SELECTING TECHNOLOGY PROJECTS BASED ON AN INFORMATION ECONOMICS APPROACH: A STEP TOWARDS INTEGRATING INNOVATION INTO BUSINESS STRATEGY

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Abstract: The diffusion of technology utilisation in the construction industry has not progressed according to expectations; there are many examples of innovative technology (e.g. construction automation, field robotics, video conferencing, web and multimedia technology etc.) failing to achieve satisfactory levels of adoption, practical application and usage if adopted. Many technology projects commenced in the construction industry fail to meet high expectations due to the lack of prior assessment of risks and returns before funding approval is provided. Senior construction professionals lack the methodology, skills and tools required for selecting a portfolio of technology projects which add the greatest value to the organisation. This paper applies the Information Economics (IE) approach to provide practitioners with the essential tools and methodology for technology project selection. IE goes beyond traditional 'business value' techniques and introduces the concepts of value and risks. The major advantage of adopting an IE approach in the construction industry is that it is virtually impossible to evaluate, if one only asks what the cold hard benefits are. They are unlikely to be perceptible in such an industry.

Keywords: Technology Projects, Information Economics, Construction Organisation; Risk

1. INTRODUCTION

Leading construction organisations use selection, monitoring and evaluation processes uniformly at an enterprise and within each business unit of the organisation. This enables an organisation, even one that is highly decentralized, to systematically identify new opportunities and to determine trade-offs between construction projects, both within and across business units.

By contrast, there is very little or no uniformity in how risks, benefits, and costs of various technology projects are evaluated at project, business unit or organisational levels of a construction company. Most construction companies choose technology projects based on inconsistent or nonexistent investment processes. Thus, making comparisons between technology projects of different size or organisational impact difficult. More importantly, construction organisations adopting limited selection criteria lack assurance that their technology projects meet company goals and objectives.

As mentioned by Hasegawa [4], those that control innovation and technology, control the market. The objective of this work is to stress that construction companies must choose technology projects which provide them with the competitive level required to successfully participate in future and present markets. Technology evaluation research has produced mostly mixed and inconclusive results which can be attributed to several problems. One is related to the definition and measurement of technology, as most studies have taken a piecemeal rather than comprehensive approach by selecting individual variables as surrogates of technology sophistication [16]. However, organisational benefits resulting from these investments are not always easy to measure [2] and none of these measurement methodologies are widely adopted by practitioners [10]. The relationship between technology investments and organisation performance remains poorly understood and some researchers in economics are concerned about the payoff from investments in innovation and technology [14].

This paper seeks to provide some guidelines for construction professionals when selecting a portfolio of existing and innovative technology projects. Technology project selection, is only one aspect of developing an efficient performance management framework. Performance monitoring and performance evaluation are two other aspects requiring research attention, before a complete performance measurement framework can be developed.

2. OVERVIEW OF THE INVESTMENT MANAGEMENT PROCESS

An investment management process is an integrated approach to managing investments that provides for the continuous identification, selection, monitoring and performance evaluation of technology investments. This structured process provides a systematic method for construction companies to minimize risks while maximizing return on technology investments. To effectively employ technology in construction, an investment management process should have elements of three essential phases;

- Technology project selection
- Technology performance monitoring
- Technology performance evaluation

However, each phase should not be viewed as a separate step. Rather, each is conducted as part of a continual, interdependent management effort. Information gained from one phase is used to support activities in each of the other two phases. Figure 1 illustrates the three phases of an investment management process, relationships between phases and appropriate management tools.

A number of performance measurement frameworks, tools and specific measures have been developed over the years which address each phase of the management process illustrated in Figure 1. Many of these frameworks have been developed with the banking, insurance or manufacturing sector in mind but these frameworks can be readily adapted to the construction industry. Following the evolution of performance measurement from single factor to multi-dimensional constructs, the following frameworks are some examples of popular multi-dimensional constructs.

- *Kaplan and Norton*: Developed a Balanced Scorecard (BSC) which allows managers to look at an investment from four important perspectives [5].
- *Martinsons*: Adapted the Kaplan and Norton BSC to specifically evaluate IT investments [9].
- Priest et. al. (1995): Evaluated IT 'business value' using a construct of domains, braided projects and programmes and activity states [12].
- *Parker et. al; Wiseman*: Introduced an information economics approach which goes beyond traditional 'business value' techniques and introduces the concepts of values and risks [11, 15].

