Exploring Fuzzy Cognitive Mapping for IS Evaluation: A Research Note

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ABSTRACT

Existing IS Evaluation (ISE) techniques tend to focus on modeling individuals, teams, organization, or systems, in relation to process and environmental boundaries. Whilst such approaches are noteworthy and of merit, they do not necessarily provide insights into those causal interdependencies that are inherent within decision-making task. As has been noted by the extant literature in the field, the ISE task is dependent upon many factors – the resulting outputs of which may be tangible or intangible. The implicit level of uncertainty associated with modeling such decision-making tasks and behaviors, are therefore difficult to comprehend and impart via wholly Quantitative and / or Qualitative analyses. The authors therefore present and propose supporting and on-going research into the application of Fuzzy Logic, in the guise of Fuzzy Cognitive Mapping (FCM) simulations, as a means to model tangible/intangible aspects of the ISE decision-making task. Such a Fuzzy Information Systems Evaluation (F-ISE) is shown via the application of the FCM technique, in terms of three models of investment appraisal that are aligned to an ISE task within a UK manufacturing organization. In doing so, it is anticipated that such a technique may be a useful addition to the plethora of ISE techniques available to both researcher and practitioner alike.

Keywords**:** Fuzzy Cognitive Mapping, Information Systems Evaluation, Benefits Realization

1. INTRODUCTION

As has been shown by Ballantine and Stray (1999) and Irani and Love (2002), many formal and informal techniques for IS Evaluation (ISE) exist. Furthermore, due to the nature of the ISE task, it is apparent that there are numerous factors that are implicit in the decision-making process and act as normative inputs to the ISE task; project costs, benefits, financial appraisal techniques, risks management and/or mitigation, organizational goals, and technical considerations. As a result, the ISE process often falls foul of assumptions that are made about each of these factors. The growth and importance of IT/IS within organizations as well as in society in general, has meant that the selection and implementation of new technology via investment justification processes and associated project appraisal techniques, has become a matter of some importance. It is also understood that as a result of ensuring 'value for money' and the requirement to quantify direct or indirect benefits arising from such Information Technology (IT), involves a lengthy, expensive and complex process of investigation and analysis (Small and Chen, 1995). In light of an increasing regulatory environment (in the guise of both financial and governmental policies), as well as intense competitive pressures (arising from improvements in supply chain efficiencies and globalization effects), there is a desire from many senior management boards to be convinced of the business justification of any Information System (IS) investment, before fully committing funds.

Conventional management accounting and costing frameworks such as Return on Investment (RoI), Internal Rate of Return (IRR) and Net Present Value (NPV) are often used to assess capital investments, albeit from a verbose financial perspective. These techniques typically set project costs against quantifiable benefits to be achieved. When attempting to quantify human and organizational benefits of an IT/IS project however, very few (if any) of these techniques can successfully encapsulate such intangible/tangible aspects, adequately. As such, the quest for a 'one size fits all' ISE method, is fraught with difficulties due to the inordinate variation in the range of circumstances to which evaluation techniques could possibly be applied (Farbey *et al*., 1993). As such, the extensive time and money invested in IT/IS is frequently not perceived to be delivering the business benefits that were initially intended, leading to the notion of the productivity paradox (Brynjolfsson, 1994).

To explore the area of information systems evaluation when set against a backdrop of human, organisational, social and technical complexities, the authors intend to present the application of an Artificial Intelligence (AI) technique. This proposition, is being made in the guise of Fuzzy Logic (Zadeh, 1965), namely Fuzzy Cognitive Mapping (FCM). This is essentially an object or 'mind map' representation of a system or set of causal statements, within a situational context, that can effectively be enumerated in terms of a simulation algorithm (Kosko, 1990; 1991). The authors present the application of this technique to a given ISE scenario, in the case presented, within a UK manufacturing organization; leading the authors to develop of the term, fuzzy-ISE (F-ISE). The application of this technique is shown via the presentation of simulation results which are analysed in detail. In doing so, the authors propose that such an AI approach in the guise of F-ISE, can become a useful technique as part of the IS researcher and practitioner's toolbox.

