Visualising a Knowledge Mapping of Information Systems Investment Evaluation

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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 emphasize 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.

Keywords: Knowledge Management, Knowledge Mapping, Knowledge Components, Supply Chain Management, IS Investment Evaluation, Expert Systems.

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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 et al., 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 et al., 2010), which facilitates an organisation to define the costs, benefits, risks and implications of investing in IS infrastructure (Remenyi et al., 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 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 et al., 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 Figure 1.

INSERT FIGURE 1 HERE

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 practices 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). Sections 3, 3.1, and 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 Figure 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 et al., 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 operational decisions. The role of evaluation has changed over the years i.e. from measuring efficiency gains to seeking enhancements in effectiveness; to appraising the contribution that IS can make to the way organisations perform (Ballantine & Stray, 1999). The latter argument is supported by Chou et al., (2006), who highlight that evaluation is vital to justify higher IS costs, uncertainty of returns from IS investments and act as a control and management mechanism. Stockdale and Standing (2004), however, argue that in evaluating IS a critical challenge is to develop frameworks that are adequately generic and can be applied to a broad range of applications but are also amply detailed to offer effective support. In this context, methodical but equally comprehensible methodologies are required to determine IS justification concerns emerging from the complexity of recent technological solutions (Gunasekaran et al., 2006). Nevertheless, selecting and effectively pursuing appropriate ISIE can lead an organisation to maintain its corporate viability and success. Several underlying principles can be extracted from the extant literature that clearly indicates why organisations pursue appraisal frameworks/methods for ISIE. Table 1 highlights some of the key rationales.

INSERT TABLE 1 HERE

These underlying rationales exhibit the importance of the ISIE process and add credence to the utilisation of appropriate evaluation methods/approaches to improve decision-making for ISIE. The extant IS literature clearly presents the importance of, and the rationale for pursuing an appropriate evaluation process for IS investments. The authors, in line with this research study, attempt to explore ISIE practices in manufacturing organisations. The essence of this investigation is to identify and present a classification of factors that define ISIE in the manufacturing sector.

3.1 ISIE in Manufacturing Organisations

Rapid transformation in the business environment caused by fierce competition and changing customer needs have compelled manufacturing organisations to be more receptive (Caldeira & Ward, 2002). In line with this, manufacturing organisations have increased their responsiveness by implementing IS to improve their business operations and the productivity of their supply chain. For example, Wang et al., (2007) report that IS is increasingly seen as a vital instrument for instigating business transformation within and between manufacturing organisations and imperative for the efficient functioning of their operations i.e. design, production, and delivery of manufactured goods. In some cases, manufacturing organisations have integrated their operations and business strategies to accomplish optimal stability of product standardisation and manufacturing flexibility (Lee, 2003). In contrast, other organisations have avoided conventional solutions and adopted ES to optimise the operation of their manufacturing systems (Metaxiotis et al., 2002). Investing in appropriate IS enhances the agility of manufacturing organisations and facilitates the development of strong, interactive links both within and external to the organisation (Coronado et al., 2004).

In reforming the management of everyday manufacturing operations, integrated IS have been implemented to share knowledge and minimise possible information management oversights in the procurement, planning, production and distribution processes (Metaxiotis et al., 2002). ERP and other IS in the supply chain have been widely implemented in manufacturing. There are cases where manufacturing organisations have failed to complete their IS projects and thus, failed to satisfy their internal and external stakeholders. For example, Irani et al., (2001) studied an SME manufacturing enterprise to gain insights into the failures of their IS implementation. The rationale inferred from the failure was a lack of focus on human and organisational factors during the evaluation and implementation process. Perera and Costa (2008) assert that even though several manufacturing organisations have invested in ERP systems, most of them have not reaped the desired returns. This argument is supported by Cebeci (2009), who highlights that selecting an ERP system is a particularly intricate and vital decision for manufacturing organisations. Such comments on IS performance indicate that while manufacturing organisations have benefited from IS, many of them have been less than satisfied.

For example, some of the apparent reasons for this discontentment are reported by Lee et al., (2008) who state that there is a lack of evidence on returns on IS investment as managements have failed to prove the tangible returns on the resources deployed to plan, develop, implement and operate IS, while, according to Small (2007), inappropriate IS investment justification practices can result in organisations not able to distinguish the vital benefits that manufacturing IS may certainly be capable of conferring. Gunasekaran et al., (2001) exemplify that ISIE, when managed and pursued effectively, can have a positive impact on organisational performance and productivity. Similarly, limited investments, that are insufficiently justified or whose costs, risks, and benefits are poorly managed, can impede an organisation's performance. Thus, a formal justification proposal must be prepared and accepted by decision-makers, prior to IS investments (Irani et al., 2002).

3.2 MOOTS Classification of ISIE Factors

Manufacturing organisations should identify opportunities for making investments in IS relevant to the objectives of their business, and investment decisions should not be based on financial returns only (Gunasekaran et al., 2001). To understand this methodically, the authors assessed the existing ISIE literature in general and in a manufacturing context (in particular) to investigate influential factors that mainly define ISIE in manufacturing organisations. The authors classify these 15 ISIE factors based on the MOOTS dimensions, with a description of each factor given below. This list of factors is not exhaustive; however, these factors and their description included in each MOOTS dimension are identified and discussed based on the literature specifically focusing on IS, ISIE, manufacturing organisations and supply chain management.

3.2.1 Managerial Dimension

- **Management Commitment (MC):** Management commitment is considered as the key to successful IS implementation and organisational change (Fardal, 2007). Investments in IS develop a foundation for continuing progression; however, their returns are not accomplished smoothly and promptly. The significance of IS does not come from deploying them in an organisation; rather from reforming both operational and management processes. Ngai et al., (2008) advocate that the key responsibility of management is the provision of adequate monetary support, resources, and their constant commitment is the only guarantee that ERP projects will have a high preference and receive the required resources and attention. With regards to investment in ERP, management skills and commitment are considered crucial for success in multinational organisations (Koh et al., 2009). Gunasekaran and Ngai (2004) report that management's commitment is vital not merely for the provision of moral support, but also to provide financial and technical support for the implementation of IS. Thus, for any organisation-wide IS, consistent management commitment is a prerequisite.

- **Management Style (MS):** The operational style of management can be effective for investing and evaluating IS (Lu et al., 2006). However, differences in ethos, policies, and management style may have an impact on IS implementation and evaluation practices (Sheu et al., 2004). For example, Zhang et al., (2005) demonstrate that managements have a propensity to administer their operations and business decisions by instinct, knowledge and experience. Ngai et al., (2008) assert that such organisational influences may exhibit themselves in attitudes towards the exploitation, control, and sharing of knowledge. Ho and Lin (2004) argue here that if the differences in opinions and management styles are not well understood and managed, they may potentially lead to the failure of projects. An effective management style can positively impact ERP investments and evaluation processes. Lu et al., (2006) consider management operational style to be a crucial element in the success of ERP systems. When management is committed to working directly with users to implement ERP, communication among business groups and disagreement resolution become achievable.

- **Managerial Capability (MC*):** The availability of personnel with ample competencies for generating innovative ideas is a vital factor in adopting new technologies (Tallon, 2008). Managerial capabilities include effective and efficient management of IS operations, synchronisation and communication with the user community, project management and governance proficiencies (Bassellier et al., 2001).Managerial capability that refers to harmonising the multidimensional operations related to successful IS implementation, is a distinctive feature of effective manufacturing organisations (Zhang et al., 2008). Thus, by ensuring the availability of capable managers, an organisation can employ their services for support in developing both new and existing sets of business requirements. Other managerial competencies include exploring avenues for implementing new technologies, evaluating their compatibility, describing IS investment priorities, and highlighting ways to develop value from their IS investments (Fink & Neumann, 2009). All such managerial capabilities impact on the design of a flexible IT infrastructure and IT skill-based resources to reduce the downside risk of rigidity traps that might otherwise damage or confine agility.

3.2.2 Organisational Dimension

- **Organisational Culture (OC):** The culture of an organisation signifies the way its workforce perceives and contemplates which has a direct influence on the ways in which individuals perform (Ke & Wei, 2008). When organisations develop distinct cultures, employees develop distinct perceptions on organisational change – which influences employees' attitudes towards accepting change (Lau and Woodman, 1995). Culture is a significant element in realising the success of ISIE that inevitably leads to organisational change and eradication of any cultural issues (e.g. linkages between culture and organisational performance, trust, openness and collegiality). Jarvenpaa and Staples (2001) assert that a lack of harmonisation between culture and cultural assumptions embedded within an IS, is likely to anticipate a costly implementation failure. Thus, the fit between IS and organisational culture is vital for businesses to acquire benefits from the system. Irani et al., (2005) indicate that IS investment decisions tend to be influenced by culture. In reducing cultural issues and risks related to IS investment, organisations need to leverage certain cultural aspects that may encourage an atmosphere that nurtures KM.

- **Organisational Performance (OP):** Organisations examine their performance in terms of effectiveness i.e., in accomplishing their vision and efficiency by deploying resources appropriately (Zhang, 2005). However, to achieve effectiveness and efficiency, organisations need to focus on measurements to assess their business performance e.g. customer satisfaction, productivity, profitability, quality output, innovation and staff (Page et al., 2006). Organisational performance measurement plays a vital role in organisational development (Velcu, 2007). By measuring performance, an organisation can ascertain and pursue progress against its predetermined targets, assess performance against internal and external benchmarks, and strive for enhancement. In the context of ERP systems, Nicolaou (2004) reports that organisations implement ERP systems with a view to replacing disparate systems and improve organisational performance. Thus, most manufacturing organisations identify ERP implementation as a key technology priority to enhance their organisational performance.

- **Organisational Size (OS):** Organisational size positively influences both IS implementation and organisational effectiveness. Love and Irani (2004) report that large organisations focus on sophisticated and advanced IS compared to small and medium organisations. The rationale is that large organisations have greater financial resources and institutional ability to support new technologies. This, however, is unlikely in the construction industry where the IS adoption rate is low, illustrating a non-significant difference in investment among organisations (Love & Irani, 2004). The latter argument is supported by Mohr (1969), who argues that large organisations, simply because they are large, are unlikely to implement IS solutions. Recognising that size and implementation are often associated, Mohr (1969) stated that size itself is not related to innovativeness by logical necessity; it becomes significant only when it indicates the conceptual variables that are vital in them. Size may have indirect effects; however, as it is also likely to lead directly to economies of scale that enhance the viability of IS implementation. Thus, as size increases, organisations tend to implement and evaluate more refined technologies to enhance their technological infrastructure.

3.2.3 Operational Dimension

- **Employee Commitment (EC):** Employee commitment signifies the responsibility an employee adopts towards an organisation (Allen & Meyer, 1990). This is recognised by organisational provision of motivation for assimilating organisational objectives and standards into a system of personal objectives and standards (Moynihan & Pandey, 2007).

Organisational change necessitates that employees commit and adapt to change without conflict. Confrontation, however, is considered as the most prevalent response to this strategic change process, (Caldwell et al., 2004). While management is taking decisions for coping with change through IS investment, they should consider not only how their organisational performance will be affected but also scrutinise their employees' commitment towards such initiatives. Shum et al., (2008) highlight here that employee commitment has a positive impact on organisational change initiatives; explicitly, change stemming from IS investment and implementation.

