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Visualising a knowledge mapping of information systems investment evaluation

Zahir Irani [a,b,*], Amir Sharif [a,1], Muhammad Mustafa Kamal [c,2], Peter E.D. Love [d,3]

[a] Brunel Business School, Brunel University, Uxbridge UB8 3PH, United Kingdom
[b] School of Professional Development, Brunel University, Uxbridge UB8 3PH, United Kingdom
[c] Brunel University, Uxbridge UB8 3PH, United Kingdom
[d] School of Built Environment, Curtin University, Australia

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ABSTRACT

Information systems (IS) facilitate organisations to increase responsiveness and reduce the costs of their supply chain. This paper seeks to make a contribution through exploring and visualising knowledge mapping from the perspective of IS investment evaluation. The evaluation of IS is regarded as a challenging and complex process, which becomes even more difficult with the increased complexity of IS. The intricacy of IS evaluation, however, is due to numerous interrelated factors (e.g. costs, benefits and risks) that have human or organisational dimensions. With this in mind, there appears to be an increasing need to assess investment decision-making processes, to better understand the often far-reaching implications associated with technology adoption and interrelated knowledge components (KC). Through the identification and extrapolation of key learning issues from the literature and empirical findings, organisations can better improve their business processes and thereby their effectiveness and efficiency, while preventing others from making costly oversights that may not necessarily be only financial. In seeking to enlighten the often obscure evaluation of IS investments, this paper attempts to inductively emphasise the dissemination of knowledge and learning through the application of a fuzzy Expert System (ES) based knowledge mapping technique (i.e. Fuzzy Cognitive Map [FCM]). The rationale for exploring knowledge and IS investment evaluation is that a knowledge map will materialise for others to exploit during their specific technology evaluation. This is realised through conceptualising the explicit and tacit investment drivers. Among the several findings drawn from this research, the key resulting knowledge mapping through FCM demonstrated the complex, multifaceted and emergent behaviour of causal relationships within the knowledge area. The principal relationships and knowledge within IS investment evaluation are illustrated as being determined by a blend of managerial and user perspectives.

1. Introduction

Today's business environment is progressively transforming into a state of hyper-competitiveness. In this context, organisations need to continuously explore innovative ways to re-orchestrate their products and services for their customers. In recent years, however, it has clearly become evident that enterprise IS (such as Expert Systems [ES], Enterprise Resource Planning [ERP], Supply Chain Management [SCM]) has played a significant role in supporting organisational agility, minimising subjectivity, dealing with uncertainty in decision-making, and coordinating information in the supply chain (Koduru, Xiao, Amirkhanian, & Juang, 2010). A significant increase in such enterprise IS investment has forced many organisations to focus on the effectiveness and evaluation of processes and methods (Stockdale & Standing, 2006). IS evaluation is considered as a decision-making method (Sharif, Irani, & Weerakkody, 2010), which facilitates an organisation to define the costs, benefits, risks and implications of investing in IS infrastructure (Remenyi, Money, Sherwood-Smith, & Irani, 2000). The evaluation of enterprise IS is inherently based upon knowledge of the organisation and strategic, tactical and operational needs (Hedman & Borell, 2004). Such IS support organisations in capturing and storing the knowledge of human experts and then replicating human cognitive and decision-making in the design, production and delivery of manufactured goods (Koduru et al., 2010).

The purpose of an evaluation process, regardless of approach, whether in manufacturing (Irani & Love, 2001) or any other organisation, is to identify a relationship between the expected value

* Corresponding author at: Brunel Business School, Brunel University, Uxbridge UB8 3PH, United Kingdom. Tel.: +44 (0) 1895 265275.

E-mail addresses: zahir.irani@brunel.ac.uk (Z. Irani), Amir.Sharif@brunel.ac.uk (A. Sharif), Muhammad.Kamal@brunel.ac.uk (M.M. Kamal), P.Love@curtine.edu.au (P.E.D. Love).

[1] Tel.: +44 (0) 1895 265326.
[2] Tel.: +44 (0) 1895 267728.
[3] Tel.: +61 8 9266 4723.

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of an investment and an analysis [often quantitative] of the costs, benefits and risks. Thus, the evaluation task in itself requires an approach that supports the mapping of goals and objectives of the organisation against some measurement criteria, noted in the way in which the organisation learns. By addressing the need for a structured evaluation tool to support decision-makers in better understanding the human, organisational and technical implications of their investment decisions, researchers have approached investment decision-making from a variety of perspectives. For example, in an ES context, these systems perform tasks that are carried out by humans with specialised knowledge or experience. The evaluation of performance requires an understanding of human expert performance and how it can be evaluated. The knowledge and experimental learning that is required within a decision-making process, is therefore crucial to the outcome. Sharing and management of knowledge in all its forms needs to be balanced and controlled to maximise its effect (Kim, Hong, & Suh, 2012). In supporting the justification of technologies and infrastructures, investment appraisal plays a vital role via the use of such methods and techniques in evaluating the benefits, costs and risks of such capital expenditure.

