A FRAMEWORK FOR MEASURING IT INNOVATION BENEFITS

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SUMMARY: *This paper presents a new framework for measuring the benefits of IT in construction. The framework is based on the principle that benefits realisation must be managed by: planning for strategic alignment and business-driven exploitation, managing the process of predicting benefits, and by measuring resulting benefits after a system or innovation is implemented. Three distinct types of benefits are identified within the new framework associated with business efficiency, business effectiveness and business performance.*

A key barrier to the more effective exploitation and application of IT in the construction sector has been the lack of investment on a scale comparable with other sectors. A primary reason cited for the low level of investment is the low level of perceived benefits from IT investments amongst construction business managers.

Many benefits evaluation methods exist and are widely applied in other sectors. Benefits evaluation methods in construction are under-utilised. One reason for this is the lack of fit between these methods, and their associated language, with the peculiarities of the construction sector. The new framework presented in this paper has been derived for specific application to the construction sector.

The framework has been subjected to testing and application within UK construction organisations. The results of this testing suggest a number of improvements in the benefits realisation process.

KEYWORDS: *information technology, business benefits, innovation, evaluation framework*

1. INTRODUCTION

A perceived lack of effective IT exploitation in construction in the past often creates difficulty in justifying future expenditure and managing the benefits of IT innovations. This reduces the motivation to innovate and

translates into missed IT business opportunities. In 1995 The UK Department of Environment IT strategy for Construction clearly defined the lack of perceived business case for IT investments as a major obstacle to effective adoption and application of the technology in the sector. The problem of identifying IT costs and benefits is neither new nor unique to the construction sector. It is a global problem experienced in all types of business sectors and organisations (Hochstrasser and Griffiths, 1991). However, the problem is more acute in construction as a result of the industry's structure, fragmentation, and under capitalisation. Many construction organisations are under financed. At any point in time there is only limited capital available for investment and IT investment must compete with other demands on capital. This means companies must recognise that the full benefits of an IT project can only be realised as part of an overall business strategy (Bruce, 1995). However construction organisations are often slow to formulate strategies that recognise the role of IT and result in corresponding IT strategies. IT spend in the sector is significantly lower than business norms, in most countries.

The business case for IT investment in construction is normally prepared by the IT manager of an organisation for decision making by senior management. IT managers frequently lack a full understanding of their organisation's business and are often not involved in the senior management decision-making of the company. Senior management who do understand the business are usually ill at ease with the emerging information technologies. When considering new IT investments senior management seldom have feedback from previous investments to provide comfort for their earlier decisions. Any tool produced to evaluate new investments should also be capable of evaluating earlier investments and providing feedback on their success or failure.

There is a clear need for a framework that enables all parties to communicate and exchange information on possible IT investments in a form that is readily recognisable within the culture of the business sector. This issue has been well understood in business more generally. Up to now, the specific needs of the construction sector with regard to this issue has been hindered by the lack of an appropriate sector-specific tool to deal with some aspects of sector-specific language and culture.

If construction organisations are to benefit from IT investments then new frameworks for identifying the costs and benefits of IT are required in their language such that construction business managers can understand and feel fully confident in applying them. This demands a full understanding of the different types of costs and benefits available. Consideration of performance benefits and effectiveness must be considered as well as efficiency.

Efficiency is, in this context, defined as the rate in which inputs are converted to outputs (doing things right), effectiveness is the rate of actual outputs compared to the planned (doing the right things) and performance is the level of new outputs enabled (doing better things). The nature of modern business is such that, increasingly, senior managers are required to think beyond the direct tactical issues of efficiency and effectiveness and more towards strategic issues. Business performance, in its broadest terms, is a major strategic issue and one that IT has much to contribute towards. A major argument being adopted within this paper is that IT benefits in construction extend beyond the tactical into strategic business performance improvement. This argument is widely adopted in other sectors but remains poorly understood and applied in construction.

2. THE RESEARCH PROGRAMME

This paper reviews current best practice in the assessment of IT costs and benefits and describes the development of an IT evaluation framework, a common basis for all organisations to evaluate both the potential costs and benefits of new systems, and the performance of systems after implementation. These issues have all been addressed in a recent research project. This was carried out as part of the UK Construct IT initiative (Construct IT, 2000). Construct IT is an example of an inter-organisational network which recent research has shown to be instrumental in promoting increased IT diffusion and adoption in manufacturing.

The project sought to address the set of issues outlined above by developing a new IT benefits measurement framework relevant to the cultural needs of the construction sector. The aim was to review previous theoretical considerations and current industry practice, and to then synthesise a new approach drawing from the best practices found within these two sources. This new approach was then worked up into an actionable framework and applied to real-life benefits measurement scenarios within construction. The project was undertaken in response to a well-defined and explicit industrial need more than as an exercise in academic curiosity.