- **Training and Education (TE):** Training and education are vital components of the continuing success of an organisation and in successfully transiting the change process (Gunasekaran & Ngai, 2004). To be successful, it is vital that the management obtains the full support of their workforce, as IS solutions alone cannot enhance competiveness (Tracey & Smith-Doerflein, 2001). In an IS implementation context, Caldeira and Ward (2002) noticed that the proficiency of a cooperative workforce, support from existing vendors, and availability of training and education influenced the implementation and use of IS. By providing training and education, Choi et al., (2007) argue that the benefits transcend simply learning the usability of IS. They further add that training and education are especially beneficial, as they can enable an affirmative attitude and increased acceptance of IS. Al-Mudimigh et al., (2001) highlight that training and education are vital change management catalysts in overcoming organisational impediments such as resistance to change.

- **Information Systems and Manufacturing Agility (ISMA):** Agile manufacturing, primarily a business concept, is today's manufacturing paradigm (Lin et al., 2004). This paradigm is seen as the winning strategy to transform organisations into world market leaders (Coronado, 2003). Achieving flexibility and responsiveness to changing market needs has been the aim of manufacturing sector (Seethamraju, 2006). Despite its significance, agile manufacturing is highly dependent on the quality of information that organisations possess and on their capability to manage and reprocess it (Panetto & Molina, 2008). Continuity in flow of quality knowledge and information is the cornerstone of agile manufacturing (Coronado, 2003). In the process of developing virtual enterprises, emerging organisations have to equip themselves with IS that assimilate their legacy IS and improve upon it (Reich et al., 1999).

3.2.4 Technological Dimension

- **Enterprise Integration in Manufacturing (EIM):** Such integration is a systemic exemplar for organising individuals and machines as a complete system, to produce integrated enterprise systems (Panetto & Molina, 2008). Enhancing IS is crucial for increasing competitiveness and profitability and thus, manufacturing organisations are developing architectures for integrating their operations with their supply chain (Gunasekaran & Ngai, 2004). Enterprise integration can materialise at two broad levels: *intra-enterprise* i.e., bringing together information, business processes, knowledge, resources and supply chain ICT within an enterprise and *inter-enterprise* i.e. facilitating the sharing and exchange of information and resources, and integrating business processes (Goh et al., 2005). Enterprise integration is a vital part of enterprise engineering that is related to the set of methods and tools used to examine, design and sustain a business organisation in an integrated state (Panetto & Molina, 2008).

- **Information Systems and Organisational Fit (ISOF):** Organisations comprise an optimal design or best fit of context, structure, and management. Diverging from that ultimate fit (i.e., misfit) can cause a lack of harmonisation and adequate communication which, in turn, leads to reduced organisational performance (Selto et al., 1995). In an IS context, organisational fit signifies IS's compatibility with the organisation's existing technological infrastructure (Livari, 1992). The fit between an IS and its organisational context will be of mounting significance as IS becomes a vital component of the organisation. In an evaluation context, Irani (2002) extrapolated several themes and one particularly relevant in this context has been to facilitate a better technology-fit and incorporation with an organisation's technological infrastructure. Hong and Kim (2002) found that organisational fit is positively related to successful implementation of ERP systems. According to Willcocks (1994), the fit and configuration of organisation, technology and staff is a vital starting point in implementing IS. It is a strategy that influences IS investment evaluation.

- **Information Systems Quality Output and Performance (ISQOP):** Evaluating IS output and performance is a challenging task (Raymond et al., 2011). The manufacturing sector has committed huge financial resources into implementing ERP systems to synchronise their functions and manage their businesses (Durán & Aguilo, 2008). According to AMR Research estimates, investment in ES amounted to more than US$ 38 billion in 2001, with analysts predicting continued high growth in the level of investment in ES (AMR, 2004). However, Patil et al., (2012) argue that to ensure enterprise IS offers quality output and performance; every manufacturing organisation must evaluate their ERP systems. This analysis can be conducted in terms of performance and profitability, quality output and ease of customisation, implementation time, cost, and customer satisfaction. A close link between business organisation strategy and technological strategy contributes highly to IS and organisational performance. Therefore, quality IS output and performance is seen as a result of direct or proximal strategic alignment of IT (Raymond et al., 2011).

3.2.5 Strategic Dimension

- **Strategic Information Systems Impact (SISI):** Strategic enterprise IS presents a vital investment option for managers in positively influencing business performance and competitiveness (Hendricks et al., 2007). A major strategic impact of ERP systems is that all the required enterprise data is gathered once in the preliminary transaction, stockpiled centrally, and updated in real time. Hendricks et al., (2007) report that this process guarantees that all levels of planning are based on the same data and that the resulting plans convincingly reflect the dominant operating circumstances of the enterprise. The huge investment in enterprise IS has forced management to consider evaluating the rewards pledged by the investment (Caldeira & Ward, 2002). In this regard, Kim and Sanders (2002), who developed a framework for assessing technological investments based on the 'real options valuation' or the 'real options analysis' concept, argued that by using this framework IT managers can assess the strategic impact of their IS investments.

- **Business Strategy and IS Alignment (BSISA):** Aligning IS with business strategy is considered to be a major problem faced by IT managers in large enterprises (Luftman et al., 2006). The misalignment of supply chain strategy with the business strategy can lead to failure of projects (Raymond et al., 2011). It is important for small enterprises and manufacturing businesses to evaluate their IS investments, and once aligned, it facilitates these organisations to perform better in terms of growth, efficiency, and prosperity (Raymond & Bergeron, 2008). The literature highlights the alignment of business and ERP implementation strategies as a major factor influencing organisational performance (Fardal, 2007). ERP systems assimilate business processes and applications, to improve the flow of information via business functions and operations. Velcu (2010) reports that ERP systems provide the business infrastructure and any change to the business strategy must be supported by the ERP system implemented.

- **Strategic IS Business Partnership (SISBP):** The development of a strategic business partnership is essential and referred to as a "technology based association between the organisation and its key business partners" (Zhang et al., 2008). Robinson and Malhotra (2005) report that to accelerate a collaborative partnership in the manufacturing sector, it is vital to implement enterprise-wide integrated IS that drives performance and efficiencies throughout a supply chain. Li et al., (2006), however, accentuate that the associating manufacturing organisations must collaborate with each other in evaluating not only their IS, but also their inventories, business processes, equipment exploitation, and work related procedures. The latter is vital in order to cut operational costs and investigate prospects for joint ventures (Li et al., 2006). Advocates argue that business partnerships are resource-intensive investments involving both financial and strategic risks, thus, the evaluation of resources including IS becomes a prerequisite (Wang et al., 2007).

Table 2 presents a summary of the ISIE factors. Symbols illustrated in columns 3 to 6 indicate the extraction of each ISIE factor from the literature focusing on manufacturing and other sector organisations based on successful and unsuccessful IS investment. Referring to the factor-oriented approach of Kurnia and Johnston (2000), the authors differentiate between the factors extracted from general organisational literature as 'Reused' in column 7 and factors from the manufacturing literature as 'Adapted' in column 8. Although all the factors are considered here, the factors highlighted in column 9 are postulated as new factors in this research.

INSERT TABLE 2 HERE

Having categorised 15 factors under the MOOTS classification of factors influencing ISIE, the authors now move on to investigating the key KC. By mapping the ISIE factors and the KC using a knowledge mapping process, the inter-relationships and complexities of decision-making constructs in this research case can be explored. Knowledge mapping is about making the knowledge that is available within an organisation transparent and is about providing insights into its inter-relationships with other entities within the organisation. To paraphrase Driessen et al., (2007), organisations draw knowledge from three sources: employees, archived documents and IS. Having said this, the following sections present the following:

- significance of knowledge and knowledge management (Section 4),
- illustrating the process of identifying ISIE related KC (Section 4.1), and the classification of KC that individually relate to each ISIE factor (Tables 3 – 7).

4. MOVING FROM KNOWLEDGE TO KNOWLEDGE MANAGEMENT

Knowledge is a vital organisational resource contributing towards managerial decision-making and enhancing organisational competitiveness (Polanyi, 1967). Advocates highlight that its effective management is essential for organisational success (Gunasekaran & Ngai, 2007). Although knowledge is a vital organisational resource, its usefulness and therefore usage will depend, to a large extent, on its quality (Rao & Osei-Bryson, 2007). Knowledge is a combination of experience, values, contextual information and expert insight that support the assessment and assimilation of new experiences and information. Organisations focusing on Knowledge Management (KM) tools and techniques have identified that exchange of knowledge within an organisation has been marked by increased productivity and sustained competitive advantage. Three key aspects can be drawn from this i.e., *People* (organisational and cultural aspects of the use of knowledge); *Process* (methods and techniques for managing the flow of knowledge); and *Technology* (tools and infrastructure that provide access to knowledge). Through these three key elements, a coherent theme has been to relate *explicit* and *tacit* forms of knowledge together (Irani et al., 2005). With regard to organisational knowledge, Nonaka (1994) reported that this level of knowledge is created through a series of socialisation, externalisation, combination and internalisation that transform knowledge between the tacit and explicit modes. In light of this vigorous process of knowledge creation, it can be said that this process of transferring tacit knowledge to explicit (and vice versa), can be regarded as a collaborative act, where knowledge is transferred within the organisation and shared with other individuals. From the above conceptualisation of knowledge two key points can be extracted:

- *First*, knowledge is in a modified form; however, to make an individual's knowledge useful to other individual(s), this knowledge must be conveyed in an effective and efficient way that it is explicable and easily accessible to others. For example, this can be achieved by employing ES – the basic notion is that knowledge from the human mind is stored in the computer and users call upon the computer for particular advice as required. The computer can make extrapolations and reach a particular decision. Then like a human expert, the computer offers recommendations and clarifies, if necessary, the logic behind the suggestion (Turban & Aronson, 2001). ES provide an influential and flexible means of finding solutions to problems that often cannot be dealt with by other, more conventional and orthodox approaches (Liao, 2004).

- *Second*, a stockpile of information is of little value to organisations – it is only when this information is dynamically processed in an individual's mind through a process of deliberation, explanation, and learning that it can be effective.

Here KM comes into play, acting as a methodical process for managing intellectual assets and knowledge resources to meet organisational objectives. The prime objective of KM is to make knowledge easily approachable and re-utilisable by the organisation. Thus, knowledge not only exists in documents and repositories, but it becomes embedded in individuals' minds over time and is demonstrated through their actions and behaviours. Similarly, in an organisational context, decision makers and their decision-making processes are influenced by the knowledge that is generated as a result of evaluating organisational IS investments (Irani et al., 2007). Kulkarni et al., (2006) highlight that knowledge is embedded and streams across manifold units within an organisation. For example, experts with specific domain expertise, explicit best practice procedures, or lessons learned from related experiences, documents, daily operational practices, and information systems. It is, thus, vital to understand the different types of KC in order to expose its potential contribution to the performance of an organisation (Pemberton & Stonehouse, 2000).

4.1 Process of Identifying ISIE related KC

In an attempt to ascertain the KC resulting from ISIE, a five-step Pairwise IS Theory Equivalence (PIE) process is followed. Figure 2 diagrammatically illustrates the five-step PIE process. Each ISIE factor defined under MOOTS classification will follow the same process in order to identify related knowledge components. As highlighted in Figure 2, the steps include (with an example of how a KC for 'management commitment' factor is identified from Step 1 to Step 5) the following:

INSERT FIGURE 2 HERE

- ***Step 1*** *is about identifying the assumptions/starting point* – For each ISIE factor an assumption is developed. The assumption is divided into the 'Focus' and 'Dependence' of the ISIE factor. For example, Focus signifies the central theme i.e. the management is committed to evaluating its IS investments – this indicates the Focus of management, whereas, Dependence signifies the state of being determined, influenced or controlled by something else i.e. management commitment is dependent on the availability and utilisation of resources. From this assumption (i.e., dependence), the keywords extracted are *availability*, *utilisation*, *resources*, and *evaluation*.

