Organizational Energy: A Behavioral Analysis of Human and Organizational Factors in Manufacturing

Zahir Irani, Amir M. Sharif, and Thanos Papadopoulos

Abstract—**This paper seeks to explore the behavior and embodied energy involved in the decision-making of information technology/information systems (IT/IS) investments using a case within a small- to medium-sized manufacturing firm. By analyzing decision making within a given case context, this paper describes the nature of the investment through the lens of behavioral economics, causality, input–output (IO) equilibrium, and the general notion of depletion of executive energy function. To explore the interplay between these elements, the authors structure the case context via a morphological field in order to construct a fuzzy cognitive map of decision-making relationships relating to the multidimensional and nonquantifiable problems of IT/IS investment evaluation. Noting the significance of inputs and outputs relating to the investment decision within the case, the authors assess these cognitive interrelationships through the lens of the Leontief IO energy equilibrium model. Subsequently, the authors suggest, through an embodied energy audit, that all such management decisions are susceptible to decision fatigue (so-called "ego depletion"). The findings of this paper highlight pertinent cognitive and IO paths of the investment decision-making process that will allow others making similar types of investments to learn from and draw parallels from such processes.**

Index Terms—**Behavior, decision making, embodied energy, energy equilibrium model, fuzzy cognitive mapping (FCM), information systems (IS), manufacturing, organizations, people, relationships.**

I. Introduction

THE IMPORTANCE of human and organizational factors for information systems (IS) adoption in manufacturing has been highlighted in the extant literature [13], [14], [16], [43]. Human factors include the views and needs of the relevant stakeholders and decision makers, and human resources such as management/staff time and training. Organizational factors may include the organizational/managerial structure, leadership, business processes, and organizational culture [22], [45].

The extensive use of IS in manufacturing is evident in its evolution, from a limited data processing perspective, to an expanded organization-wide scope of manufacturing computer-based activities [48]. Such IS regards information as a corporate resource, with much potential to improve strategic, tactical, and operational processes. Information systems evaluation (ISE) involves, inter alia, information technology/information systems (IT/IS) investments justification (decision making) at the organization's strategic, tactical, and operational levels [3], [4].

The justification for IT/IS investments in both the manufacturing [25] and service sectors [16] includes an estimation of the potential value of the IT/IS against well-organizational benefits, costs, and risks. These benefits, costs, and risks are measured through established criteria that enable organizational IT/IS decision making and learning [18], [28], [34], [42]. Methods that do not balance between benefits, costs, and risks impact negatively IT/IS investment decisions, which may lead to IT/IS failure [8], [24], [26], [53]. This has led scholars to conclude that there is almost the same number of failed and successful IS implementations [38].

To succeed in IT/IS investment decisions, organizations need to better understand their human, organizational and technical dimensions. No matter if various evaluation methods and perspectives exist [21], [22], organizations are still using the traditional appraisal techniques that are based on financial measures and projections of the investment in question and do not consider human or organizational factors [4], [14], [17], [20]. Hence, such methods pay limited, if any, attention, to the intangible nature of many of IT/IS benefits and indirect costs associated with the IS/IT investment [24], [30], [49].

To address this gap, this paper contributes to the ISE literature by providing an in-depth understanding of the behavior and embodied energy of IT/IS investment decision making in a manufacturing context focusing on human and organizational factors. The reason for taking such a stance is rooted in the argument put forward by Courtney *et al.* [10], who suggest that organizations that are unable to identify an underlying causal model that influences and drives their decision making will be liable to utilize decision-making tools and approaches that may be inherently biased toward predetermined (even unsuccessful) outcomes. Furthermore, Baumeister [2] and Anderson [1] highlighted the importance of understanding the individual and organizational energy involved in making successive executive decisions, which in themselves may impact on the decision-making process. A case study [54] on an IT/IS investment decision that included, *inter alia*, Enterprise Resource Planning (ERP) systems [5], [9], [33], [35] in a manufacturing Small and Medium-sized Enterprise (SME) was followed, because of the importance of ERP systems and the challenges related to IT/IS

Manuscript received April 15, 2014; revised September 3, 2014 and December 27, 2014; accepted January 15, 2015. Date of publication March 6, 2015; date of current version April 15, 2015.

Z. Irani and A. M. Sharif are with Brunel Business School, Brunel University, Uxbridge UB8 3PH, U. K. (e-mail: zahir.irani@brunel.ac.uk; amir.sharif@brunel.ac.uk).

T. Papadopoulos is with the Department of Business and Management, University of Sussex, Brighton BN19SL, U. K. (e-mail: Athanasios.Papadopoulos@sussex.ac.uk).

Color versions of one or more of the figures in this paper are available online at http://ieeexplore.ieee.org.