2. FUZZY COGNITIVE MAPPING (FCM)

2.1 Structure and composition

The technique of FCM is a natural extension to cognitive maps, which can be found in the fields of economics, sociology and political science (Axelrod, 1976; Mentazemi and Conrath, 1986). An FCM is a method to graphically represent state variables within a dynamical system through links that signify cause and effect relationships; being augmented with fuzzy or multivalent weights that are quantified via numbers, or words (Kosko, 1990; Mls, 2004). Visually, an FCM is a non-hierarchic flow graph from which changes to each statement (fuzzy concept, i.e. node), are governed by a series of causal increases or decreases in fuzzy weight values (i.e. links between nodes). The advantage of modelling dynamic systems using a FCM is that even if the initial mapping of the problem concepts is incomplete or incorrect, further additions to the map can be included, and the effects of new parameters can be quickly seen (thus, providing a holistic picture of the scenario being modeled).

2.2 Enumeration and simulation

As a result of the structured approach to mapping concepts using weightings, FCMs are highly amenable to enumeration (Cordoro and Palaez, 2002; Stylios *et al*., 1997). The underlying mathematical theory that supports FCM modeling in the equations that follow, is as defined by Kosko (1991) and is presented below. The causal interrelationship mappings that are linked provide the basis for analysis via computational means, and can be used as an AI system. Given an FCM with a number of nodes, C_i where $i = 1,\ldots, n$ exists, the value of each node in an iteration, can be computed from the values of the nodes in the preceding state, using the following equation:

$$C_i^{t+1} = f\left(\sum_{j=1}^{n} W_{ij}\, C_i^t \right) + C_i^{t-1} \quad (1)$$

where C_i^{t+1} is the value of the node at the $t + 1$ iteration, C_i^{t-1} is the value of the node at the t - 1 iteration, f is a given threshold or transformation function, W_{ij} is a corresponding fuzzy weight between two given nodes, i and j, and C_i^t the value of the interconnected fuzzy node at step t. The threshold function, f (x), can be constructed as being bivalent (x = 0 or 1); trivalent (x = -1, 0 or 1); hyperbolic (usually tanh(x)); or the sigmoidal / step function (x = 1 / 1 + e^{-cx}, where c is a constant). The dynamic simulation of an FCM behavior requires the additional definition of the fuzzy weights, W_{ij}, within a connection matrix, W, and the initial or starting input vector at time t, C^t. As such, the latter is a 1 x n rowvector with the values of all concepts, C_1, C_2,…, C_n for n concepts or nodes in the FCM, whilst the former is a n x n matrix of weights between any two fuzzy nodes, w_{ij}. If there is no direct relationship between the i^{th} and j^{th} nodes, then the value of the connection strength is zero. As such, the connection / influence matrix, W, can be written as:

$$W = \begin{bmatrix} \dots & \dots & \dots \\ \dots & w_{ij} & \dots \\ \dots & \dots & \dots \end{bmatrix} \quad (2)$$

Whilst the initial rowvector can be represented as:

$$C^0 = \left(w_{i,j}^1, \dots, w_{i+1,j+1}^n \right) \quad (3)$$

for n nodes in the FCM. The simulation proceeds by computing C_i^{t+1} based upon the initial starting vector, and the given threshold function in f, as well as the causal connection strengths in the n x n matrix, W. Each subsequent t + 1 iteration then uses the values of the preceding t – 1 row vector in S. Therefore, by calculating each subsequent value of equation (1), the FCM subsequently simulates the dynamical system being modeled. Each corresponding causally-linked node within the mapping then reacts and responds to its respective inputs – the state of each, in a cumulative sense, presage any underlying modality or hidden 'pattern of inference', which belies the implicit system dynamic of the FCM and demonstrates it as a suitable tool for modeling and simulating ISE. As such, the input influence matrix in equation (2) is essentially a set of training data, and thus the iterative application of equation (1) describes a machine learning process (similar to a supervised Neural Network as detailed in Simpson, 1990). This can be seen further if the behavior of the computed rowvector, C, is also analyzed in terms of limit cycle, fixed point or chaotic attractor behavior. An FCM can be said to approach a limit cycle, when the values of the states of the constructed FCM are effectively 'trapped' in a repeating or alternating sequence of states, the divergence from which is not ascertainable with respect to any increases in the number of iterations carried out. For n iterations, a limit cycle can be said to exist if for each rowvector C_i^{t+1} computed,

$$C^t \to C^{t+1} \to \dots \to C^{t+n} \to C^t \to \dots \quad (4)$$

In (4), C^t is the initial phase of the rowvector C when the limit cycle begins, and C^{t+n} is the last face, after which the initial or preceding rowvector is then repeated, to infinitum (regardless of any change in iterations). In contrast, a fixed point can be said to be the convergent case of a limit cycle, in that once a particular value for the computed rowvector is achieved, any increase in the number of iterations carried out to compute the t + 1 solution does not change the resulting state of the FCM any further. Thus, the following (5) provides the definition of a fixed point with respect to a rowvector, C^t.