- ***Step 2*** *is about identifying the relevant IS theories, models or frameworks* – In this step, the authors identified two relevant IS theories for each ISIE factor. The decision to select two appropriate IS theories, models, or framework was made on the understanding that it would allow flexibility in extracting a relevant KC. For example, for the 'management commitment' factor, the resource-based view and contingency theory were considered relevant based on their dependent and independent constructs.

- ***Step 3*** *is about developing the rationale* – Identifying the main dependent and independent constructs relevant to an IS theory, model or a framework. However, from these available constructs (columns 4 and 5 in Tables 4 to 8), only those constructs were selected that clearly associate an individual ISIE factor with the two relevant IS theories, models or frameworks. For example, the constructs that were deemed relevant from the two IS theories, models or frameworks (those extracted in Step 1) are *assets*, *resources*, *efficiency*, *capabilities* and *organisational performance*.

- ***Step 4*** *is about conducting a relevance check* – Identifying the link between Step 1 and Step 3. This relevance check enabled the authors to relate the keywords extracted from the assumption (Step 1) to the dependent and independent constructs of each IS theory, model or framework (Step 3) to identify a gap.

- ***Step 5*** *is about identifying a gap as a result of Step 4.* Based on the relevance check of keywords and dependent and independent constructs an appropriate KC is extracted (that fulfils the gap). The authors assert that a KC is based upon relevant IS theories, models or frameworks that, in turn, support that KC. For example, for the 'management commitment' factor, the knowledge component identified is *Effective Use of Resources*. This KC is developed based on the correlation between the keywords (Step 1) and the dependent and independent constructs (Step 3).

A similar process for extracting the relevant KCs (of Step 1 to 5) is followed for each of the ISIE factors and presented in the following Tables 3 - 7.

INSERT TABLES 3 - 7 HERE

5. VISUALISING THE KNOWLEDGE MAP

The 15 ISIE related KCs formulated across Tables 3-7 were grouped into six key thematic areas as shown in Table 8, i.e., constructed to be within a morphological field of factors (Rhynne, 1995).

INSERT TABLE 8 HERE

By doing so, the authors wished to carry out a pairwise analysis to determine and remove any redundant / duplicated factors. This approach has been successfully used before (Sharif and Irani, 2006). In comparing any and every two sets of factors, a reduced morphological field was generated leading to an 83% reduction of ISIE related KCs (i.e. from 90 to 15). The method for doing so was based on identifying those ISIE pairwise combinations where four or more similar dependent/independent sub-constructs existed. The resulting reduced morphological field of ISIE factors is therefore shown in Table 9.

INSERT TABLE 9 HERE

This set of ISIE factors was then used as the basis for constructing the fuzzy cognitive map. Causal relationships were developed by the researchers based upon the PIE construct in Tables 3-7, to yield the fuzzy weight matrix in Table 10. Subsequently the FCM in Figure 3 was constructed as a directed graph, wherein the strength of causality between each node (hence USEIT – TRANSF in the weight matrix) was determined by the thickness of the line connecting each factor. A thicker line / thinner line denotes stronger/ weaker causal relationships, respectively, and a value of 0 or no line indicates no relationship.

INSERT TABLE 10 HERE

INSERT FIGURE 3 HERE

5.1 Knowledge Mapping and Simulation of the FCM

The subsequent mapping and simulation of the FCM follows the technique as defined by Kosko (1991) and as denoted by Sharif and Irani (2006). The authors subsequently used the TAPE framework (Sharif, 2004) to identify two scenarios in manufacturing ISIE (one from a user's perspective of evaluating an IS; and one from a manager's perspective of evaluating an IS). These were used as 'seed' factors in the FCM – wherein each of the identified FCM nodes were further classified into explicit or tacit knowledge components.

5.2 Analysis

In both scenarios (Figures 4 and 8) the overall results illustrate that the dynamics are predicated on high to low causal responses ranging from TRANSF, PERF, RES, PAST MGMT through to USEIT, respectively. In the first scenario, there is a significant shift in terms of the negative causal response related to USEIT and RES; with opposite causal responses from all other factors. In the second scenario, there continues to be a large negative reduction in the USEIT variable (from 0.93 to 0.09 which highlights that this has little or no causal effect whatsoever); and a corresponding reduction in causal effect for RES and TRANSF. However, there are causal increases for PAST MGMT and PERF, respectively. This is even more prominent when the starting and ending nodal values are plotted for each scenario as shown in Figures 6, 7, 10 and 11, respectively.

INSERT FIGURE 4 – 11 HERE

Plotting the separate responses on a polar and/or Cartesian scale, magnifies the respective scenario results further as shown in Figures 12 and 13. Here, across both scenarios there appear to be two key dynamic factors which dominate the results – namely the interactions between nodes PERF and RES which show an out-of-phase relationship with one another (highlighting that as the causality of organisational benchmarks and performance increases, the causality of better management of resources decreases (and vice versa). Underlying all of these factors, the dynamic of the past management experience node (PAST MGMT) appears to have a stabilising effect on all of the other nodes – i.e., when this nodal response stabilises, all the other nodes stabilise soon afterwards as well. Hence it can be said that in mapping the knowledge involved in ISIE, the PAST MGMT factor appears to have a tacit controlling impact over all other factors. However, analysing the FCM results which ultimately encode the knowledge within the ISIE process in this vein, reveals that this is only part of the overall picture.

INSERT FIGURE 12 HERE

INSERT FIGURE 13 HERE

Figures 5 and 9 show the respective reconstructed FCM diagrams as following each of the simulation runs. The redrawn FCM in both cases were constructed through matrix manipulation of the computed results, scenario vectors and the original fuzzy weight matrix. This yielded the computed fuzzy eight matrices in Tables 11 and 12 for scenarios 1 and 2, respectively. The FCMs were once again drawn and constructed based upon the pairwise relationship between each node and the strength of each of the causal links determined the thickness of the lines connecting nodal points. Ultimately for both scenarios and FCMs, these diagrams show that each scenario involves an inherent range of inter-relationships belying the initial FCM.

INSERT TABLE 11 HERE

INSERT TABLE 12 HERE

First, analysing scenario 1 through the redrawn FCM in Figure 5 highlights that strong causal relationships continue to exist between PERF – RES and USEIT-TRANSF, a range of others have either strengthened, weakened significantly or new relationships have emerged. These are highlighted in Table 13. The resulting FCM clearly shows a unique set of internal 'knowledge loops' emanating from the USEIT node supplemented by inputs into the PERF component also. The strength of these causal inter-relationships appear to suggest that factors of USEIT, PERF and RES are given more prominence by users of IT in any evaluation of IS, based upon how they may perceive the utility and benefit of IS in the work that they do.

INSERT TABLE 13 HERE

In this FCM it is also interesting to note that there are significantly weak causal relationships in the 'outer loop' of relationships (between PERF-PAST MGMT and PERF-RES especially) that highlight the challenges that management faces in overcoming the 'benefit of hindsight' effect in relation to past experiences of IT benefits and risks (and the resulting resource implications this may have). This is consistent with previous research of Irani et al., (2001) where tactical and operational considerations within the IS evaluation process also shared a similar relationship.

Second, analysing scenario 2 through the redrawn FCM in Figure 9 shows that there are a range of strong causal inter-relationships principally emanating from the PERF and TRANSF nodes. These knowledge loops subsequently jointly feed into the USEIT and PAST MGMT nodes (with the latter having a strong reinforcing loop back to PERF). Here, it is evident that while there may be implicit and weak causal links between the impact of resources applied to IS and the impact that IS has on organisational performance, it is interesting to note that the majority of the negative causal loops in the resulting FCM are related to those factors which implicitly involve the interactions between users and how resources may be used to derive benefit from IT. As identified within Table 13, even though the initial FCM started off with a greater proportion of positive/strong to negative/weak causal links (i.e., 12 versus 3) between the scenarios explored, there are 88% more weak causal links that emerged overall as a result of each of each of the FCM simulations. There are almost three times as many weak relationships as strong relationships in scenario 1 (i.e., 17 versus 5), although there is a better balance between these in scenario 2 (i.e., 10 versus 9). This shows that ultimately a mapping of the knowledge inherent in these IS evaluation scenarios gives an indication of the dynamics of just how difficult and complex it is to overcome organisational culture and technology adoption factors (encapsulated by the explicit knowledge PERF component) as well as integrated and effective efficiency strategies (encapsulated by the tacit knowledge TRANSF component).

6. CONCLUDING COMMENTS

The main contribution of this paper is the investigation of the nature of knowledge (through exploring and visualising a knowledge mapping) in relation to ISIE in the context of manufacturing organisations. In essence, the authors have sought to extend the view and understanding of knowledge by applying a cognitive knowledge mapping technique to explore knowledge-based decisions involved in the evaluation of IS investments. In light of the observations and analyses in the literature (conceptual contribution), the authors were able to formulate the MOOTS classification of factors defining ISIE in the manufacturing context (Figure 3). Having proposed the MOOTS classification, the authors investigated the key KCs related to each ISIE factor. These KCs were identified using the five-step PIE framework (Figure 2). Thereafter, the MOOTS and the PIE classification approach is combined with expert knowledge to construct a matrix (i.e., a morphological field) of ISIE factors – this step led toward the fuzzy cognitive mapping of ISIE factors. The latter process enabled the authors to identify the inter-relationships and complexities of decision-making constructs in this research case. As the concluding step in analysing and synthesizing the findings, the authors presented the algorithmic process of FCM simulation.

The FCM approach used sought to identify those KCs which are relevant to the IS evaluation – hence knowledge-based – process. This paper has been able to present this technique as a means of exploring and hence mapping the knowledge inherent in IS evaluation from both user as well managerial perspectives. The research approach used also complements and favourably compares with the define-map-extract-profile-link and validates the approach for knowledge mapping as defined by Kim et al., (2003) as identified within the research methodology and design. The resulting mapping – hence knowledge mapping through the application of an FCM – has shown the intricate, complex and emergent behaviour of causal relationships within the knowledge area. The principal relationships and knowledge within ISIE have been shown to be driven by a mixture of managerial as well as user perspectives. These are ultimately balanced by strong (as well as weak) driving elements centering around:

- the actual (intended) usage of IT/IS and the immediate operational/tactical benefits this can provide from a user perspective (within FCM scenario 1); and
- a clear set of relationships based upon how organisational culture, technology adoption and the integration of IT/IS for the benefit of the organisation from a manager's perspective (within FCM scenario 2).

6.1 Research Findings

Some additional findings drawn from knowledge mapping are summarised below:

- ES perform tasks that are carried out by humans with specialised knowledge or experience. Their performance evaluation requires an understanding of human expert performance and how it can be evaluated.

- There are cases where manufacturing organisations have failed to complete their IS projects and thus, failed to satisfy their internal and external stakeholders. The reasons inferred from such failures have been a lack of focus on human and organisational factors during the evaluation and implementation process. The literature exemplifies that ISIE, when managed and pursued effectively, can have a positive impact on organisations' performance and productivity.

- This paper aimed to probe and map ISIE factors and interrelated KC using a fuzzy ES based knowledge mapping technique, resulting in exploring the inter-relationships and intricacies of decision-making factors in a manufacturing context. The rationale for exploring ISIE and related KC is that a knowledge map will materialise for others to exploit during their specific technology evaluation.