Technology project selection is the first phase in the three-phase management process. This paper focuses only on the technology project selection phase.

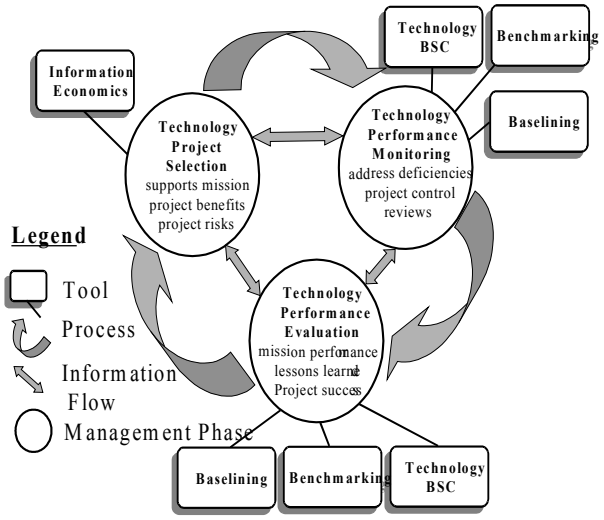

Figure 1. Phases and tools for an effective technology management process

3. TECHNOLOGY PROJECT SELECTION

In this phase, the construction organisation determines the priorities and makes decisions about which technology project will be funded. A starting point for the selection phase is the screening process, in which technology projects being submitted for funding are compared against a uniform set of screening criteria and thresholds in order to determine whether the projects meet minimal requirements and to identify at what organisational level the projects should be reviewed. The costs, benefits and risks of all technology projects (proposed, under development, operational etc.) are then assessed and the projects are compared against each other and ranked or prioritised. As part of this process, weighting factors may be attached to the ranking criteria. These ranking criteria should, at a minimum, include cost, risk and benefit factors, as well as an assessment of how well the project meets mission needs. Finally, senior management executives make decisions about which projects to select for funding based on mission needs and organisational priorities. The systems and projects that are selected for funding make up the portfolio of technology investments.

The selection phase helps ensure that the organisation (1) selects those technology projects that will best support mission needs and (2) identify and analyse a project's risks and proposed benefits before a significant amount of funds and resources are allocated. A critical aspect of this phase is management understanding, participation and accurate, up-to-date decision-making.

The investment management process is a dynamic process. Figure 2 illustrates how this process can work when technology spending for all projects (new proposals and ongoing projects) is decided each year as part of an annual budget process. Both proposed and ongoing projects enter into an investment planning and analysis stage, which examines the existing inventory of systems and applications to review costs, benefits and risks associated with all technology investments. Selection decisions are based on analysis of where needs of the construction organisation are greatest. Projects that are terminated or delayed as part of selection decisions are evaluated immediately to allow the organisation to assess the impact of future proposals and to quickly benefit from lessons that are learned.