$$C^t \to C^t \to C^t \to \dots \quad (5)$$

Finally, an FCM can be said to deviate from either a limit or fixed point cycle towards a chaotic (i.e. non-linear, transitive dynamic) response, if for any subsequent iteration, for each node weighting in *W*,

$$C^{t} \neq C^{t+1} \rightarrow \ldots \neq C^{t+n} \neq C^{t} \neq \ldots \tag{6}$$

That is the result of each proceeding rowvector, is different from the preceeding one and no limit or fixed point cycle is reached even for a modest to large increase in the number of computed cycles for the FCM.

3. RESEARCH METHODOLOGY AND PROBLEM DOMAIN FOCUS

The authors now outline the research methodology used in applying the concept of Fuzzy Cognitive Mapping to an investment justification process within a given case organization. The FCM approach used by the authors was applied to model those aspects that impinge upon given ISE processes. This approach entailed identifying an investment justification process; gathering the relevant case data; developing specific FCMs of the ISE; and finally, generating and analyzing simulations of each FCM in relation to training set data. To succinctly define the research process and research design, the authors present Table 1, which culminates aspects of the proposed methodology. This tabulation, allows the researcher to specify the focus of the research design along dimensions of research scope, methodology, data collection and analysis.

Research Component	*Supporting Context*	*Grounding (Reference Source)*
Scope	ISE within a manufacturing organization	Irani and Love (2001) Pouloudi and Serafeimidis (1999) Remenyi *et al.* (2000)
Methodology	Interpretivist (Qualitative), Empirical Case Study	Hakim (1987) Yin (1994)
Data Collection	▪ Background theory / literature survey; ▪ Purposive sampling (selection of case participants); ▪ Primary sources: participant observation (overt observation, time bound and predetermined); semi-structured interviews with senior management and project implementation team (using filter questions, with "probes" and verbalisation) ▪ Secondary sources: company reports;	Fiedler (1987) Shaughnessy and Zeichmester (1994)
Data Analysis	Application of FCM technique and narrative description, in order to elucidate key aspects of ISE within the case organization	Denzin (1984); Kosko (1990)

Table 1. Research methodology components

The methodological approach used was based on the human, organizational, management and process perspective, (Irani and Love, 2001; Pouloudi and Serafeimidis, 1999), wherein a case study research strategy was followed as advocated by Hakim (1987) and Yin, (1994) thus, supporting the capturing of the context associated with the ISE decision-making task. The findings are considered appropriate to provide others with a frame of reference (even though Company A was not systematically sampled). Although, it is worth noting that it is not possible to generalize the findings to a wider population, however, this paper seeks to add to the field of simulation / evaluation approaches which complement existing ISE techniques. The data collection procedure has followed the major prescriptions within the literature for doing fieldwork research (Fiedler, 1978; Yin, 1994).

One-on-one interviews were conducted with the Managing Director (MD) of the case organization, as well as the Financial Director (FD), Production Control Manager (PCM) and IT manager (ITM). The interviewer carefully ensured that the interviewees were fully informed about the purpose of the interviews. Shaughnessy and Zechmeister (1994) suggest that interviewer bias needs to be addressed, which often results from the use of probes (follow-up questions used to get respondents to elaborate on ambiguous / incomplete answers). Care was therefore taken to reduce bias to a minimum through refraining, as much as possible, from asking leading questions and by not introducing any ideas that may form part of the respondent's subsequent answer. Furthermore, the interviewer was also mindful of the feedback respondents gained from their verbal and non-verbal responses. After every interview that was undertaken, notes were given to each person to check, where any discrepancies that may have arisen were resolved thus, supporting the elimination of interviewer bias. A variety of secondary data sources were also used to collect data, such as internal as well as budget reports. Additional data were used to derive the findings presented in this paper, which included interviews, observations, illustrative materials, and archived documentation.

4. APPLYING FCM TO ISE

4.1 Case Organization

The case organization used for the research, Company A, is a manufacturing organization within the UK, which specializes in the manufacture of bespoke aerospace, automotive, and other engineering components. The development and growth of this company has largely been due to previous successful technology investment in recent years. It's approach to evaluating and assessing investments in projects was deemed to be suitable for modeling using an FCM; although it incorporated a typical financial accounting approach, it attempted to include human as well as costs and benefits. The decision-making scenario that was investigated, involved the evaluation of an integrated Manufacturing Resource Planning (MRPII) system (Irani *et al*., 2001a). At the time of conducting the case enquiry, this investment would enable Company A to maintain competitive advantage through the innovative use of this integrated manufacturing system.