- The authors reviewed the existing ISIE literature in general and in a manufacturing context (in particular) to investigate the influential factors that define ISIE in the manufacturing organisations. The authors classified the ISIE factors based on the MOOTS dimensions – Managerial, Organisational, Operational, Technological, and Strategic. Factors included in each MOOTS dimension are identified from IS, ISIE, manufacturing organisations and supply chain management literature.

- Knowledge exists not only in documents and repositories, but it becomes embedded in individuals' minds over time and it is shown through their actions and behaviours. Similarly, in an organisational context, the decision makers are influenced by the knowledge that is generated as a result of evaluating organisational IS investments. Knowledge is embedded and streams across manifold units within an organisation. It is thus vital to understand the different types of KC in order to expose its potential contribution to the performance of the organisation. In doing so, the authors identified relevant KC for each ISIE factor through a three-step PIE process.

6.2 Research Implications

This paper has shown how the use of the FCM technique via the two presented scenarios has allowed knowledge within the ISIE process to be explored and mapped. The identification of tacit and explicit knowledge drivers as features within the knowledge domain was then made possible. This approach and findings were therefore concomitant with those as identified by Shaw and Edwards (2005), Sun (2010) and also those influential KM drivers of top/executive management, organisational culture and infrastructure as identified by Kazemi and Allahyari (2009). Furthermore, no claim(s) for generalisation is made for research of this type. It is not the intention of this paper to offer prescriptive guidelines for this type of research, but rather to describe the visualisation of KC with related ISIE factors in a manufacturing context that may allow others to relate their experiences to those reported herein. Moreover, the authors hope to encourage a debate and further analysis of the ISIE factors and related KC. In anticipation, it has been shown that mapping and identifying KC within such a context, can be a useful step in the ISIE process. The authors further believe that by applying complementary techniques and methodologies, such as those presented within this paper, this debate can move forward. Hence, from a research implications perspective, this paper offers a broader understanding of the phenomenon of visualising a knowledge mapping of ISIE factors. Moreover, the implications of the current research on manufacturing organisations can be summarised as follows e.g.:

- Top management, decision makers and practitioners may be able to understand the very complex nature of visualising knowledge mapping, and

- Enhance the decision-making process when preparing to evaluate IS investments in manufacturing organisations.

6.3 Research Limitations and Future Research Recommendations

The combination of theoretical discussions, analysis of the literature and findings presented earlier represents the start of research on visualising a knowledge mapping of ISIE factors in a manufacturing context. Nevertheless, the findings presented in this paper are confined to the limited context of manufacturing organisations. Therefore, it may be difficult to generalise the results of this research to organisations in other sectors. Although, this paper attempted to demonstrate the FCM technique via the two scenarios presented, this has allowed knowledge within the IS evaluation process to be explored and mapped, the research presented in this paper is no exception; as a result this research can be further developed. The authors assert that as the manufacturing sector's managerial, organisational, operational, technological and strategic characteristics can be distinct compared to organisations in other sectors, therefore; similar implications may not be anticipated in other sector organisations. Therefore, in the light of the reflection and the limitation/implications, it is recommended that further work could usefully be pursued to understand visualisation of knowledge mapping of ISIE factors in other sector organisations.

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References	Rationale for ISIE	Focus of ISIE
Irani and Love (2008)	Acting as a catalyst to determine whether to subsidise, adjourn or decline investment demands.	• Investment demands.
Chou *et al.* (2006), Smithson and Hirschheim (1998)	To justify the huge expenditure, comprehend uncertainty of returns, act as a control and administrative mechanism that provides feedback to managers, and form an essential part of the organisational learning process.	• Justifying costs. • Return on investment. • A framework for organisational learning
Kim and Sanders (2002)	Organisations and managements involved in the ISIE process will be able to recognise and comprehend potential risks and rewards.	• Recognition and comprehension of investment impediments.
Willcocks (1994), Boaden and Dale (1990)	To recognise the financial repercussions of ISIE and its ensuing impact on the organisation.	• Impact of evaluation.
Remenyi *et al.* (2000)	Facilitating organisations in standardising and controlling costs, benefits, risks, adoption and implementation of IS solutions.	• Developing benchmarks.
Angell and Smithson (1991)	Act as a standard process to guarantee that IS continues to progress against planned deliverables.	• Developing standard processes.

Table 1: Examples of Rationales Influencing ISIE

Dimension	ISIE Factors	Literature Findings				Reused	Adapted	Regarded as New Factor for the Research in Context
		Other Sector Organisations		Manufacturing Organisations				
		Successful IS Investment Perspective	*Unsuccessful IS Investment Perspective*	*Successful IS Investment Perspective*	*Unsuccessful IS Investment Perspective*			
Managerial	*Management Commitment (MC)*	⦿	–	✧	–	⦿	✧	✧
	Management Style (MS)	⦿	◈	✧	–	⦿◈	✧	✧
	Managerial Capability (MC)*	⦿	◈	✧	–	⦿◈	–	–
Organisational	*Organisational Culture (OC)*	⦿	◈	✧	–	⦿◈	✧	✧
	Organisational Performance (OP)	⦿	◈	✧	⊡	⦿◈	✧⊡	✧⊡
	Organisational Size (OS)	⦿	◈	✧	–	⦿◈	✧	✧
Operational	*Employee Commitment (EC)*	⦿	–	✧	–	⦿	✧	✧
	Training and Education (TE)	⦿	–	✧	–	⦿	✧	✧
	Information Systems and Manufacturing Agility (ISMA)	⦿	–	✧	⊡	⦿	✧	✧
Technological	*Enterprise Integration in Manufacturing (EIM)*	–	–	✧	–	–	✧	✧
	Information Systems and Organisational Fit (ISOF)	⦿	–	✧	⊡	⦿	✧⊡	✧⊡
	Information Systems Quality Output and Performance (ISQOP)	⦿	–	✧	⊡	⦿	✧⊡	✧⊡
Strategic	*Strategic Information Systems Impact (SISI)*	⦿	◈	–	–	⦿◈	–	–
	Business Strategy and IS Alignment (BSISA)	⦿	–	✧	–	⦿	–	–
	Strategic IS Business Partnership (SISBP)	⦿	–	✧	–	⦿	✧	✧

Table 2: MOOTS Classification of Factors Defining Information Systems Investment Evaluation

ISIE Factors	MANAGERIAL DIMENSION STEP 1 – Assumptions	STEP 2 – IS Theories	STEP 3 – Main Dependent & Independent Constructs for Selecting Theories Dependent	Independent	STEP 4 – Relevance Check Relevant Keywords from Step 1	Relevant Constructs from Step 3	STEP 5 – Knowledge Components Related to each ISIE Factor
Management Commitment	***(a) FOCUS:*** Management is committed to evaluating their IS investments. ***(b) DEPENDENCE:*** Management commitment is dependent on the availability and effective utilisation of financial and other organisational resources e.g. if there is enough investment to implement and conduct IS evaluation, management will be committed towards promoting/pursuing the evaluation.	• Resource Based View	• Competitive Advantage • Organisational Performance	• Assets • Capabilities • Resources	• Availability • Utilisation • Resources • Evaluation	• Assets • Resources • Efficiency • Capabilities • Organisational Performance	• Effective Use of Resources
		• Contingency Theory	• Efficiency • Organisational Performance	• Strategy • Technology • Task • Organisational Size • Structure & Culture			
Management Style	***(a) FOCUS:*** Management style is innovative and flexible enough to evaluate their IS investments. ***(b) DEPENDENCE:*** Innovative management style is dependent on the effectiveness and efficiency of the managers i.e. if the management style is functional, innovative and receptive, management will be committed to promoting/pursuing the evaluation.	• Absorptive Capacity Theory	• Quality of Knowledge Absorption • Quality of Knowledge Transfer • Innovation • Organisational Performance	• Prior Related Knowledge	• Innovative • Efficiency • Effectiveness • Functional • Receptive • Evaluation	• Prior Related Knowledge • Efficiency • Innovation • Organisational Performance	• Past Management Experience
		• Contingency Theory	• Efficiency • Organisational Performance	• Strategy • Technology • Task • Organisational Size • Structure & Culture			
Managerial Capability	***(a) FOCUS:*** Greater managerial capabilities facilitate the process of IS investments evaluation. ***(b) DEPENDENCE:*** Managerial capability is dependent upon access and use of resources to meet their capability demands i.e. if the managers are knowledgeable and have access to enough resources in the organisation, they will be able to fulfill their capability requirements, improve performance and will promote/pursue their IS investments evaluation.	• Resource Based View	• Competitive Advantage • Organisational Performance	• Assets • Capabilities • Resources	• Access • Resources • Capability • Knowledgeable • Enhance Performance • Evaluation	• Assets • Resources • Efficiency • Capabilities • Organisational Performance • Quality of Knowledge	• Improved Performance and Management of Resources
		• Absorptive Capacity Theory	• Quality of Knowledge Absorption • Quality of Knowledge Transfer • Innovation • Organisational Performance	• Prior Related Knowledge			

Table 3: Managerial Dimension ISIE Factors and related Knowledge Components

ORGANISATIONAL DIMENSION

<table>
<tr><th rowspan="2">ISIE Factors</th><th rowspan="2">STEP 1 – Assumptions</th><th rowspan="2">STEP 2 – IS Theories</th><th colspan="2">STEP 3 – Main Dependent & Independent Constructs for Selecting Theories</th><th colspan="2">STEP 4 – Relevance Check</th><th rowspan="2">STEP 5 – Knowledge Components Related to each ISIE Factor</th></tr>
<tr><th>Dependent</th><th>Independent</th><th>Relevant Keywords from Step 1</th><th>Relevant Constructs from Step 3</th></tr>
<tr><td rowspan="2">Organisational Culture</td><td rowspan="2">(a) FOCUS: Responsive organisational culture is significant in realising organisational effectiveness and its innovativeness and successful IS investments and evaluation.
(b) DEPENDENCE: Organisational culture is dependent on the effectiveness of its standards, beliefs and overall internal environment i.e. if the organisational culture is innovative, receptive and influential; it is more likely that the organisation will promote/pursue the evaluation of its IS investments.</td><td>• Organisational Cultural Theory</td><td>• Performance
• Organisational Effectiveness
• Employee Commitment
• Employee Satisfaction</td><td>• Organisational Culture Type
• Organisational Culture Strength
• Culture Congruence</td><td rowspan="2">• Effectiveness
• Standards
• Environment
• Innovative
• Receptive
• Evaluation</td><td rowspan="2">• Organisational Effectiveness
• Employee Commitment
• Organisational Cultural Type
• Environmental Context</td><td rowspan="2">• Effective Organisational Benchmarks and Performance</td></tr>
<tr><td>• Technology-Organisation-Environment Framework</td><td>• Technology Adoption</td><td>• Technological Context
• Organisational Context
• Environmental Context</td></tr>
<tr><td rowspan="2">Organisational Performance</td><td rowspan="2">(a) FOCUS: Organisational performance measurement and assessment of IS investment plays a vital role in organisational development.
(b) DEPENDENCE: Effective and efficient organisational performance is dependent on evaluating some key variables i.e. productivity, profitability, customer and staff satisfaction, and IS investments.</td><td>• Organisational Cultural Theory</td><td>• Performance
• Organisational Effectiveness
• Employee Commitment
• Employee Satisfaction</td><td>• Organisational Culture Type
• Organisational Culture Strength
• Culture Congruence</td><td rowspan="2">• Effectiveness
• Efficient
• Performance
• Evaluation
• Productivity
• Profitability
• Satisfaction</td><td rowspan="2">• Performance
• Efficiency
• Organisational Effectiveness</td><td rowspan="2">• Performance Management Metrics</td></tr>
<tr><td>• Contingency Theory</td><td>• Efficiency
• Organisational Performance</td><td>• Strategy
• Technology
• Task
• Organisational Size
• Structure & Culture</td></tr>
<tr><td rowspan="2">Organisational Size</td><td rowspan="2">(a) FOCUS: Organisations are inclined to evaluate their IS investments, in order to justify their spending.
(b) DEPENDENCE: Organisational size is dependent on the availability of financial resources and capability i.e. larger organisations will be more inclined to evaluate their IS investments compared to smaller organisations due to their individual capacity.</td><td>• Resource Based View</td><td>• Competitive Advantage
• Organisational Performance</td><td>• Assets
• Capabilities
• Resources</td><td rowspan="2">• Availability
• Resources
• Capability
• Evaluation
• Capacity</td><td rowspan="2">• Assets
• Capabilities
• Resources
• Discretion</td><td rowspan="2">• Better Management of Resources</td></tr>
<tr><td>• Resource Dependency Theory</td><td>• Power of one Organisation over the other</td><td>• Resource Importance
• Alternatives (for resources)
• Discretion</td></tr>
</table>