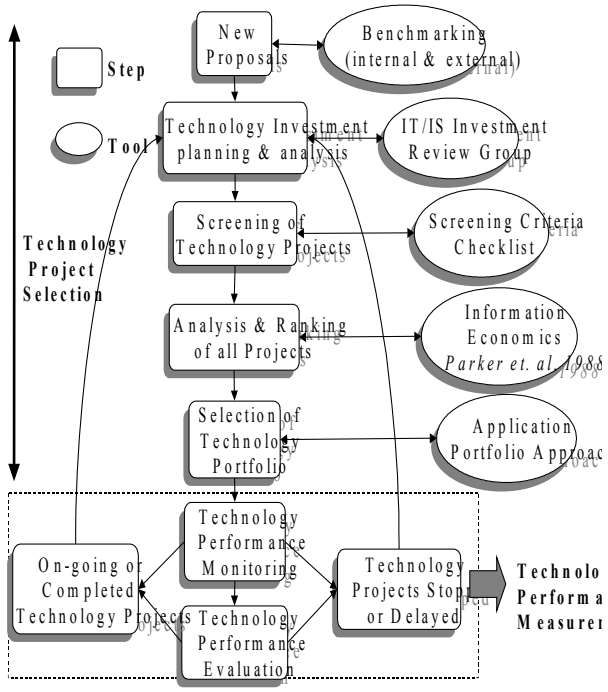

Figure 2. Technology Investment Evaluation Process

Figure 2 also details a number of 'technology performance evaluation' tools or techniques that can be adopted by construction professionals at each step of the investment management process. Brynjolffson et al. [3] note that managing and coordinating increasingly complex systems requires increasingly sophisticated tools. These tools must, however, be supported by mutually reinforcing practices. Existing practices may need to change and it is the cultural characteristics of a business that will determine its receptiveness to change. This organisational distinctiveness will influence both the format of outputs and the way they are used.

4. SCREENING PROJECTS

The construction organisation should have a process that outlines how to introduce technology projects for funding and how these projects will be screened for relevancy to company goals and objectives. Executives of the construction organisation should;

- Define what constitutes a technology project,
- Identify initial requirements that technology projects must meet in order to be seriously considered for funding,
- Explain how screening will be conducted, and
- Establish roles and responsibilities for conducting the screening.

As part of the initial screening process, there should be documented screening criteria that all technology projects are expected to meet. The documented screening criteria should serve three main functions:

1. Identify whether the project meets initial acceptance criteria.
2. Ensure that the project is being reviewed at the most appropriate organisational level.
3. Identify what level of management scrutiny is appropriate given the project's type, size and risks.

On the basis of this screening process, proposed projects will either move on for more in-depth analysis or will be sent back to the originating program group.

5. ANALYSING PROJECTS

The benefit, cost and risk information of all technology projects (initial, concept, proposed, under development, operational) should be analysed and assessed in detail.

Each project should have a business case developed that provides the sponsor's justification for the 'business value' of the project. The business case should identify the organisational needs that the project is meeting or proposes to meet; provide information on the benefits, costs and risks of the project; and establish proposed project development time frames and delivery schedules. The information in the business case should be continuously updated to ensure that it always reflects the current situation.

The absence of an adequate definition of 'technology business value' is a major omission in this research area. When an attempt is made to define the concept, the definition varies among researchers. The term 'technology business value' is a more recent term,

appearing predominantly in the 1990's and, according to literature, may equate to:

- Service to the business [8];
- Value added as equal to revenue minus purchases [13];
- Value technology adds to business [7];
- Economic contribution that technology can make to the management's goal of profit maximization [1];
- Strategic value [6];

IE goes beyond the above traditional 'business value' techniques and introduces the concepts of value and risks. The major advantage to adopting an IE approach in the construction industry is that it is virtually impossible to evaluate, if one only asks what the cold hard benefits are. They are unlikely to be perceptible in such an industry. For example, a newly introduced technology may or may not bring hard benefits to the first major construction project for which it is used. It will certainly make a difference to every subsequent construction project. How do we bring all these factors into the equation when trying to decide on the investment in the first place.

IE offers solutions to these problems by offering a framework within which the total positive and negative impacts that technology projects can have on an enterprise can be discussed and evaluated. It looks at how technology will be used, as well as what benefits it may bring. Thus it encompasses a number of human and management factors. Since the success or failure of a technology largely depends on these factors, as well as business factors [15].

5.1 Determining the value of a technology project

To determine the value of technology investments according to business priorities, construction organisations can use the techniques of IE to go beyond traditional NPV and ROI analysis methods. IE is based upon the concepts of value and two-domain analysis. Value is the contribution of technology to enable the success of the business unit. Two domain analysis segments organisations into business and technology domains to assess the impact of technology and innovation on each domain [11].

IE provides the means to analyze and select technology investments that contribute to organisational performance based upon business value and risk to the organisation. This is done using the following business and technology domain factors. Detailed descriptions of each domain factor can be found in [11].

The business domain factors include the following:

- Return on investment (**ROI**): Assesses the cost-benefit analysis plus the benefits created by the technology investment on other parts of the organisation.
- Strategic Match (**SM**): The degree to which a proposed technology project supports the strategic aims of the organisation.
- Competitive Advantage (**CA**): Assesses the degree to which technology projects create new business opportunities, facilitate business transformation, increases company profile etc.
- Management Information Support (**MI**): Assesses the projects contribution to management's need for information about core activities.
- Organisational Risk (**OR**): Assesses the degree to which a technology project depends on new untested corporate skill, management capabilities and experience.