The research team comprised experienced academics and industry representatives all of whom had direct experience in the implementation of IT based systems within construction organisations. The initial work on the project consisted of reviews of current knowledge in the subject area. Two principal methodologies were used: a literature review and a current practice review. These reviews were conducted to determine which methods and tools were currently being used in construction and other industries to justify expenditure on IT. The current practice review included telephone interviews and exchanges of information with the senior management of major construction organisations, management consultants and system suppliers. Projects, where a major investment in IT had been made to facilitate improved communication, were studied for feedback on their IT investment appraisal methods. Full details of these interviews and of the organisations consulted are too voluminous for reproduction here but are available from the research team.

The findings from this first phase of the research confirmed the need for a new approach to the evaluation of IT investments by construction organisations. No satisfactory method for individual construction organisations was found to exist. It was recognised that current consideration of supply chain management across organisations, in a fragmented and project-oriented sector such as construction, necessitates common management and IT tools whereby organisations can integrate their business processes. This view was widely supported by the members of the Construct IT group of contractors and construction organisations. The next stage of the research therefore became the development of a framework for evaluating the benefits of IT. This framework recognised the need for a 'business language' for construction and a focus on before (expected), and after (measured), systems implementation benefits. From the outset it was recognised that this framework needed to be actionable, easy to use, provide prompting to users and take account of the business processes within construction organisations. It had to meet the needs of both IT specialists and senior managers. This approach, which came to be termed, "Measuring the Benefits of IT Innovation" was produced as both a paper based and a computer based tool for use by senior managers within construction organisations. The team developed the technique on an iterative basis; at each stage, seeking industry feedback to confirm the appropriateness of the framework and its ease of use. The framework was then tested using historical and current data before completion and publication. (Construct IT, 1998)

3. INVESTING IN IT

Since the late 1960's there has been recognition that investments in IT are difficult to evaluate (Mcrea, 1970). Evaluation, which was considered as difficult in the data processing era, has become even more problematic in the "information age" as IT systems have grown from those designed to perform specific tasks (e.g. processing payroll) to those which extend across business processes and organisations. Viewed another way the development of IT usage has moved from a purpose of aiming to "automate" to "informate" to "transformate" (Remenyi et al., 1995). The difficulty in evaluation centres on the fact that both costs (particularly intangible costs) and benefits are difficult to quantify. In addition, there are often hidden costs and benefits. Overly (1973), notes that technology based programmes often result in benefits and costs which were not identified or acknowledged in the planning and resource allocation process.

Some construction companies regard the use of evaluation techniques as a "ritual of legitimacy" and they are often considered as being more costly than the value that they generate (Andresen, 1999b). Currie (1995) argues that organisations merely use such techniques to support business decisions that have already been made. Powell (1992), furthermore recognises the political dimension of IT investment, addressing the issues as to why firms or individuals may wish not to engage in the formal evaluation of IT projects. Other organisations adhere strictly to formal appraisal techniques developed from economic analysis.

Overall there is broad agreement on the need to evaluate systems for a number of reasons (Farbey et al, 1992) that would include:

- To justify a proposed or existing system.
- To enable comparison of different projects.
- To provide a tool for managing the project.
- To enable learning experience.

3.1 IT Investment Evaluation

The essential questions are how and when to evaluate IT investments. There are three inter-related questions. How does information technology (IT) improve business performance? How do we decide the IT 'projects' in which to invest? How do we assess the performance of systems after their implementation? The use of different appraisal techniques to answer these questions varies from organisation to organisation. Research into the use of these techniques and their value to different organisations provides varying responses. (Farbey et al, 1992; Willcocks and Lester, 1994).

Earl (1989), stresses that not all organisations face an identical challenge, their business sectors differ, the competitive forces they combat vary, their histories are not alike and they make different strategic choices. In addition, organisations must evaluate where in their evolution of IT developments they stand so as to ensure that they are able to make and manage the appropriate degree of strategic change. When considering the implementation of a new system it is essential to understand whether you seek efficiency, effectiveness, or overall business performance benefits, or which combination of these. It is also crucial to adopt an overall business process perspective rather than being constrained by current organisation of business functions.

Farbey et al (1993) argue that the search for a single technique for evaluating investments in IT is fruitless. The range of circumstances that one technique would have to be applied to is so wide that no single technique is likely to be applicable. The first step therefore is to understand more about the context in which the evaluation is taking place and then apply the appropriate technique.