Table 4: Organisational Dimension ISIE Factors and related Knowledge Components

ISIE Factors	OPERATIONAL DIMENSION						
	STEP 1 – Assumptions	**STEP 2 – IS Theories**	**STEP 3 – Main Dependent & Independent Constructs for Selecting Theories**		**STEP 4 – Relevance Check**		**STEP 5 – Knowledge Components Related to each ISIE Factor**
			Dependent	**Independent**	**Relevant Keywords from Step 1**	**Relevant Constructs from Step 3**	
Employee Commitment	***(a) FOCUS:*** Employees are committed towards supporting the management in facilitating the process of ISIE i.e. an organisational change initiative. ***(b) DEPENDENCE:*** Employee commitment is dependent on the benefits realised from the use of IS i.e. if IS positively impacts the operations of the employees, they will be more committed towards supporting the management in pursuing the evaluation.	• Technology Acceptance Model	• Behavioural Intention to Use • System Usage	• Perceived Usefulness • Perceived Ease of Use	• Use of IS • Benefits • Satisfied • Evaluation	• Behavioural Intention to Use • User Satisfaction • Perceived Ease of Use	• Actual Use of IS
		• Delone and McLean IS Success Model	• Intention to Use • User Satisfaction	• System Quality • Information Quality • Service Quality			
Training and Education	***(a) FOCUS:*** Availability of appropriate training and education provision is vital for organisational success (at both managerial and employee levels). ***(b) DEPENDENCE:*** IS initiatives alone cannot improve organisational effectiveness and performance. To be successful, it is essential that management acquires the full support of a trained and knowledgeable workforce, as trained and knowledgeable staff support and interest can also develop an positive attitude towards IS evaluation.	• Stakeholder Theory	• Organisational Performance	• Stakeholder Interests	• Organisational Effectiveness • Performance • Trained • Knowledgeable • Attitude • Evaluation	• Organisational Performance • User Satisfaction • Stakeholder Interests	• Skills Identification and System Training
		• Delone and McLean IS Success Model	• Intention to Use • User Satisfaction	• System Quality • Information Quality • Service Quality			
Information Systems and Manufacturing Agility	***(a) FOCUS:*** Manufacturing organisations are focused on implementing and evaluating IS to improve their agility. ***(b) DEPENDENCE:*** Agility is highly dependent on the quality of organisational information and their ability to manage and reprocess it. Information is stored, handled and reutilised through appropriate IS. Thus, organisations are dependent on their IS to generate quality output. Nevertheless, organisations need to evaluate their IS to justify their investments and benefits realised from the use of IS.	• Delone and McLean IS Success Model	• Intention to Use • User Satisfaction	• System Quality • Information Quality • Service Quality	• Agility • Information Quality • Quality Output • Evaluation • Benefits • Use of IS	• Agility • Intention to Use • Information Quality • Capabilities • Absorptive Capacity	• Consistent Information Output
		• Dynamic Capabilities	• Sustainable Competitive Advantage	• Capabilities • Absorptive Capacity • Environmental Turbulence • Agility			

Table 5: Operational Dimension ISIE Factors and related Knowledge Components

<table>
<tr><th rowspan="3">ISIE Factors</th><th colspan="8">TECHNOLOGICAL DIMENSION</th></tr>
<tr><th rowspan="2">STEP 1 – Assumptions</th><th rowspan="2">STEP 2 – IS Theories</th><th colspan="2">STEP 3 – Main Dependent & Independent Constructs for Selecting Theories</th><th colspan="2">STEP 4 – Relevance Check</th><th rowspan="2">STEP 5 – Knowledge Components Related to each ISIE Factor</th></tr>
<tr><th>Dependent</th><th>Independent</th><th>Relevant Keywords from Step 1</th><th>Relevant Constructs from Step 3</th></tr>
<tr><td rowspan="2">Enterprise Integration in Manufacturing</td><td rowspan="2">(a) FOCUS: Enterprise Integration focuses on organising and interconnecting human and technical (including supply chain) resources – to develop an integrated and interoperable enterprise system.
(b) DEPENDENCE: Enterprise Integration can be materialised at inter-enterprise (i.e. linking information, processes, knowledge, and other resources) and intra-enterprise (i.e. sharing information and resources, integrating processes) level. The dependency is on efficiently re-engineering the enterprise system and enhancing performance to respond to the market and technological needs.</td><td>• Contingency Theory</td><td>• Efficiency
• Organisational Performance</td><td>• Strategy
• Technology
• Task
• Organisational Size
• Structure & Culture</td><td rowspan="2">• Re-engineering
• Information
• Efficiency
• Performance
• Resources</td><td rowspan="2">• Resources
• Assets
• Capabilities
• Efficiency
• Organisational Performance</td><td rowspan="2">• Radical Transformation</td></tr>
<tr><td>• Resource Based View</td><td>• Competitive Advantage
• Organisational Performance</td><td>• Assets
• Capabilities
• Resources</td></tr>
<tr><td rowspan="2">Information Systems and Organisational Fit</td><td rowspan="2">(a) FOCUS: The fit between an IS and organisation is vital for appropriately implementing IS. This strategy influences IS investment and evaluation
(b) DEPENDENCE: To increase overall business performance, organisations are dependent on implementing and employing new IS that fits within their existing technological infrastructure with no likelihood of misfit between the two.</td><td>• Fit-Viability Theory</td><td>• Performance</td><td>• Fit
• Viability</td><td rowspan="2">• Business Performance
• Implementation
• Technological Infrastructure
• Employing</td><td rowspan="2">• Performance
• System Utilisation
• Technology Characteristics</td><td rowspan="2">• Use of System</td></tr>
<tr><td>• Task Technology Fit</td><td>• Individual Performance
• System Utilisation</td><td>• Task Characteristics
• Technology Characteristics</td></tr>
<tr><td rowspan="2">Information Systems Quality Output and Performance</td><td rowspan="2">(a) FOCUS: Manufacturing organisations are focused on realising quality output and performance from their IS investments.
(b) DEPENDENCE: To ensure organisational IS provide quality output and performance and its capacity in achieving organisational goals, organisations are required to evaluate their IS investments. The evaluation can be conducted on the basis of performance and profitability, quality output and easiness of customisation, implementation time, cost, and customer satisfaction.</td><td>• Fit-Viability Theory</td><td>• Performance</td><td>• Fit
• Viability</td><td rowspan="2">• Quality Output
• Performance
• Capacity
• Evaluate
• Profitability
• Customisation
• Satisfaction</td><td rowspan="2">• Performance
• Viability
• User Satisfaction
• Quality</td><td rowspan="2">• Quality Production and Performance Measurement</td></tr>
<tr><td>• Delone and McLean IS Success Model</td><td>• Intention to Use
• User Satisfaction</td><td>• System Quality
• Information Quality
• Service Quality</td></tr>
</table>

Table 6: Technological Dimension ISIE Factors and related Knowledge Components

<table>
<tr><th rowspan="3">ISIE Factors</th><th colspan="7">STRATEGIC DIMENSION</th></tr>
<tr><th rowspan="2">STEP 1 – Assumptions</th><th rowspan="2">STEP 2 – IS Theories</th><th colspan="2">STEP 3 – Main Dependent & Independent Constructs for Selecting Theories</th><th colspan="2">STEP 4 – Relevance Check</th><th rowspan="2">STEP 5 – Knowledge Components Related to each ISIE Factor</th></tr>
<tr><th>Dependent</th><th>Independent</th><th>Relevant Keywords from Step 1</th><th>Relevant Constructs from Step 3</th></tr>
<tr><td rowspan="2">Strategic Information Systems Impact</td><td rowspan="2">(a) FOCUS: Manufacturing organisations implement strategic IS in order to impact and enhance their business performance and facilitate their overall competitiveness.
(b) DEPENDENCE: In order to realise the full benefits, competitiveness and potential from the implementation of strategic IS resources, manufacturing organisations need to constantly evaluate their IS investments.</td><td>• Resource-Based View</td><td>• Competitive Advantage
• Organisational Performance</td><td>• Assets
• Capabilities
• Resources</td><td rowspan="2">• Benefits
• Resources
• Evaluate
• Potential
• Implementation
• Competitiveness</td><td rowspan="2">• Competitive Advantage
• Assets
• Resources
• Efficiency
• Performance</td><td rowspan="2">• Enhancing Organisational Competitiveness</td></tr>
<tr><td>• Contingency Theory</td><td>• Efficiency
• Organisational Performance</td><td>• Strategy
• Technology
• Task
• Organisational Size
• Structure & Culture</td></tr>
<tr><td rowspan="2">Business Strategy and Information Systems Alignment</td><td rowspan="2">(a) FOCUS: Organisations are inclined towards aligning their IS and business strategies, in order to improve their business performance.
(b) DEPENDENCE: In order to evaluate IS investments, organisations are initially required to align their IS and business strategy. Once aligned this will facilitate organisational performance in terms of efficiency and progress.</td><td>• Resource-Based View</td><td>• Competitive Advantage
• Organisational Performance</td><td>• Assets
• Capabilities
• Resources</td><td rowspan="2">• Performance
• Efficiency
• Progress
• Evaluate
• Align</td><td rowspan="2">• Performance
• Fit
• Resources
• Assets</td><td rowspan="2">• Strategic Alignment/Fit Procedures</td></tr>
<tr><td>• Fit-Viability Theory</td><td>• Performance</td><td>• Fit
• Viability</td></tr>
<tr><td rowspan="2">Strategic Information Systems Business Partnership</td><td rowspan="2">(a) FOCUS: Manufacturing organisations implement enterprise-wide strategic IS to promote a collaborative association within the supply chain and improve their performance.
(b) DEPENDENCE: Organisations willing to associate with other organisations, need not only to evaluate their IS but also their business processes, existing product portfolio, efficiency, use of resources, and other operational procedures.</td><td>• Resource-Based View</td><td>• Competitive Advantage
• Organisational Performance</td><td>• Assets
• Capabilities
• Resources</td><td rowspan="2">• Evaluate
• Business Processes
• Product Portfolio
• Resources
• Performance</td><td rowspan="2">• Resources
• Capabilities
• Performance</td><td rowspan="2">• Development and Effectiveness of Relationship</td></tr>
<tr><td>• Contingency Theory</td><td>• Efficiency
• Organisational Performance</td><td>• Strategy
• Technology
• Task
• Organisational Size
• Structure & Culture</td></tr>
</table>