The motivation for this paper is to attempt to map out and visualise the range and aspects of knowledge that are relevant to the Information Systems Investment Evaluation (ISIE) process in the manufacturing context, based upon the extant literature and managerial, operational, organisational, technological and strategic aspects of an organisation's strategy. As such, the motivation rests with attempting to understand what aspects of this relevant expert knowledge ultimately drive this knowledge-intensive evaluation task, thereby highlighting some of the dynamic inter-relationships inherent within the field as well as in a practical context. Therefore, in reviewing the literature, the authors conceptualised 15 relevant factors influencing the decision-making process for ISIE and their relevant knowledge components (KC). Albeit, there are a number of factors reported in the literature, these 15 factors are more closely related to the context of this research. Moreover, there is embedded knowledge that is applied within an organisational context that also has an impact on the way ISIE decisions are made. Management and sharing of such knowledge is the key to transforming organisational competencies and operations (Kim et al., 2012). The paper, thus, aims to probe and map the 15 ISIE factors and interrelated KC using a fuzzy ES-based knowledge mapping technique, resulting in an exploration of the inter-relationships and intricacies of decision-making factors in a manufacturing context.

2. Research design

The key task in developing a research structure and design is to define the research approach being adopted by the research team (Walsham, 1995). As a result, a robust research structure and design was constructed, which acted as a blueprint for the research process and is presented in Fig. 1.

Using this figure as a roadmap of the research process, the focus of this paper is to extract and understand those KCs that emerge as a result of the evaluation of IS investment within the manufacturing context. This research is based on the following four steps. Each step acts as a foundation for the next step. For example:

Step 1 is about identifying and classifying influential factors that define ISIE in the manufacturing sector. This was achieved through studying the extant general IS and manufacturing literature – with a specific focus on successful and unsuccessful IS implementation in organisations. This research exercise facilitated the authors' understanding of ISIE practises in manufacturing organisations and, as a result, supported the identification and defining of the influential factors. These factors are classified according to the 'MOOTS' dimensions – **M**anagerial, **O**rganisational, **O**perational, **T**echnological, and **S**trategic. There are 15 factors defined within the MOOTS dimensions (with each dimension comprising three influential factors). Section 3, Section 3.1, and Section 3.2 present the initial discussion and explanation of each factor.

Step 2 is about identifying and correlating KC with the relevant ISIE factor. These KCs are identified using the five-step Pairwise IS Theory Equivalence (PIE) framework (as illustrated in Fig. 2). The PIE process is further divided into five sub-steps (as explained in Section 4.1). For example, for each ISIE factor an assumption is developed, thereafter, two relevant IS theories are identified for each ISIE factor – this allowed more flexibility in extracting a relevant KC. Then a rationale is developed that supports the identification of the dependent and independent constructs relevant to each IS theory. From these constructs only those are selected that clearly associate the ISIE factor with the two chosen IS theories. After identifying the constructs, a relevance check is conducted – this sub-step is merely to ensure the whole process is moving in the right direction, resulting in identifying a gap. This void is then translated into a single KC for each ISIE related factor.

Step 3 details the process by which the MOOTS and the PIE classification approach is combined with expert knowledge to construct a matrix (hence a morphological field) of ISIE factors. Through pairwise comparison – the so-called Field Anomaly Relaxation (FAR) as stated by Rhynne (1995) – these factors then determine the scope of the knowledge to be mapped. Each of these factors are then assigned fuzzy weightings using a range of positive to negative values (in this instance where a value of 1 implies positive causal linkage and -1 implies negative causal linkage). A directed graph can be constructed of these pairwise fuzzy values – which ultimately becomes the Fuzzy Cognitive Map (FCM). In the context of this paper, this is then the knowledge map of the ISIE factors.

Step 4 involves the algorithmic process of the FCM simulation. This requires a number of simulation scenarios to be identified. These scenarios are effectively vectors which represent the initial states of the ISIE factors from Step 3. These vectors are enumerations of expert knowledge encoded into numerical fuzzy values per factor. These vectors are, in turn, fed into the simulation algorithm (essentially an incremental product result of the fuzzy weight matrix and scenario vector) where the successive nodal states of each factor in the directed graph are updated from the preceding nodal state until an equilibrium is achieved (i.e. no numerical change in ISIE nodal values). The output values for each node, hence the ISIE factor, are plotted against iterative steps. Finally, the updated FCM (hence knowledge map) is created through calculating the inverse of the fuzzy weight matrix and the final ISIE nodal values. Changes to the positive and negative causal weights are subsequently identified as well resulting in the knowledge map.

3. Information Systems Investment Evaluation (ISIE)

Information systems constitute a considerable financial investment for organisations (Irani, 2010), thus, they should be justified, evaluated and managed with caution (Chou, Chou, & Tzeng, 2006). Irani (2010) further advocates that management needs increasingly to evaluate their IS investment expenditure using rigorous forms of decision-making and corporate governance. The latter argument is essential as it may assist management to avoid possible investment perils and payoffs (Kim & Sanders, 2002). This makes ISIE a necessity for management. This is because enterprise-wide IS implementation has a huge impact on the way organisations function and influences their strategies, tactics and