In essence, management viewed the investment in an MRPII system as being a strategic innovation programme, which would inherently have and provide realizable benefits; as a result of providing Company A acquiring competitive advantage in its market. It was also understood that in doing so, any such investment would require a significant amount of support and training, for all those stakeholders involved in using the system and in benefiting from the results of the system. All the appraisal perspectives taken by Company A have been summarized in Table 2, in terms of Innovation (i.e. Strategic), Maintenance (i.e. Tactical) and Support (i.e. Operational) factors. The given components of the appraisal approach as defined in table2, although not completely formalized by the company, were seen to be an accurate reflection of the very much informal and ad-hoc decision-making process employed.

Management very much viewed project justification as a hurdle that had to be overcome, and not as a technique for evaluating the project's worth in any sort of rigorous terms. This had significant implications, as during the preparation of the MRPII project's proposal, managers spent much time and effort investigating its technical and financial aspects (in a strategic sense), rather than risk and benefit aspects (in a tactical / operational sense). Hence, the managing director of the firm became committed to the belief that the project was essential. As a result, the remaining project team members tried to address implementation and human resource risks, against estimated cost implications. So, whilst there was a desire to invest and implement in technology, there were, in a sense, opposing causal views of the justification process, which were sought to be accommodated within the proposed FCM.

	Type of initiative	Typical ISE approach	Priority	Resource allocation	Business Process Change	Assumed Benefits	Business Vision	Management
Innovation	Strategic programme / functionally aligned portfolio of tactical projects	Multi-year budget, validated every planning cycle	Aligned with achieving maximum, market-leading benefits; Solving greatest perceived problems at the time	Assign / re-assign after project is completed	High probability of change required	High Value and on-going but with Risk	Very clear	Highly Desirable
Maintenance	On-going changes to an existing system, where it is required to have a team in place	N/A	Quarterly evaluation carried out by business (board and project team members)	Re-allocate / rationalize as efficiency and capability increases	Limited	Remain in business – i.e. keep within "steady state"	None	Necessary but keep to a minimum in terms of overhead and running costs
Support	Steady stream of support services (general infrastructure, production machinery, planning resources, IT/IS infrastructure)	N/A	None applied	No	None	Necessity to business survival	N/A	Costs should reduce over time for a given level of support

Table 2. Company A project appraisal framework

4.2 Generation of FCM scenarios

Against the backdrop presented in Table 2, the authors now present the generation of three FCMs relating to these factors. In doing so, attempting to highlight their use as a decision-making tool associated with capital expenditure. The process for generating the FCM simulation results is as shown in Figure 1. In considering such factors, the authors felt that it was possible to encapsulate the ISE approach taken in Company A, by evaluating fuzzy connectivity. This approach helped to support the active involvement of the domain experts (i.e. case participants) in the formation of the FCM, and also for the researchers to better understand any nuances inherent in the formation of each causal node. As such, Figure 2, 3 and 4 respectively detail particular ISE views within the case company.

The FCM in figure 2 shows a managerial view of the case study company's ISE approach (Irani *et al*., 2001b), using a Strategic, Tactical, Operational and Financial lens - henceforth known as the acronym, STOF; Figure 3 shows a functional project risks, benefits and costs view based upon team member responses (Sharif and Irani, 1999) - henceforth known as the acronym, PRB; and finally, Figure 4 shows a revised, conglomerated model of both of these views - henceforth known as the acronym, REVFCM. In Figure 2, A are Strategic Considerations; B are Tactical Considerations; C are Operational Considerations; D are Financial Considerations; + is a causal increase; and finally, - is a causal decrease. Likewise, in Figure 3, V denotes project value; PB are project benefits; PC are project costs; FA is financial appraisal; and RF are project risk factors. Finally, in Figure 4, AC are Acceptability criteria; PR are Productivity criteria; EF are Efficiency criteria; BE are Benefits; DC are Direct costs; RI are Risks; EM are Evaluation Modes; and IC are indirect costs.