3.2 Review of Evaluation Methods

There are at least 30 currently available IT benefits evaluation methodologies. (Andresen, 1999a) These may be categorised into objective methods, i.e. those seeking to quantify system inputs and outputs in order to attach values to them, and subjective methods, i.e. those relying on the attitudes and opinions of users and system builders. The early investment appraisal methods are primarily based on financial measures such as Return on Investment (ROI) and Net Present Value (NPV). These methods are, however, found to be inadequate when used to evaluate IT investments because of their use of only one measure (monetary value). More complex methods, designed for evaluation of IT investments, have emerged such as Information Economics (IE), Return On Management (ROM) and SESAME. (Parker and Benson, 1988, Strassmann, 1985, Lincoln et al, 1990). These complex methods are, however, rarely used in construction for a number of reasons. First, because of little awareness of the methods. Second, because of the methods' large operation requirements. Third, some critical problems are still not solved in the methods.

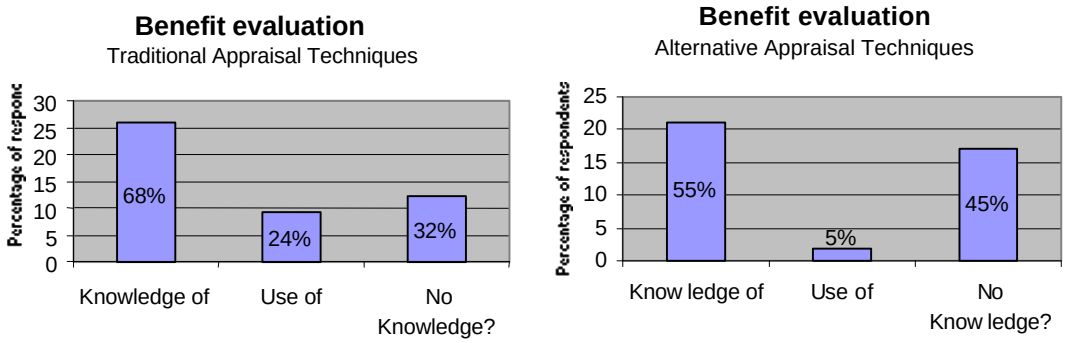

Fig. 1: Analysis of awareness of appraisal techniques used in construction (Pittard, 1995)

Pittard (1995) investigated the issues associated with the appraisal of IT benefits within construction organisations. This study included both the industry awareness and use of IT investment techniques and an evaluation of possible relationships between formal investment appraisal and benefit realisation. His survey results are summarised in Fig. 1: in which the vertical axis indicates the numbers of respondents who are aware of the techniques. These include details of an organisations knowledge of, and use of evaluation techniques. The

findings show that the respondents were more aware of traditional appraisal techniques than alternative methods. Discounted Cash Flow (DCF) was the most popular technique, 63% of the respondents knew of the technique and 16% were using the technique. Of the 'Alternative' techniques, 50% were aware of the Risk Assessment Method (RAM) although very few (5%) have used it. However, many organisations used no specific assessment method relying on "gut feel" to make investment decisions. Whilst these findings are not statistically significant and offer no consensus explanation for lack of use of methodologies the survey does support the findings of other researchers.