The technology domain factors include:

- Strategic Architecture Alignment (**SA**): Assesses the degree to which the proposed project fits into the overall organisational structure.
- Definitional Uncertainty Risk (**DU**): This assesses the degree to which the users' requirements or specifications are known.
- Technical Uncertainty Risk (**TU**): This looks at the readiness of the technical domain itself to embrace the technology project.
- Technology Infrastructure Risk (**IR**): This assesses the degree to which extra investment, outside the specific project, may be necessary to undertake the project.

IE examines the value and risk that technology contributes to the business and technology domains separately. This provides a more accurate assessment of the impacts of the investment to the organisation.

6. APPLICATION

Construction organisations are starting to develop and adopt information technology (IT) to facilitate the process of information management amongst project teams. IT is seen by many construction professionals as the best way to improve the delivery process. The following hypothetical example explains the employment of the IE technique for assessment of the proposed development and implementation of a project web information management extranet for all construction projects undertaken by a construction contractor. A brief summary of the steps undertaken for the example include;

6.1 Establish weights

Once the business and technology factors have been agreed, the managers must decide their relative importance to the enterprise, and show this by assigning weights (say one to ten) to them. This means getting consensus on what the business's strategic direction and culture are. The weightings reflect a specific organisation's outlook and decisions, and is a way in which IE is tailored to the organisation.

6.2 Evaluate value factors and risks

The construction contractor needs to set up an Investment Review Committee (IRC) that can assign a score of one to five for each domain factor according to specific criteria. The sum of the value factor scores multiplied by the factor weights constitutes the IT project value. The sum of the risk factor scores multiplied by the factor weights constitutes the IT project risks. The factor weights and risks can be displayed in an IE Scorecard as shown in Table 1.

In this hypothetical example, the construction contractor placed the highest weight, 10, on ROI; and 5, or half the importance of ROI, on strategic match. The construction contractor rated the proposed project web system high (4) on the ROI factor due to the high savings in standard operating costs resulting from improvements in delivery processes, responsiveness, reporting and turnaround. A high score (3.5) was also placed on competitive advantage (CA) since the project web system would act as a showcase for the construction company in delivering a high profile project through the use of innovative, business-to-business information management tools that offer significant value to project stakeholders. The project web system received a 3 on the risk factors OR, DU, TU and IR because of the lack of technology leadership, user resistance to change, and low technology literacy and capabilities of some project participants.

6.3 Multiple Technology Project Assessment

For multiple technology projects, the project scores by factor can be displayed in a table as shown in Table 2. In this example the construction contractor has a variety of technology projects proposed for the financial year. The Investment Review Committee (IRC) can use the IE method to choose the best project based on balancing value and risk. In this hypothetical example, the maximum possible value score is 100. The maximum possible risk score is 35. For a project to be selected it must have a minimum acceptable score, for example 80 and it's risks must be manageable. Minimum acceptable standards are usually through information economics experience and previously undertaken benchmarking and baselining activities.

After the scores for each proposed project are known, the IRC can rank the projects according to their total value scores and select the projects that provide the most value at an acceptable and manageable level of risk.

The IRC may wish to adopt a graphical tool to assist in the final selection of an appropriate technology investment portfolio.

Table 1. Information Economics Scorecard for the Web Based Project Information System (Project 1)

	BUSINESS DOMAIN					TECHNOLOGY DOMAIN				IT PROJECT SCORE	
Factor	ROI	SM	CA	MI	***OR***	SA	***DU***	***TU***	***IR***	Value	Risk
Score	4	2	3.5	2	*3*	3	3	3	*3*		
Weight	10	5	5	5	*2*	5	2	2	*2*	**92.5**	**24**

Table 2. Technology Project Scores for a Construction Company Using Information Economics

	BUSINESS DOMAIN					TECHNOLOGY DOMAIN				IT PROJECT SCORE	
Factor	ROI	SM	CA	MI	***OR***	SA	***DU***	***TU***	***IR***	Value	Risk
Score	4	2	3.5	2	*3*	3	3	3	*3*		
Weight	10	5	5	5	*2*	5	2	2	*2*	**92.5**	**24**
Project 1	**40**	**10**	**17.5**	**10**	***6***	**15**	***6***	***6***	***6***		
Project 2	40	10	4	6	4	12	6	2	0	72	12
Project 3	35	10	10	20	6	15	6	6	6	90	24
Project 4	15	8	0	4	0	2	3	2	0	30	4