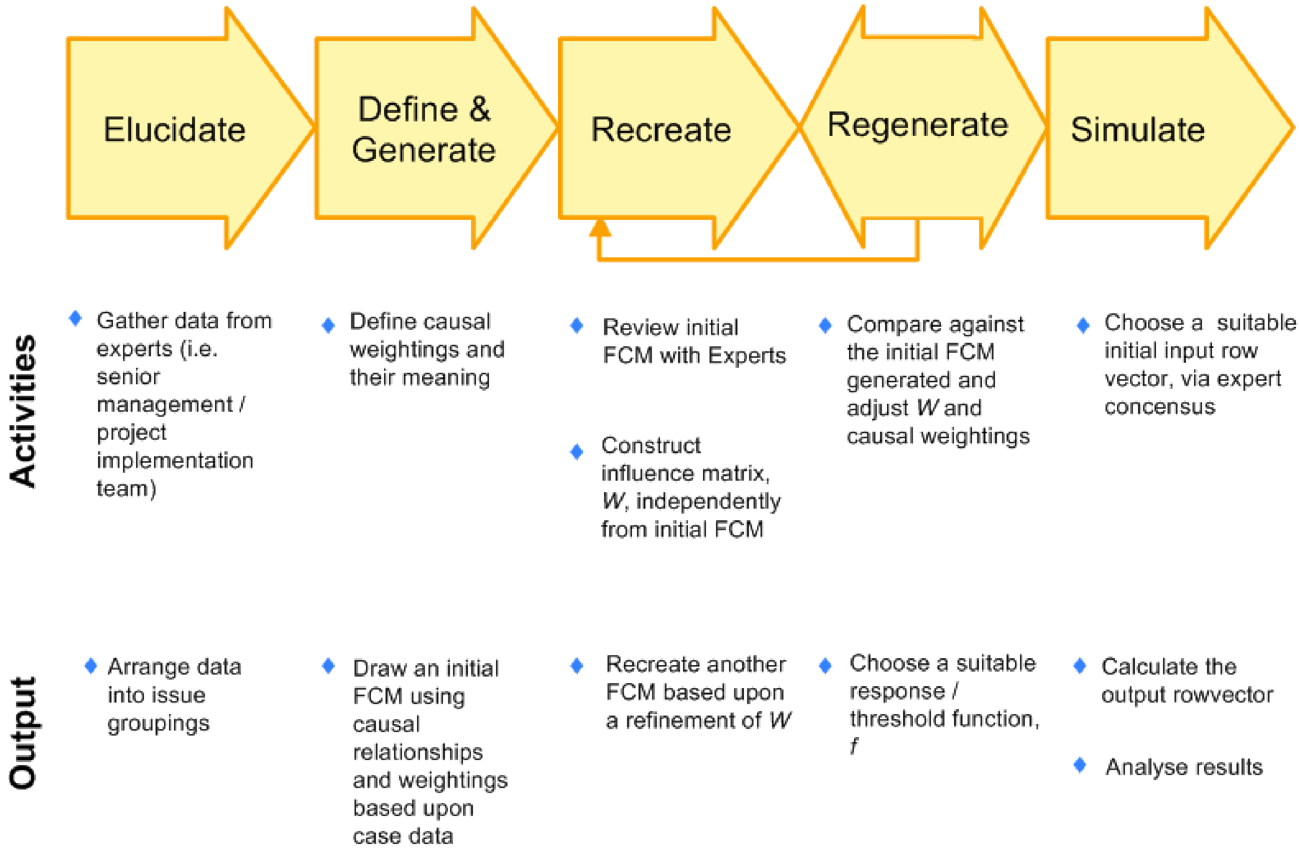

Figure 1. Process flow in FCM generation

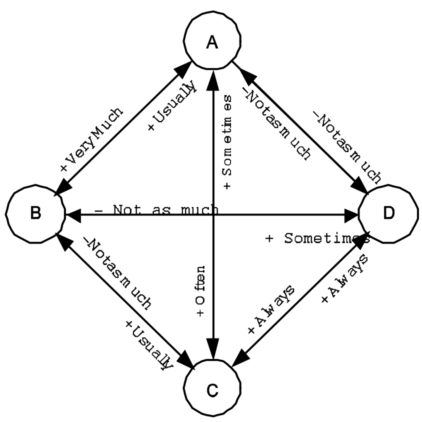

Figure 2. STOF FCM

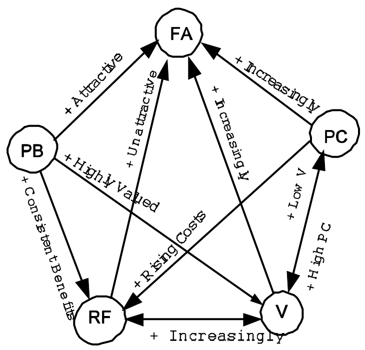

Figure 3. PRB FCM

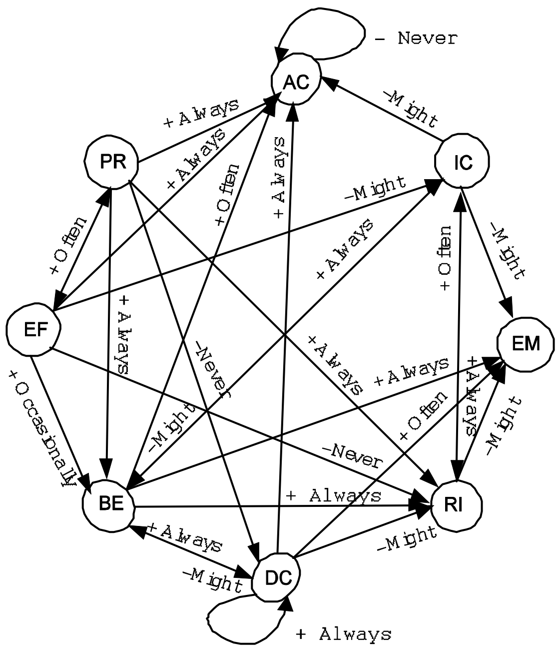

Figure 4. REV FCM

Using equations (1 – 3), we now present results of executing each FCM. To generate the results shown in the proceeding sections, the authors used a spreadsheet-based model employing matrix multiplication and graph drawing add-ins in Excel (Volpi, 2004) in order to both generate the directed (di)graph representation and also in order to run cognitive simulation scenarios based upon causal weightings and input vector states.

The fuzzy connection matrices, are given in equation (4), (5) and (6):

$$W = \begin{bmatrix} 0.000 & 0.750 & 0.250 & 0.125 \\ 0.375 & 0.000 & 0.375 & 0.475 \\ 0.475 & 0.125 & 0.000 & 1.000 \\ 0.125 & 0.125 & 1.000 & 0.000 \end{bmatrix} \tag{4}$$

$$W = \begin{bmatrix} 0.000 & 0.000 & 0.000 & 0.000 & 0.000 \\ 0.750 & 0.000 & 0.250 & 1.000 & 0.000 \\ 0.500 & 0.000 & 0.000 & 0.500 & 0.000 \\ 0.500 & 0.000 & 0.000 & 0.000 & -0.250 \\ -1.000 & 0.000 & -0.250 & -0.500 & 0.000 \end{bmatrix} \tag{5}$$