Table 7: Strategic Dimension ISIE Factors and related Knowledge Components

ICT	MGMT	PERF	RES	SKILLS	STRAT
Actual Use of IS	Past Management Experience	Improved Performance and Management of Resources	Effective Use of Resources	Skills Identification and System Training	Enhancing Organisational Competitiveness
Use of System	Better Management of Resources	Effective Organisational Benchmarks and Performance	Development and Effectiveness of Relationship		Strategic Alignment/Fit Procedures
		Performance Management Metrics			
		Consistent Information Output			
		Radical Transformation			
		Quality Production and Performance Measurement			

Table 8: ISIE Factors Constructed as a Morphological Field

ICT	MGMT	PERF
Actual Use of IS	Past Management Experience	Effective Organisational Benchmarks and Performance
	Better Management of Resources	Radical Transformation

Table 9: ISIE Factors Following Pairwise Analysis

		USEIT	PAST MGMT	RES	PERF	TRANSF
		Actual Use of IS	Past Management Experience	Better Management of Resources	Effective Organisational Benchmarks and Performance	Radical Transformation
USEIT	Actual Use of IS	0	0.333	0.667	0	1
PAST MGMT	Past Management Experience	1	0	-0.333	-0.333	0
RES	Better Management of Resources	0.333	0	0	0.333	0.667
PERF	Effective Organisational Benchmarks and Performance	0.333	0	1	0	1
TRANSF	Radical Transformation	-0.667	0.333	0	0.667	0

Table 10: Fuzzy Weight Matrix for the ISIE Factors

	USEIT	PAST MGMT	RES	PERF	TRANSF
USEIT	0.000	0.956	0.915	0.977	0.842
PAST MGMT	-0.948	0.000	-0.445	-0.445	-0.671
RES	-0.742	-0.552	0.000	-0.742	-0.859
PERF	-0.897	-0.809	-0.972	0.000	-0.972
TRANSF	-0.915	-0.988	-0.977	-0.994	0.000

Table 11: Final Fuzzy Weight Matrix for Scenario 1

	USEIT	PAST MGMT	RES	PERF	TRANSF
USEIT	0.000	-0.883	-0.938	-0.785	-0.968
PAST MGMT	-0.546	0.000	0.617	0.617	0.369
RES	-0.561	-0.293	0.000	-0.561	-0.748
PERF	0.729	0.851	0.253	0.000	0.253
TRANSF	0.938	0.620	0.785	0.372	0.000

Table 12: Final fuzzy weight matrix for Scenario 2

Aspect	Initial FCM	Scenario 1	Scenario 2
Decrease of Causal Knowledge Relationships	N/A	USEIT-TRANSF PAST MGMT-TRANSF RES-USEIT RES-TRANSF PERF-USEIT PERF-RES PERF-TRANSF TRANSF-USEIT TRANSF-PAST MGMT TRANSF-PERF	USEIT-PAST MGMT USEIT-RES USEIT-TRANSF PAST MGMT-USEIT RES-USEIT PERF-RES PERF-TRANSF TRANSF-PERF TRANSF-PERF
Increase of Causal Knowledge Relationships	N/A	USEIT-PAST MGMT USEIT-RES	PAST MGMT-PERF PAST MGMT-TRANSF PERF-USEIT TRANSF-USEIT TRANSF-PAST MGMT
New Causal Relationships	15	USEIT-PERF RES-PASTMGMT RES-PERF PERF-PASTMGT TRANSF-RES	USEIT-PERF PAST MGMT-RES PERF-PAST MGMT TRANSF-RES
Total Negative Causal Relationships	3	17	9
Total Positive Causal Relationships	12	5	10