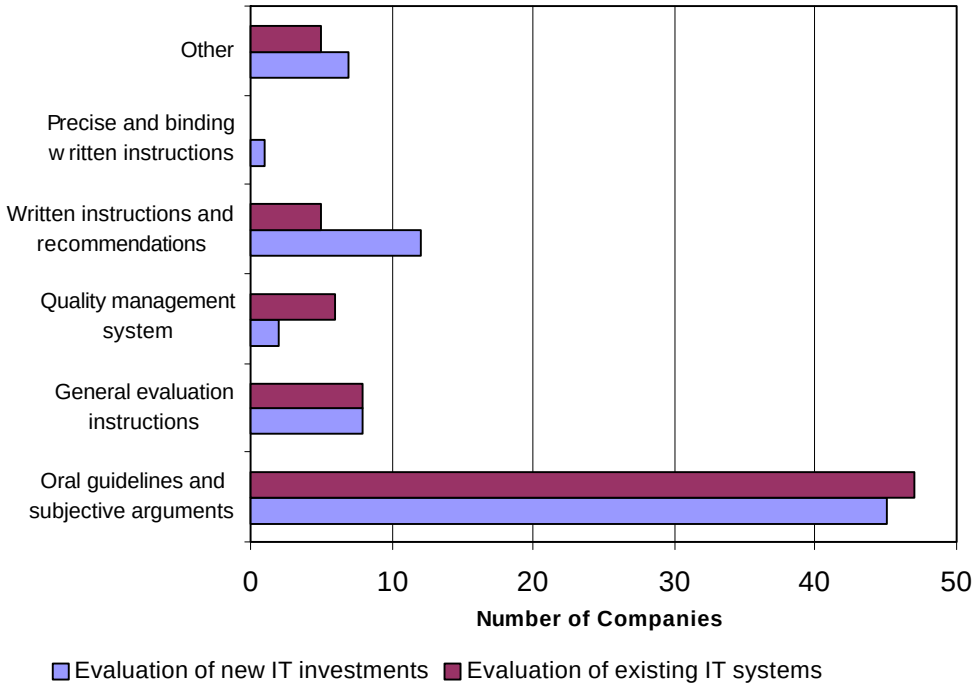

Fig. 2: Procedures used in requesting an IT benefit evaluation

A more recent survey in the Danish construction industry examined the sophistication of the respondents' IT strategy use and how the construction companies evaluate their IT investments and existing IT systems. The respondents chosen were architects, consulting engineers and contractors. The survey found that a large majority of the respondents use informal procedures when they evaluate IT investments and existing IT systems (Andresen, 1999b). Furthermore only 17% of the evaluation procedures used in the stage "before investment " were procedures developed with a focus on IT evaluation. The findings are shown in Fig. 2. The figure illustrates the way evaluation of investment is called for by senior managers for both existing and new IT systems. The scale of the survey was not significant enough to be able to make generalisation for the whole Danish construction industry, but may indicate some tendencies.

3.3 Assessment of Evaluation Methods

Ballantine and Stray (1998) found that many evaluation techniques reflect traditional cost-benefit methodologies and the application of standard accounting techniques to the problem. In their review of these techniques they conclude that for all their benefits, fundamental problems still exist with a dependence on this type of IT appraisal. Semich, (1994), agrees, arguing that traditional ROI virtually ignores all that most companies are trying to achieve with IT and that a new method for measuring the value of apparently unquantifiable benefits of strategic systems is necessary. The most appropriate method is "information economic analysis" which gives decision-makers a way to quantify and compare the importance of intangible benefits while still showing the direct economic costs and benefits of investment choices.

Powell (1992) concludes that evaluating or justifying investment in IT is problematic. IT investment is more difficult than many other investment decisions because the costs and benefits are hard to identify and quantify and the intangible factors present are likely to be significant. He argues that the rapid change of pace in IT causes serious starting problems for any large investment. This does not, however, negate the need to evaluate projects. The justification of IT investments is difficult, yet techniques are available which give broad indications of success or failure. These standard techniques do not appear to be widely used in construction even though they have been employed usefully in other fields and are recognised as useful. This is often because they are designed for continuous process activities common to commerce and most of industry, rather than the one off projects of the construction industry. The lack of fit with sector culture and language is also a major inhibitor.

In a study of UK construction organisations, CIRIA (1996) reviewed the procedures used by seven major construction organisations for their internal assessment of potential investments in IT. These organisations included building and civil engineering contractors, civil engineering consultants and one large joint venture construction project. CIRIA concluded that, in the construction industry, formal cost-benefit analysis is not widely used to assess possible investments in IT. A successful strategy can be implemented which does not use formal methods. The falling cost of IT hardware and software, and the similarity in the functionality of alternative products, is leading to hardware and software being treated as a commodity. Even the simplest form of analysis of costs and benefits of smaller items can cost more staff time than the item itself; and advancement of IT within organisations appears to be almost cyclical, alternatively evolutionary and revolutionary with periods of consolidation and evolution following radical assessments of IT strategy. This is a classic IT problem. For instance when Project Management software is introduced the software and hardware are a small part of the total cost-benefit equation. Staff training often costs more than the system, but the benefits of the training generally outweigh the costs.

The findings from the literature review were supported by the findings from the practice review. Which showed neither a consistent approach within individual organisations nor a consistent approach across organisations. The interviews with multi-sector management consultants and IT system suppliers offered no appropriate solution from other sectors.

The overall results of the initial data collection were reviewed in an open forum addressing the following questions: What are the benefits that arise from IT investment in construction? How are the costs and benefits of IT currently measured in the construction industry? How are the costs and benefits currently measured in other industries? What are the problems in measuring an IT innovation's costs and benefits?

As a result of this industry-based debate of this issue, informed by academic perspectives reflecting the literature review conducted, a framework of construction IT benefits was synthesised. Table 1 shows a summary of the typical, process-based benefits that arise from IT investments that were synthesised. They are divided into three categories: typical efficiency benefits; typical effectiveness benefits; and typical performance benefits.