$$W = \begin{bmatrix} -1.000 & 0.000 & 0.000 & 0.000 & 0.000 & 0.000 & 0.000 & 0.000 \\ 1.000 & 0.000 & 0.667 & 1.000 & -1.000 & 1.000 & 0.000 & 0.000 \\ 1.000 & 0.667 & 0.000 & 0.333 & 0.000 & -1.000 & 0.000 & -0.333 \\ 0.667 & 0.000 & 0.000 & 0.000 & -0.333 & 1.000 & 1.000 & 1.000 \\ 1.000 & 0.000 & 0.000 & 1.000 & 1.000 & -0.333 & 0.333 & 0.000 \\ 0.000 & 0.000 & 0.000 & 0.000 & 0.000 & 0.000 & -0.333 & 0.667 \\ 0.000 & 0.000 & 0.000 & 0.000 & 0.000 & 0.000 & 0.000 & 0.000 \\ -0.333 & 0.000 & 0.000 & -0.333 & 0.000 & 1.000 & -0.333 & 0.000 \end{bmatrix} \tag{6}$$

The threshold function, *f*, for advancing the FCM simulation as given in equation (1), was set to be the hyperbolic function, $f(x) = \tanh(x)$, for all FCMs. The goal or objective ISE task situation was defined to reflect that used by senior management within Company A, in relation to the investment decision. That is implementing the chosen MRPII system, i.e. a Strategic-driven view which assumes assuming Financial considerations are always inherently a part of any investment justification The initial FCM data, or starting row vector C^0, was set accordingly for each FCM as follows:

- [1.000 –1.000 –1.000 1.000] for the STOF FCM;
- [1.000 0.000 -1.000 0.000 1.000] for the PRB FCM;
- [1.000 0.333 1.000 0.000 1.000 0.333 1.000 -0.333] for the REVFCM;

The causal modifiers are given in Table 3, 4 and 5 and for each FCM respectively (i.e. STOF, PRB, REV).