Table 13: Summary of Causal Relationships

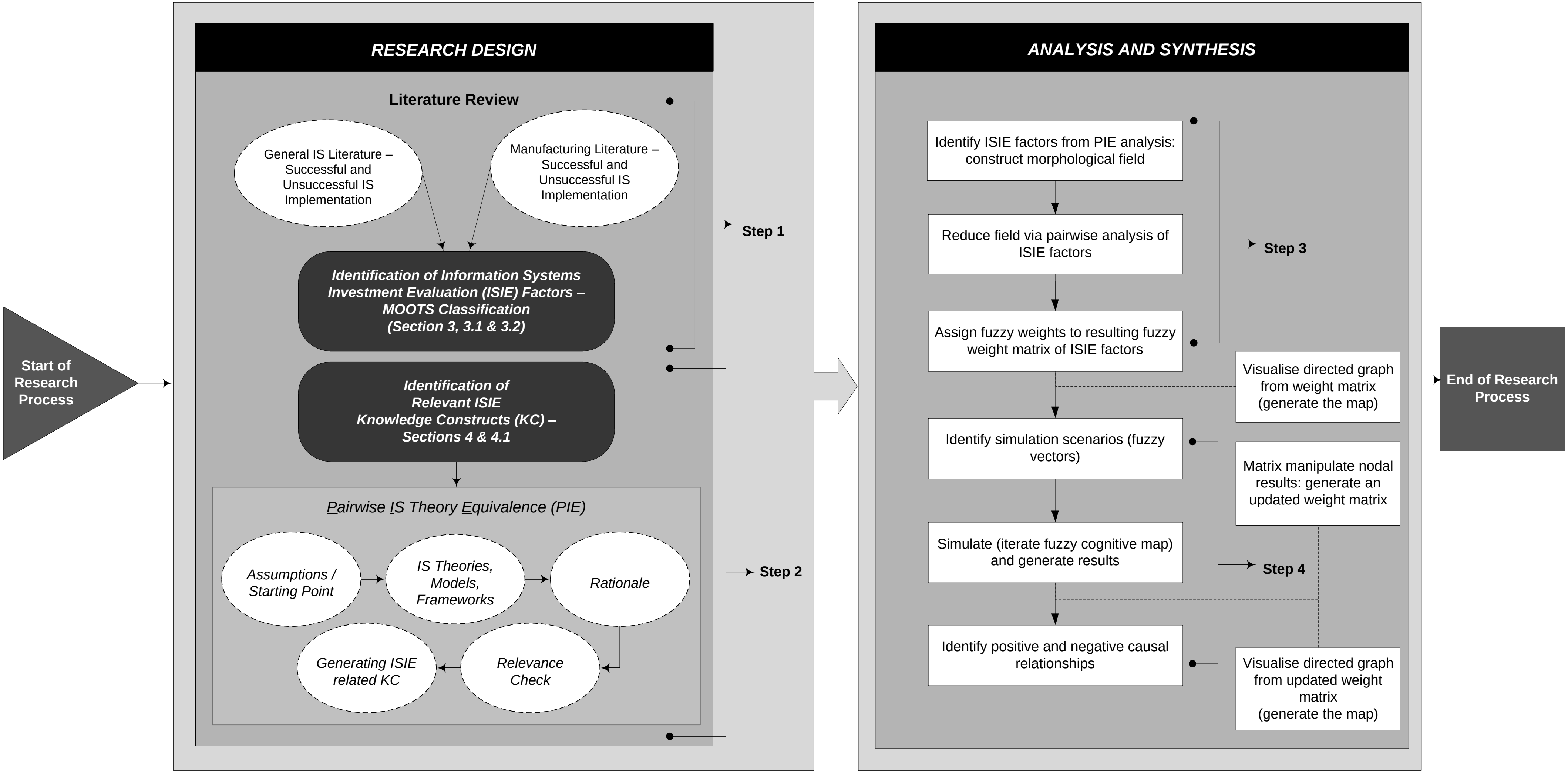

Figure 1: Research Design

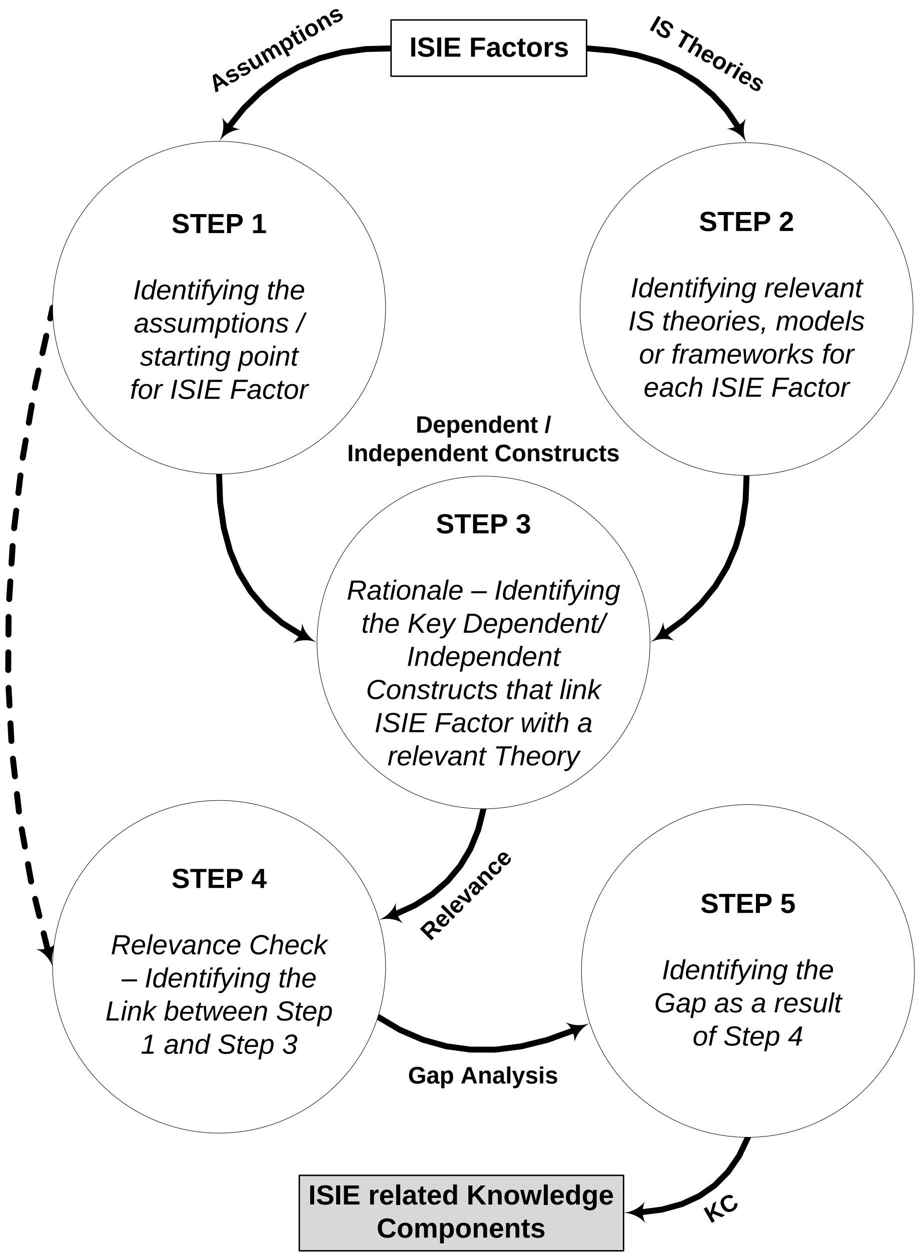

Figure 2: A Three-Step PIE Process for Identifying ISIE Related KC

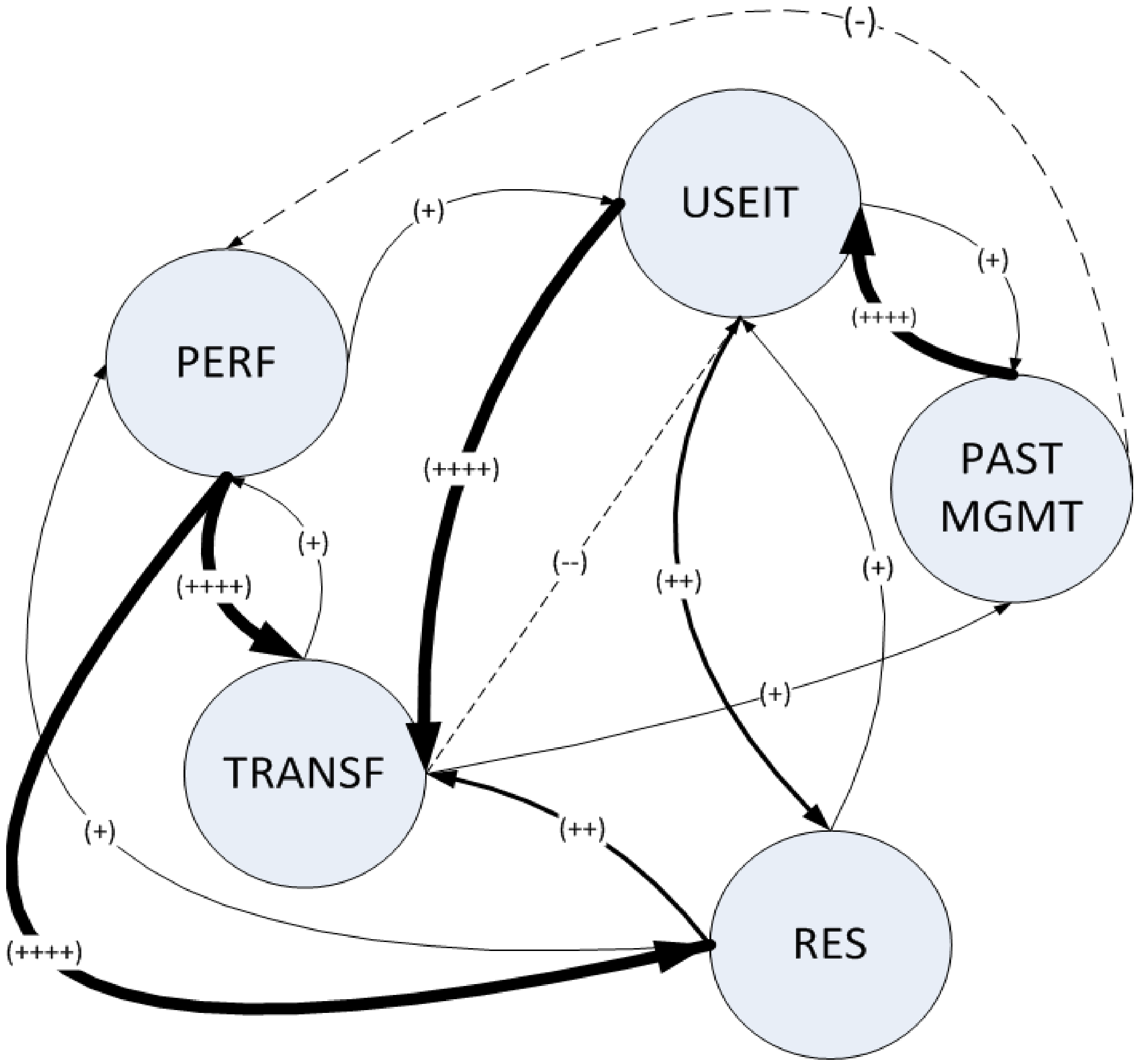

Figure 3: FCM of ISIE Factors

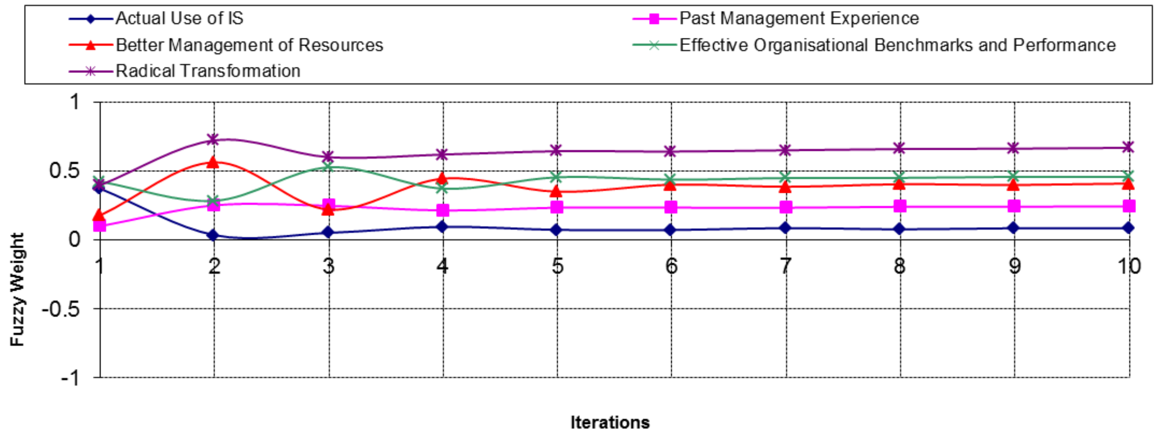

Figure 4: FCM Results for Scenario 1

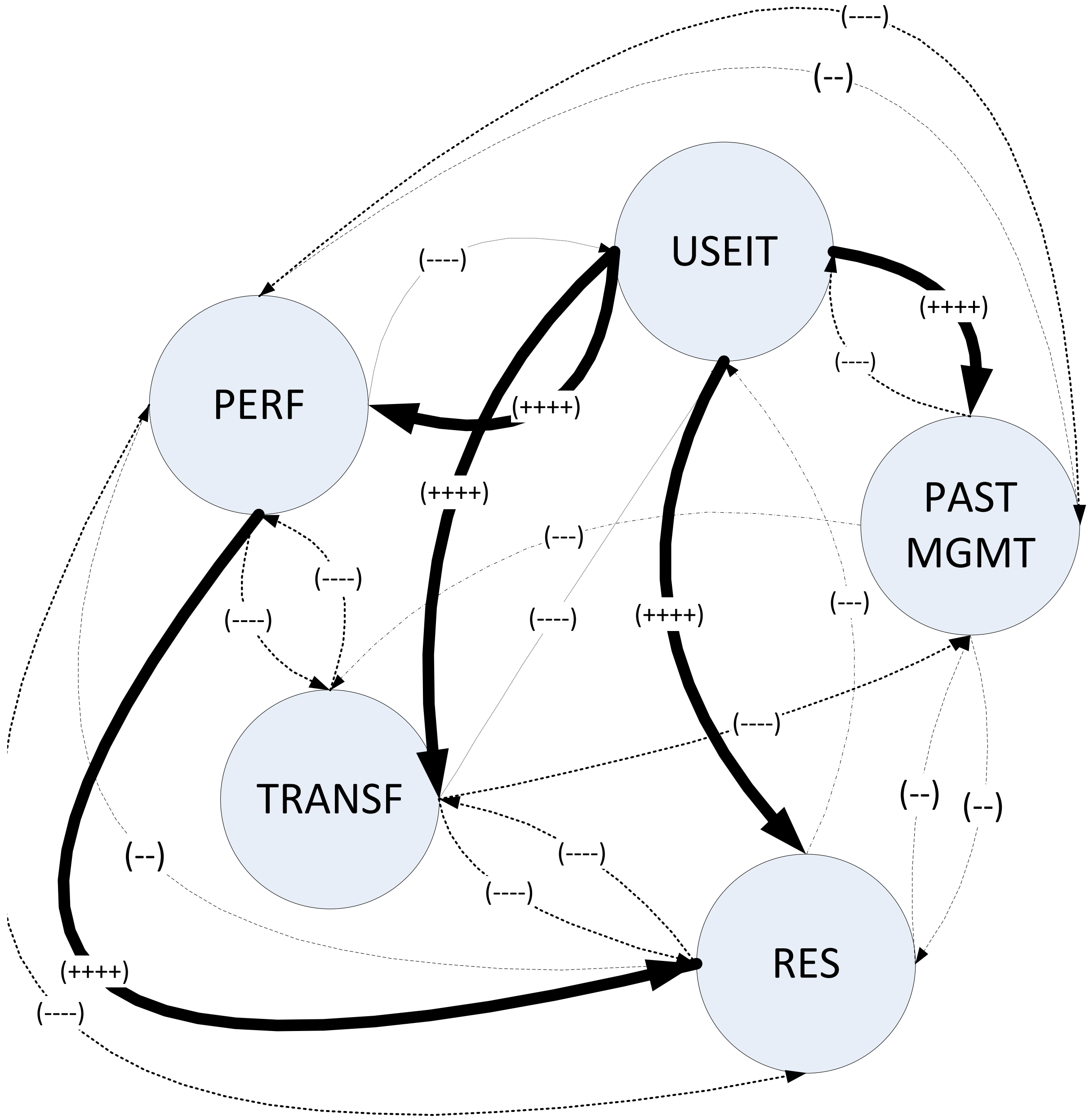

Figure 5: Resulting FCM for Scenario 1

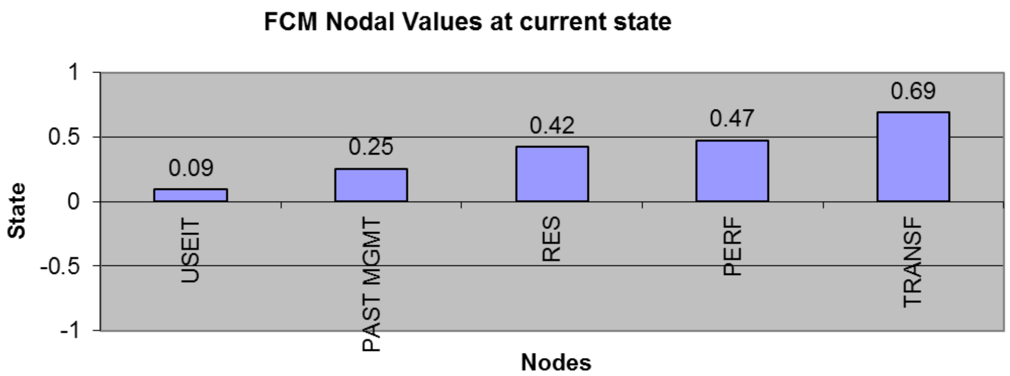

Figure 6: Starting Nodal Values for Scenario 1