Table 1: Typical IT benefits

Construction Business Process	Typical Efficiency Benefits	Typical Effectiveness Benefits	Typical Performance Benefits
Business Planning	Reduced planning times	Increased Sales Minimising business risk Strategic competitive advantage Increased business flexibility Maintaining competitive capacity Reduced risk in new business ventures	Providing space and capacity for business growth Safeguarding future flexibility Overcoming obsolescence Increasing responsiveness of senior management to business problems
Marketing	Reduced marketing costs Ability to handle more enquiries	Improved company image Generating new business Increased market share	Improved strategic intelligence for new markets Improved public relations targeting and delivery

Construction Business Process	Typical Efficiency Benefits	Typical Effectiveness Benefits	Typical Performance Benefits
Information Management	Reduced communications costs Reduced paperwork Reduced IT costs	Easier international links Fewer information bottlenecks Improved quality of output Sustaining market share	Improved information version control Ease of capture of meaningful information More relevant and reliable data Improved filtering of info
Procurement	Reduced storage requirements Reduced transaction times Reduced transaction costs Improved delivery scheduling	Maintaining competitive capacity Faster response to supplier quotations Ability to provide instant price quotations to clients	Improving external access to stock levels and price information More effective identification and assessment of new suppliers
Finance	Faster invoicing Reduced transaction costs	Minimising business risk Better control of cash flow Reduced lead times for financial reporting	Improved/new transaction methods Improved forecasting and control Greater integration with other functions
Client Management	Quicker response to client enquiries Quicker response on current project progress	Improved quality of output Faster delivery of services Improved focus on client requirements	Improved information exchange with clients Increased client satisfaction Strategic competitive advantage
Design	Reduced lead times for design Reduced rework Increased information exchange	Improved quality of output Reduced technology risks More responsive ability to arrange meetings Increased speed of new design development	Improved idea sharing among project teams Improved integration
Construction	Reduced construction times Improved productivity Reduced waste	Improved quality of output Reduced technology risks Ability to exchange data	Improved idea sharing among project teams Improved integration Improved project relationships with strategic partners
Operation and Maintenance	Reduced operating costs Quicker access to operation and maintenance data	Improved quality of output Ability to refer back to data	Improved capture of design and construction decisions Improved full life-cycle information management
Human Resources	Reduced staff requirement Reduced training requirements	Improved record of staff skills Improved ability to select appropriate team members	More effective assembly of project teams Enabling of cross-functional teams Improved human relations Regularised working arrangements

The set of typical benefits in Table 1 may have some similarities with those to be found in other sectors. In itself, this checklist of typical benefits does not provide a methodology for IT benefits evaluation and realisation. The next phase of the research was to take this starting point in developing an actionable benefits measurement and realisation methodology for construction businesses.

4. A NEW EVALUATION FRAMEWORK

A proposal for a new evaluation framework is based on a systematic overall approach to realising IT benefits. This process, represented in Fig. 3, has some key features like identifying the business case and the strategic issues concerning an IT-based business innovation, allocating responsibility for benefits management, applying a process before and after an IT innovation, and evaluation and feedback. It is part of an integrated total approach

to IT benefits evaluation where all stages are interdependent and where the success of the whole exercise is dependent on all stages being performed.

This figure and the process it represents can be described in some detail. The first stage involves identifying the business case for a new IT innovation. This is key to successful business exploitation. Why is the business requiring an IT innovation to be made? The second stage involves checking the fit between the proposed innovation and business and information strategies. Business benefits are only likely to arise if they are strategy-driven. A key aspect of the framework is to assign responsibility for realising strategies to an individual or a group empowered to overcoming barriers that would prevent them happening. The framework then envisages applying an appropriately selected appraisal technique to allow predicted benefits to be calculated and documented in advance. Without such a documented benchmark, subsequent benefits attainment and measurement is impossible. The process of benefits realisation is one that has to be proactively managed with reference made to earlier parts of the overall process. It is easy for the benefits focus to become lost if this stage of the framework is not explicitly followed. Benefits resulting from an IT innovation must be monitored during the course of an IT project and documented at a final stage in a way that allows comparison with predictions. This is necessary to allow post-innovation benefits evaluation to be undertaken and for the whole process to be evaluated to allow learning to take place within the organisation and feedback to future exercises.