Descriptor	*Weight*
Never	0.000
Not as much	0.125
Often	0.250
Usually	0.375
Sometimes	0.475
Very much	0.750
Always	1.000

Table 3. Causal weights for STOF FCM

Descriptor	*Weight*
Attractive	0.75
Increasingly	0.50
Consistent Benefits	0.25
Highly Valued	1.00
Low V	-0.25
High PC	-0.50
Rising Costs	-0.75
Unattractive	-1.00

Table 4. Causal weights for PRB FCM

Descriptor	*Weight*
Never	-1.00
Unlikely	-0.67
Might	-0.33
Neutral	0.00
Occasionally	0.33
Often	0.67
Always	1.00

Table 5. Causal weights for REV FCM

Figure 4 shows operational and financial considerations are almost double those of the Strategic and Tactical ones. This possibly highlights the dynamic of taking long term costs and / or investments into account, until Strategic goals can be achieved. As such, it can be seen that overall, the influence of investment costs tend to reduce over time as Tactical and then Operational factors are brought into play. This is perhaps not surprising as expenditure on direct costs will have been made and benefits start to be generated. It is also interesting to note that the periodic response of this scenario is primary driven by the reducing effect of Tactical considerations, from iteration 4 onwards. Between iteration 11 and 12, when Strategic and Financial factors are very closely in phase and intersect one another, the cumulative effect of reducing Tactical considerations, suddenly has a strong dampening effect on the whole system.

