoft Excel™. 84% of the sample preferred it over all other formats. It is ideally suited to the task due to ease of data entry and the ability to let the author lock those cells that need protection. It dynamically calculates results, and is widely available to the industry as part of the Microsoft Office™ suite of software.

This research requested the contractors to rank Compact Disk write–once (CDR) based system used by RSNI. The results in figures 6 and 7 show the complete sample and the sample excluding those who had no experience of using the system respectively.
Figure 6 shows 84% of those surveyed rated the system as satisfactory or better. This included 10% of the overall sample who had no experience of using the CDR-based system. When this 10% of the overall sample with no experience are removed (Figure 7) the results show high satisfaction levels with 93% of respondents stating that the system was satisfactory or better. 52% of the sample rated the system as good with the mean value falling into this category. This indicates that the majority of Contractors are satisfied with the system.

Figure 5 Contractors preferred format for Schedules of Rates / Bills of Quantities
The study revealed that contractors were less sure about moving to a fully web-based solution as indicated in Figure 8.

Figure 8 indicates that only 42% preferred to move to a web-based system. This re-emphasises the concerns which will have to be addressed prior to the construction industry moving to a fully web-based system, and validates this research’s identification of the need for ranking drivers and barriers as a pre-strategy to providing e-procurement solutions to the construction industry.

4. CONCLUSIONS

In Northern Ireland the majority of contractors receive less than 10% of their contract documentation in electronic form. The use of the four CITE approved programmes namely Icepac/ Ripac, Qumic, Cato Pro, and Causeway Estimating is low amongst contractors surveyed with less than 20% having used these programmes. The preferred format for BOQ / SORP was Microsoft Excel™ spreadsheet with 84% choosing this option. This shows that there are more e-procurement barriers to be overcome than the mere provision of a standard format for data exchange.

The pilot study assessing the drivers and barriers to construction e-procurement in Northern Ireland showed that ‘improving communication’ and ‘reduced
administration costs’ are the two most important drivers and ‘security of transactions’ and ‘being unsure as to the legal position of e-procurement’ are the two most important barriers. These are mostly in line with the findings of a similar investigation within the Canadian construction industry (Rankin et. al 2006) although differing in performance and effect from goods and services procurement. These differences are significant and therefore further research should exploit these differences in providing solutions to barriers in e-procurement.

This paper illustrated a detailed research methodology for the development of a model for establishing the e-procurement capability maturity (e-readiness) of construction organisations. It is intended to develop an object oriented classification hierarchy of drivers and barriers to construction e-procurement based on results of a detailed UK wide survey of the construction industry. Many of the drivers and barriers identified in the literature are polymorphic and therefore may be inherited by more than one class. Thus, an object oriented model will provide the facility to analysis the level of maturity of construction organisations to procure construction contracts electronically.

5. REFERENCES

CSSP (2006) “IcePac Website” available online at http://www.cssp.co.uk/icepac.htm