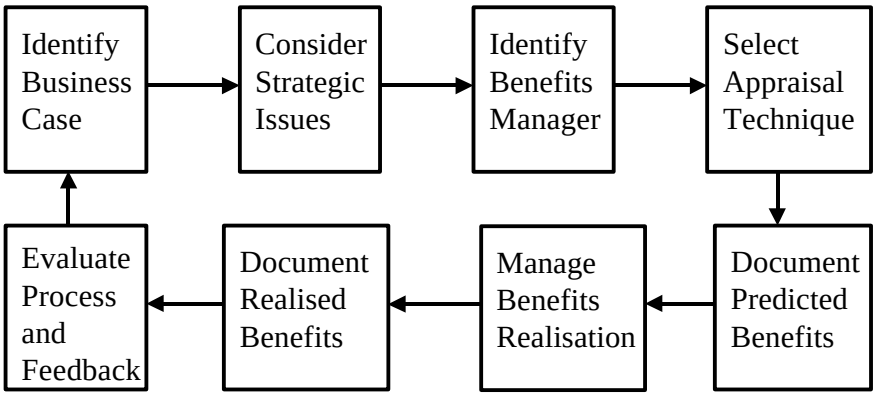

Fig. 3: The IT benefits measurment process.

The framework as a whole allows construction organisations to assess ways in which IT innovation can benefit a construction business by improving efficiency, effectiveness and performance. Efficiency is financially measurable and is represented by money. Effectiveness is measurable but not in monetary terms. It is represented by improved operations. Performance is not directly measurable in quantifiable terms but is judged qualitatively on the basis of the impact of a successful implementation in influencing long-term business performance and market share.

The framework comprises three separate evaluation tables, one for each of the criteria, together with associated flow charts and checklists. The methodology guides the user through each stage of the measurement process. The approach taken within the framework is to suggest that innovating with IT can improve business processes within construction organisations. Within the context of the framework, business processes were defined as processes that cut through an entire organisation and that enable the organisation to exist as a business entity and add value to fragmented, multi-participant, project-based supply chains. Ten construction business processes were identified: business planning; marketing; information management; procurement; finance; client management; design; construction; occupation and maintenance; and human resources. This generic model was not specific to any one type of company in the sector but designed to cover the full range of types of organisations in the sector.

Table 2 shows the framework for evaluating business efficiency benefits. Tables 3 and 4 show the similar tables developed for evaluating effectiveness and performance benefits. In each framework the user first identifies the business processes that will be affected by the new IT innovation and selects the specific IT benefits that might be realised partially using the checklist in Table 1.

Table 2: Measuring Efficiency Benefits

					Expected Benefits			Measured Benefits	
1. Business Process	2. Specific Benefits	3. Implication to this benefit of not making the innovation	4. Means by which benefit will be measured	5. Person responsible for achieving and measuring this benefit	6. Monetary Value (£)	7. Likelihood of benefit occurring (%)	8. Expected benefit (£) Col 6 * Col 7	9. Specific Benefit Resulting	10. Monetary value (£)
Business Planning									
Marketing									
Information Management									
Procurement									
Finance									
Client Management									
Design									
Construction									
Operation and Maintenance									
Human Resources									
						Total	£		£

Table 3: Measuring Effectiveness Benefits

					Expected Benefits			Measured Benefits	
1. Construction Business Process	2. Specific Benefits	3. Implication to this benefit of not making the innovation	4. Means by which benefit will be measured	5. Person responsible for achieving and measuring this benefit	6. Likelihood of benefit occurring (%)	7. Weighting (column total = 100)	8. Predicted Benefit - (Col 6/100) *Col 7 (max = 100)	9. Specific benefit resulting	10. Measured benefit (max = 100)
Business Planning									
Marketing									
Information Management									
Procurement									
Finance									
Client Management									
Design									
Construction									
Operation and Maintenance									
Human Resources									
					Total				

Table 4: Measuring Performance Benefits

					Expected Benefits		Measured Benefits	
1. Business Process	2. Specific Benefits	3. Implication to this benefit of not making the innovation	4. Means by which benefit will be measured	5. Person responsible for achieving and measuring this benefit	6. Likelihood of benefit occurring (%)	7. Qualitative rating and description of the impact of the expected benefit. A = Very significant B = Significant C = Moderate D = Low	8. Specific benefit resulting	9. Qualitative rating and description of the impact of the measured benefit. A = Very significant B = Significant C = Moderate D = Low
Business Planning								
Marketing								
Information Management								
Procurement								
Finance								
Client Management								
Design								
Construction								
Operation and Maintenance								
Human Resources								

Table 5: Overall Business Benefits

Types of Benefits	**Expected benefits**	***Measured Benefits***
Efficiency Benefits - Quantifiable and Valuable	Total forecast monetary value £	*Total realised monetary value £*
Effectiveness Benefits - Quantifiable but non-valuable	Total forecast score /100	*Total realised score /100*
Business Performance Benefits - Non-quantifiable and non-valuable		