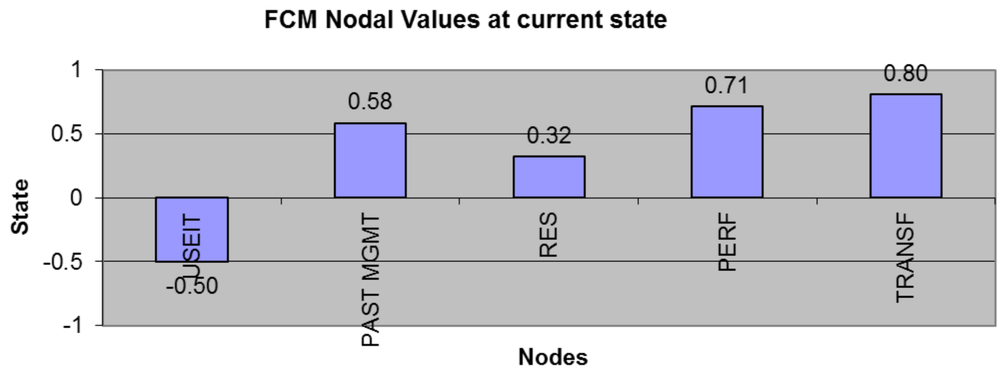

Figure 7: End Nodal Values for Scenario 1

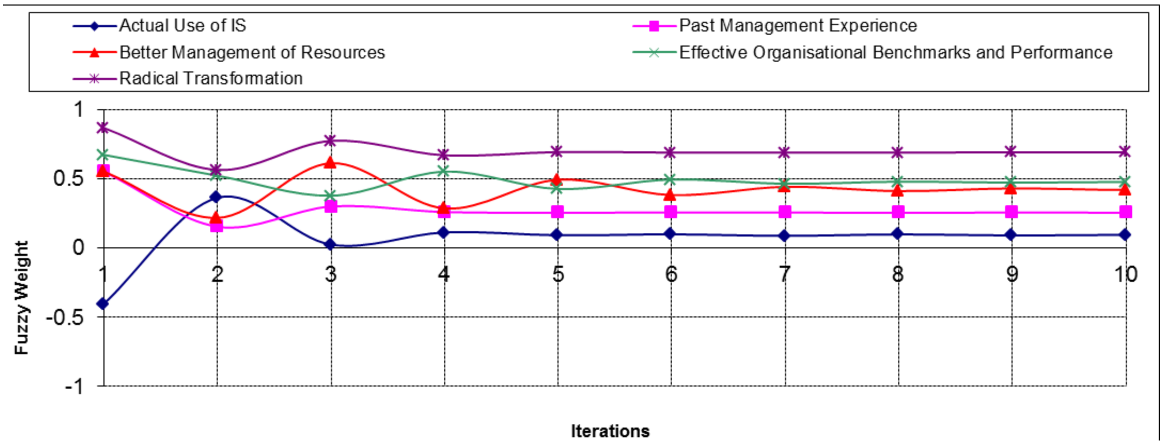

Figure 8: FCM Results for Scenario 2

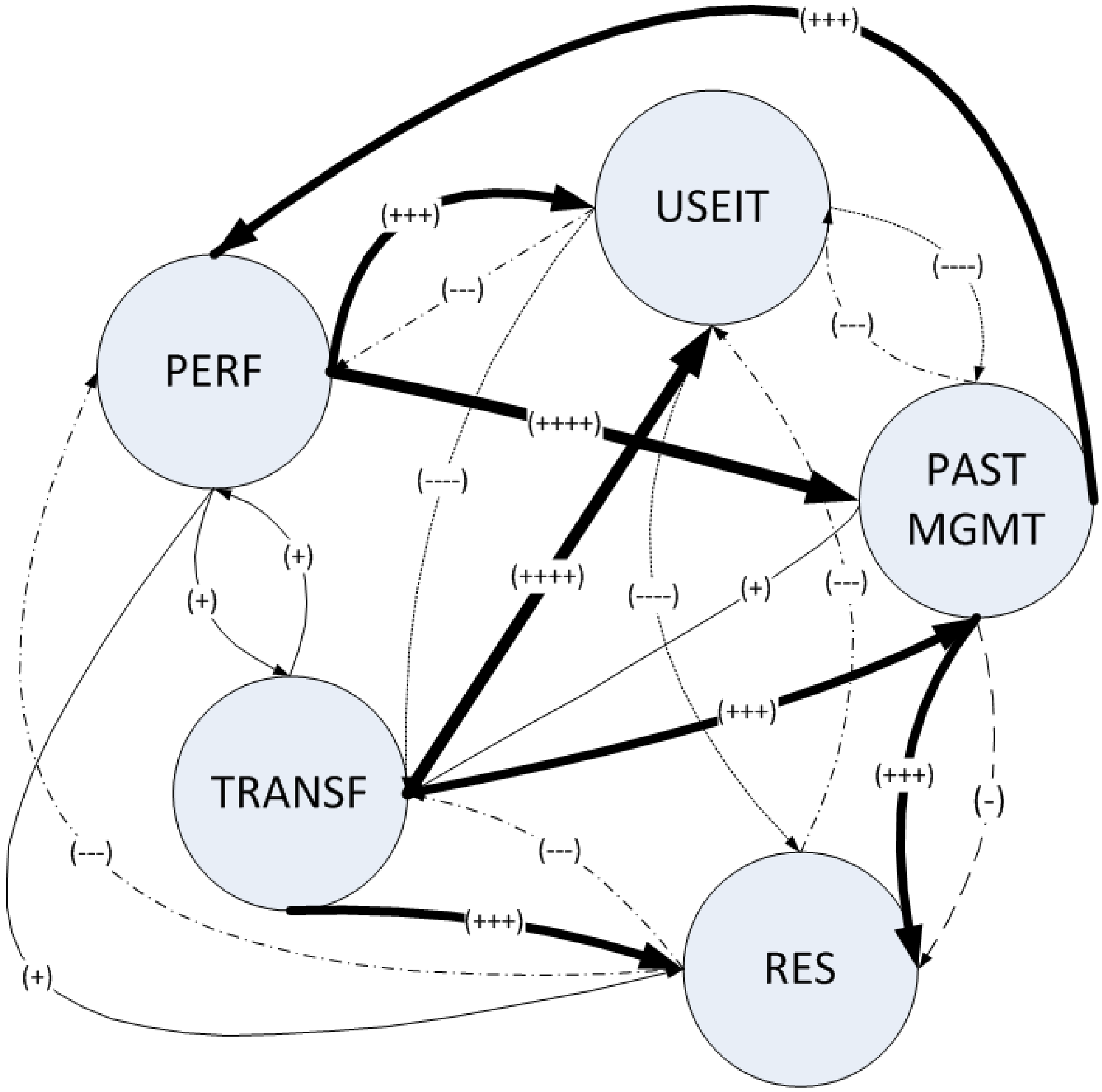

Figure 9: Resulting FCM for Scenario 2

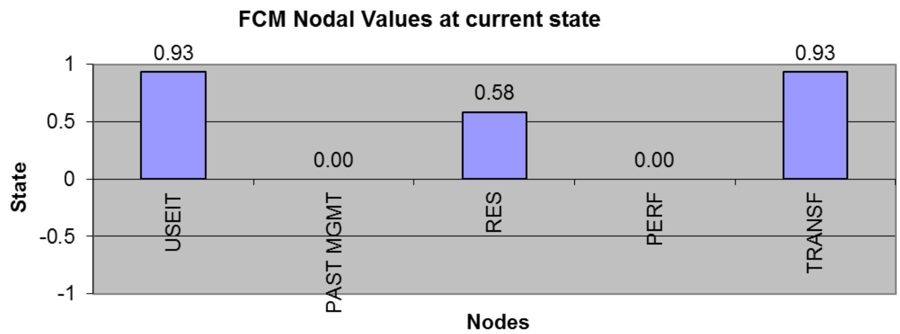

Figure 10: Starting Nodal Values for Scenario 2

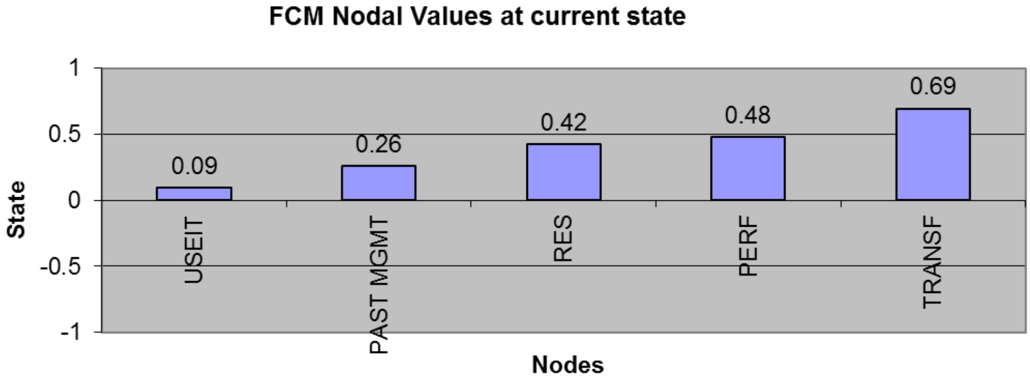

Figure 11: End Nodal Values for Scenario 2

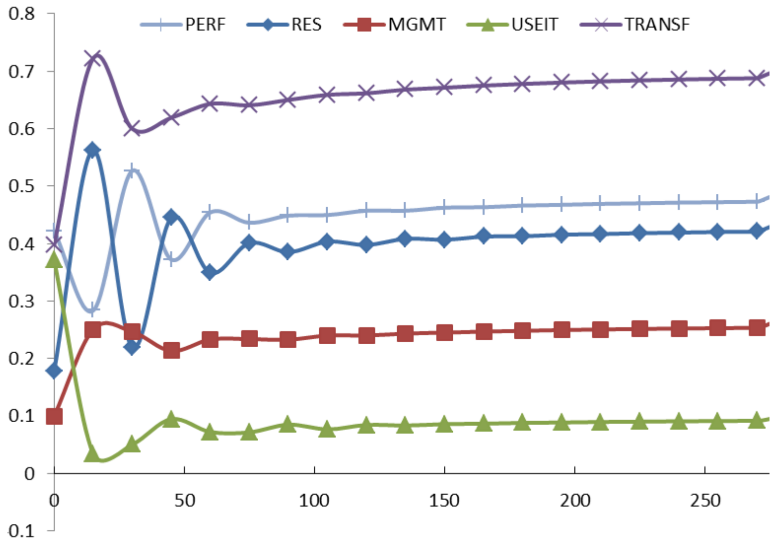

Figure 12: Scenario 1 Phase Plot

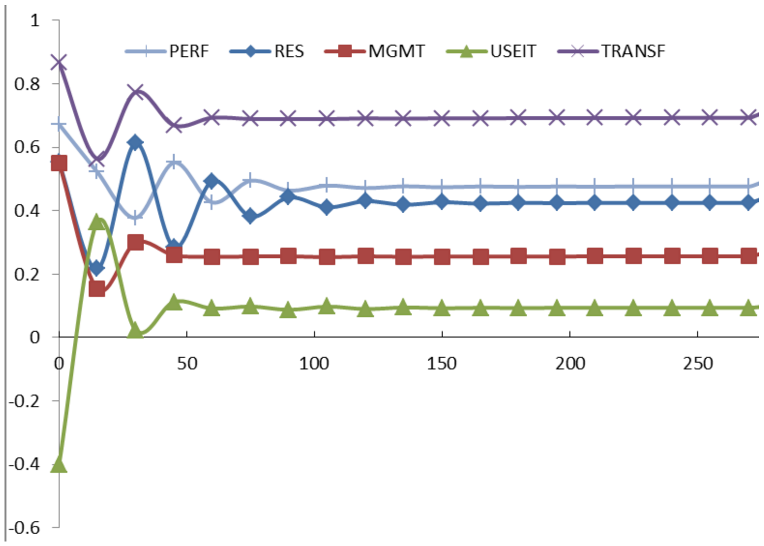

Figure 13: Scenario 2 Phase Plot