6.4 Adaptability to Construction

There is a further aspect to adaptability which is linked to the question of how relevant are the factors produced by Parker et al. [11] to the construction industry. They appear to be well-chosen and cover all the issues. This does not mean they should be treated as carved in stone. Another strength of the IE approach is that it can be further developed, as well as adapted, to reflect newer thinking or new situations and environments [15]. This is particularly beneficial to the construction industry which holds few similarities to other industries employing technology for automation i.e. manufacturing, insurance, banking, etc.

7. CONCLUSION

Increasing global competition and market forces demand technology integration in the construction industry. Global forces and market forces are also forcing construction executives to report on "business value" generated from their technology investments. A new standard for management expertise is evolving: setting performance targets, designing efficiency and effectiveness measures, systematically and accurately measuring outcomes, and then using the results for informed decision-making. This paper employs IE as a tool for technology project selection. IE provides construction professionals seeking to employ a diverse range of technology projects within their organisation, a procedure to assist implement innovative technology with performance evaluation and management as an integral part of the process.

REFERENCES

[1] R. Banker, R. Kauffman. "Quantifying the Business Value of IT: An Illustration of Business Value Linkage Framework." Working Paper. 1991.

[2] E. Brynjolfsson. "The Productivity Paradox of Information Technology." *Communications of the ACM*, Vol. 36 No. 12 pp. 67-77. 1993.

[3] E. Brynjolffson, A. A. Renshaw, M. V. Alstyne. "The Matrix of Change." *Sloan Management Review*, Vol. 38. 1997.

[4] F. Hasegawa. *Built by Japan: Competitive Strategies of the Japanese*, John Wiley & Sons. 1988.

[5] R. Kaplan, D. Norton. "The Balanced Scorecard – Measures that Drive Performance." *Harvard Business Review,* Vol. 70 No. 1 pp. 71-79. 1992.

[6] A. Katz. "Measuring Technology's Business Value." *Information Systems Management*, Vol. 10, No. 1 pp. 33-39. 1993.

[7] R. Kauffman. "Introduction to Part I." In Banker, Kauffman & Mahmood (eds.), *Strategic Information Technology Management*, Idea Group Publishing, Harrisburg, P.A., pp. 15-24. 1993.

[8] B. Konsynski. "A Perspective the Case Study Approach to IT Investment Evaluation." *In Strategic Information Technology Management*, Idea Group Publishing, Harrisburg, P.A., pp. 15-24. 1993.

[9] M. G. Martinsons. "Strategic Thinking About Information Management." *Keynote Address to*

the 11th annual conference of the International Association of Management Consultants, Toronto, 1992.

[10] N. McBride, C. Fidler. "An Interpretative Approach to Justification of Investment in EIS." *Proceedings of 1st European Conference on IT Evaluation*, Henley, UK, pp. 16-26. 1994.

[11] M. Parker, R. Benson, H. Trainer. *Information Economics: Linking Business Performance to Information Technology,* Prentice-Hall, Englewood Cliffs, NJ. 1988.

[12] J. G. Priest, L. Doukas, N. Blaikie. "Investigation of Factors that Strongly Influence the Outcomes of Information Technology (IT) Systems Investments." *IEEE Engineering Management Conference*, 1995.

[13] P. A. Strassmann. "The Business Value of Computers: An Executives Guide*" The Information Economic Press*, New Canaan, Connecticut. 1990.

[14] L. Uchitelle. "We're Leaner Meaner and Going Nowhere Faster" *New York Times*, Section 4 (May 12 1996), pp. 1-4. 1996.

[15] D. Wiseman. "Information Economics: a Practical Approach to Valuing Information Systems." *Journal of Information Technology*, Vol. 7 pp. 168-176. 1992.

[16] P. Weill, M. H. Olson. "Managing Investment in Information Technology, Mini Case Examples and Implications." *MIS Quarterly,* Vol. 13 No. 1, pp. 3-18. 1989.