Each table is divided into three sections. The first section is about setting up the basis for the IT evaluation project. It contains an identification of specific benefits, implication to the benefit of not making the innovation, an identification of the means used to measure the benefit and an identification of the person responsible for achieving and measuring the benefit (columns 2, 3, 4 and 5 in Table 2). The second section involves an estimation of the expected benefits, which is conducted before the investment is undertaken. In Table 2, two factors are used in order to make the estimation; first, the likelihood of the benefits occurring is estimated and second the value is estimated (column 6, 7 and 8 in Table 2). The word *Value* is used in this context because the output from the three spreadsheets is measured in money, non-money and improved operations respectively. The last section of the framework is about measuring the benefits that have occurred when the IT innovation has been implemented (column 9 and 10 in Table 2). The results produced from analysis, in Tables 2 to 4, are then summarised in Table 5. Along with a set of preliminary strategic questions, and a request for a detailed specification of the proposed IT innovation, this represents the framework that has resulted from the synthesis phase of this study. It is presented here as a sector-specific example of information economic analysis that has been developed in response to a defined industry need.

5. TESTING THE FRAMEWORK

The prototype framework was applied in action research case studies with three different organisations that had recently undertaken the implementation of different types of IT systems in construction. These case studies explored whether the framework was practical, identified difficulties that they had with the process and the format, and illustrated the advantages the framework brought to the evaluation of IT benefits. The case studies included: a new civil engineering estimating system, a human resource management system, and a document management system. All three cases were in large contracting environments.

All three users found the structural approach to assessing IT benefits useful. Whilst it was not always possible to enter accurate cost data with respect to benefits, guideline figures enabled an approximation to be calculated. Similarly, the users found the estimation of the likelihood of benefits occurring within the effectiveness framework and the adoption of the qualitative rating within the performance framework a little daunting to complete but recognised the usefulness of this structured approach. In effect, in all three cases, the way organisations used the framework differed in detail while following some generic principles. The detail was dependent upon working principles, organisation structure, and accounting practices, within the companies concerned. General principles that arose from the cases focussed on the value from the overall structured approach towards strategic thinking that the framework encouraged.

One feature of the framework is that it encourages the comparison of the actual (measured) benefits against the expected benefits. The importance of this aspect of the framework was recognised by the users although doubt

was raised as to whether, in practice, organisations or their representatives would have the inclination or the discipline to re-visit their investments. This would require a significant culture change.

Overall, the framework was considered usable, practical and informative although requiring a structured, disciplined approach. On this basis the research team made minor amendments to the tables and completed the framework. The tables presented here are as a result of those minor amendments.

Further testing of the completed framework was undertaken by an experienced researcher using three different, but related, historical studies. These studies were undertaken as part of the ISOCCrates project (Carter et al, 1999). The cases related to the introduction of a document management system, video conferencing for Design and Build Collaboration and video conferencing for organisational communications on a major building project.

It was concluded that the framework provided a practical tool for the construction industry to use for benefits assessments, as a component of an overall evaluation strategy. It assisted with benefit identification and evaluation for the preparation of business cases and for the evaluation of benefits realised following implementation. Whilst recognising that the framework does not provide a single, objective measure of benefits of an IT innovation, it did enable comparisons between competing investments, and showed the relative impacts of a proposed investment. As with any appraisal technique, difficulties with the identification and evaluation of benefits required careful consideration. However, the framework presented a clear basis for the appraisal and a record of evaluation of the investment both before and after implementation.

6. RELEVANCE TO SMALL AND MEDIUM SIZED ENTERPRISES AND THE IMPACT OF TECHNOLOGY DEVELOPMENT

Problems in assessing the benefits of IT innovation include: identifying the intangible benefits; estimating hidden costs; understanding how the new system will impact upon the organisation culture; allowing for the 'political' influences which will impact the new implementation. The extent of these and other problems differ between the 50 or so very large companies, on which this research was based, and the very large number of SME-sized enterprises in UK construction. The applicability of this framework in other geographical environments remains to be tested in further research.

Future development of this research could look at the problems encountered by Small and Medium Enterprises (SME's) utilising this sort of evaluative approach. The rate-of-change of technology occurring within the IT community is potentially seen by SME's as being both its biggest drawback and its biggest challenge.