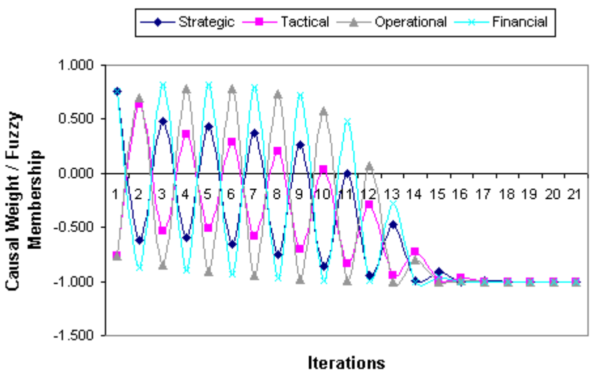

Figure 5. STOF FCM response

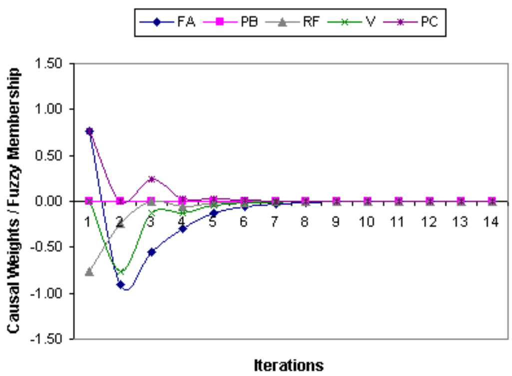

Figure 6. PRB FCM response

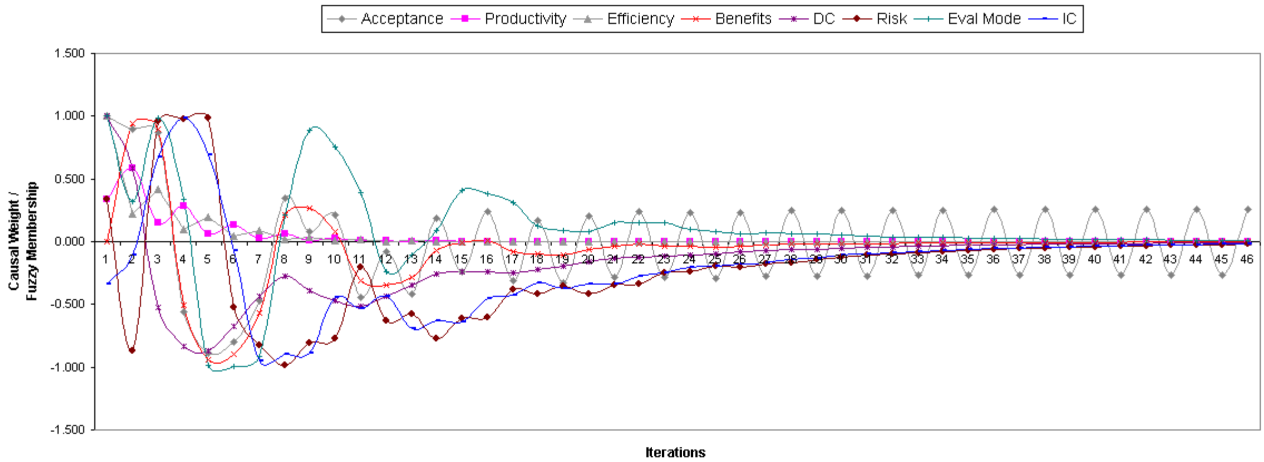

Figure 7. REV FCM response

In Figure 6 it can also see that, within 8 iterations, no single concept dominates. Although known costs have an adverse effect on risks, these costs cannot be realized until a projects value emerges (in terms of realizable / evident benefits at iteration 2). In other words, once a projects' value is defined / realized project risks stabilize. As can be seen from the graph, risk factors RF, tend to stabilize and approach the fixed point equilibrium first, followed by project benefits, PB; project value, V; project costs, PC; and finally financial appraisal techniques, FA. This furthermore denotes that in the absence of any associated project risks, investment evaluations that include at least benefit, value, and cost factors tend to dominate any financial motivations that may be involved or that may drive the initial justification (as shown from iteration 3 to iteration 6).

Finally Figure 7 shows the result for the REV FCM, which can be said to be a combination and henceforth optimization of both the STOF and PRB FCMs. This trace involves a more complex response than the previous two FCMs, with there being a convergence within 45 iterations for all factors except of the Acceptance criteria (which continues oscillating). In itself, this is an interesting reaction to the given initial rowvector of the cognitive map, and may well denote acceptance of an IT/IS investment is intrinsically linked to the Evaluation mode chosen (i.e. the IS appraisal method itself). Familiarity with a given evaluation approach thereby confers stability with regards to the acceptance of that approach (as can be seen in the closely linked behavior of both of these curves between iterations 4 through to 8). Likewise there is an inherent relationship with the level of risk – in this case, the risk curve is out of phase with the evaluation mode curve, denoting that ambiguity or uncertainty relating to the application of an ISE approach, which implies all intangible factors are adversely affected. In other words, from this graph, intangible factors are those that predominantly dominate the lower, negative, half of the y-axis (such as Indirect costs and risk factors); whilst those more tangible factors dominate the upper, positive, half of the y-axis (such as evaluation mode, benefits, acceptance, efficiency and productivity). Productivity and efficiency gains are almost inextricably linked, achieving fixed point convergence within 11 iterations. The relationship between direct and indirect costs is also worthy to note, as the response given highlights that indirect costs only stabilize or as subsumed within the investment, once benefits start to be realized (i.e. once an up-front investment in "visible" and physical products or services occurs, seen as the stabilizing effect of direct costs on benefits from iteration 8 onwards). In such a way, the authors believe that the application of an FCM approach provides further insight and stimulates discussion about the investment process and variables involved.

5. CONCLUSIONS

This paper has shown the application of Fuzzy Logic in the guise of a Fuzzy Cognitive Mapping (FCM) approach, to elucidate key aspects of an investment justification process. This was achieved by defining causal relationships within this decision-making task, in terms of three FCMs: Strategic, Tactical, Operational and Financial criteria (STOF FCM); Project benefits, risks, costs and value characteristics (PRB FCM); and a revised FCM which consolidated both of these previous FCMs together (REV FCM). The investment justification approach used by Company A was thus, abstracted using this Fuzzy ISE (F-ISE) method by modeling interdependencies within the investment justification task, and applying a given ISE goal scenario using initial data for the FCM. Simulation results were generated which provided further insights into the investment justification process involved within the company. These results have shown that:

- Highlighting the effect of Tactical and Operational factors reduces the costs of investment in terms of a long term Strategic consideration (i.e. the STOF FCM);

- Once a project's value is defined / realized, project risks stabilize and in the absence of any associated project risks, investment evaluations which include at least benefit, value, and cost factors tend to dominate any financial motivations which may be involved or that may drive the initial justification (i.e. the PRB FCM); and finally,

- The acceptance of an IT/IS investment is intrinsically linked to the Evaluation mode chosen (i.e. the IS appraisal method itself), and that any ambiguity or uncertainty relating to the application of an ISE approach, implies intangible factors are adversely affected (i.e. the REV FCM).

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