Construction companies, especially SME's, are very traditional in their outlook and there are many possible reasons for their reluctance to adopt innovative ideas. Examples of such reasons would include: their conservatism; their experience of the high risk of litigation following the use of innovative solutions that subsequently fail; and the very high rates of change of technology and business solutions. In addition, the lack of investment in training of users; the over selling of benefits by IT solution providers; the lack of standardisation leading to incompatibilities, conflicts and too great a choice; are all inhibitors. For many years the construction industry has faced reducing profit margins leaving little room for investment, especially in such a rapidly changing environment as IT. A method of appropriately evaluating the benefits of an IT innovation before, during and after its implementation must be viewed as a major strategic issue, irrespective of the size of the enterprise.

In the uptake of proprietary 'Integrated Software Systems' , most SMEs venturing down this route, appear to prefer costly bespoke software solutions as their means of integrating organisational functions. Historically the use of IT and IS within such companies had grown organically as the enterprise recognised a need. Usually 'Stand Alone' systems were seen as a solution and little consideration had been given to integrating with other functions. IT managers were seldom in evidence and those who were in-post, had few (if any) formal IT qualifications. As a result, the experiences of individuals counted highly in much of the decision-making when selecting both hardware and software. Their experiences do not make convincing evidence when attempting to evaluate the benefits of the use of innovative IT; this is often because the enterprise has suffered from an, at best, disjointed approach to the adoption of IT systems.

Enterprise Resource Planning was much in vogue in construction during the 1990's and large sums were spent by some major organisations integrating all back office functions in an attempt to produce a smooth functioning system for supply chain management. Again, many of the organisations utilising this form of IT system failed to see the recent growth in the 'front office' applications particularly the massive growth in the Internet and the use of e-commerce. The rigours of Internet computing are only just becoming apparent and once again IT systems are being challenged by the radically different alternatives offered by the web. SME's investing in integrated IT systems based on early evaluations will now find themselves very much at a loss as they adapt (again) to meet the needs of the customer or others in the supply chain who are quite literally, demanding information 24 hours a day. Measurement of the benefits of Innovative IT to SME's would need to take into consideration the aspects outlined above, however, our research work identifies the ground for this to be undertaken in the future.

7. CONCLUSIONS

Measuring the benefits of IT innovation has always proved difficult. There are at least 30 different methods of evaluation, some based on traditional investment appraisal techniques (primarily financial ratios), others adopt subjective approaches. No one technique predominates within the construction industry. There is neither a consistent approach within individual organisations nor a consistent approach across organisations.

The benefits of IT are only fully realised when systems and available technology are applied to specific and relevant tasks and aligned with the organisation business strategy. IT benefits should also be considered as a portfolio of benefits distributed across several organisations. To establish the scope of this portfolio, and how best to realise the benefits, a list of requirements for all relevant stakeholders should be produced. The ultimate criterion for success is an overall improvement in the business position of the organisation. Therefore, the alignment of the business and technology strategy is of paramount importance. The nature of IT is such that the development of IT infrastructure cannot be regarded as another capital investment but as an inseparable part of business processes and design.

The framework produced by the research team and presented in this paper, proved to be a readily applicable tool, promoting thought on a number of issues relevant to an innovation. By dividing the benefits into efficiency, effectiveness and performance benefits, a clearer evaluation of alternative investments could be completed. Feedback from the use of the framework in industrial organisations revealed a number of direct and indirect benefits from using the tool. These included: a clear statement of the means by which benefits are measured; clear accountability for actions; a focus on strategic thinking; identification of benefits that were previously unquantified and 'unidentified'; the creation of a learning culture; and a means for comparing alternative proposals and solutions.

Unidentified benefits are of particular relevance to non project-specific IT infrastructure investments. The potential future benefits from subsequent applications using the infrastructure are often unknown or ignored when the original infrastructure investment evaluation is undertaken. It is only by re-assessing the results of the installed systems that these benefits may be identified and a better understanding of the possible benefits from new systems evaluated. The type of framework presented here may have its greatest value in cumulatively assessing the summative benefits from a series of linked IT investment projects.

Some limitations with the proposed framework were evident through its application in three case studies. These arise from the difficulties of applying generic evaluative approaches like this within organisations that have their own practices, culture, and modes of working. The framework produced is clearly a generic approach rather than a rigid methodology. Individual organisations are best advised to consider the approach behind the framework and attempt to tailor it to the specific situation of their own organisation. The continuing research issues that arise from the experience of applying it in case studies include: a need to identify how specific organisational constraints effect the way the framework can be applied, the suitability of the framework for different types of IT innovation, the extent to which applying a framework like this can give a clearer picture of the extent to which the sector is benefiting from IT investments. These, and other issues, are being addressed in ongoing work being undertaken by the authors.

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