Digital Object Identifier 10.1109/TEM.2015.2402215

decision making in manufacturing SMEs [49], such as limited IS resources and competencies, diversity of suppliers, size, limited organizational specialization, intuitive strategic planning, risk aversion, and environmental uncertainty; and the lack of research on the behavior and embodied energy involved in IT/IS investment decision making. The focus so far has been on holistic models that integrate financial and nonfinancial factors using multicriteria decision making, stochastic programming, and real option approaches [25].

The contribution of this paper to the ISE literature lies in using the lens of behavioral economics, causality, input–output (IO) equilibrium, and the general notion of depletion of executive energy function [29], [31], [37] to discuss dynamic individual and organizational behaviors—that is, "individual and organizational behavioral energy"—embodied in investment decisions and ego-depletion, that is, a behavioral effect, which occurs as a result of both loss of self-control (the conscious effort to alter intrinsic behavior), and self-regulation (behavior, which is driven by extrinsic norms and goals). This paper argues, following Baumeister [2], that an individual's internal energy and executive ISE decision-making resources can become depleted following successive "withdrawals" from the need to make ISE decisions.

II. ISs Evaluation

The IS investment decisions are frequently based upon *a priori* determined, financially oriented criteria that aim to quantify intangible benefits, costs, and risks, and are underpinned by poor managerial control and responsibility, and limited understanding of the external and internal context. ISE requires an understanding of the implications of technology for an organization's strategic, tactical, and operational goals. There is a need to understand both the basic principles and cultural aspects of the business and its context (including human behavior), as well as the prospective benefits, costs, and limitations of the IS/IT investment in question. Current evaluation methods and tools focus on measurable criteria and pay limited attention to those human and organizational factors that significantly affect IT/IS investment appraisal [21], [22]. This paper addresses this gap and contributes to the extant literature by *providing a deeper understanding of the behavior and embodied energy involved in the decision-making in a manufacturing organization, focusing on human and organizational factors*. The next section discusses the research approach followed in this paper.

III. Research Approach

An exploratory case study research strategy [19], [54] was adopted on a U.K.-based manufacturing SME, known, henceforth, as Alpha, Inc. The nature of the research question, manifested as a need to capture rich data in the form of human and organizational characteristics, and then, evaluate the investment decisions warranted a mixed-methods approach [52]. The research design [11] is depicted in Fig. 1.

A. Data Collection

The data collection phase followed the normative literature for conducting fieldwork in business management and the social sciences [19], [44], [46], [54]. Following ethical approval, interviews and observations were conducted, supported by internal and budget reports, filed accounts and archived documentation. The authors drew upon their own extensive industrial experience to inform and guide the design of an interview protocol that defined the scope of the necessary data to explore ISE [30].

Semistructured interviews were conducted with the Managing Director (MD), Production Director (PD), and Production Manager (PM). They were followed by interviews with employees at the shop floor of Company A. Their duration was 1 h on average. The interview questions focused on the necessity for ISE decisions to be informed by human and organizational factors. The interview guide was tested and piloted before data collection, and the questions were formulated to permit comparisons across interviews [27] and avoid interviewer bias [44]. The interviews were conducted at the offices of the interviewees and were tape recorded and transcribed verbatim. The details of the interviewees were coded to allow strict confidentiality and anonymity, although all interviewees were aware that they could be identified through the content of the text. After every interview, each interviewee checked their transcript and resolved any issues as per typical research approaches in this vein [27].

B. Data Coding

Data were coded using Qualitative Content Analysis (QCA) [32], [46] to build an inductive frame of reference explaining human and organizational factors in ISE decision making. The researchers paid attention to how many times interviewees referred to each factor and how they reacted when asked to explain forecasting factors involved in their area of responsibility. The importance of each factor was graded as "High," "Medium," "Low," or "Do Not Know." Hence, a clustering of the frequency of these responses was carried out to confirm the aforementioned list of given decision factors. Concepts from behavioral economics (BE) were used to further understand the QCA factors [15], [47], [51]. BE studies anomalous investor market behavior and events based upon decision-making effects. It aims at understanding the human decision-making processes and especially value and risk decisions [15], [25], [47], largely (idiosyncratic) investor decisions, emotions, cognitive, and economic errors [2], [25]. The morphological analysis (MA) technique [55] was used to remove redundancies in the data collected and to identify so-called "genuine uncertainties." This involved categorizing the QCA data into a series of themed subgroups, hence, morphological dimensions. Then, following field anomaly relaxation (FAR) [40], a pairwise comparison between each of these factor lists was carried out to remove duplicate items. This approach is a well-grounded scenario planning technique used in strategy formulation and futures forecasting [12], [15], [39] and was used to code and structure the data for the analysis.

C. Data Analysis

Data Analysis involved mixed methods (see Fig. 1). These are briefly discussed as follows.

1) Fuzzy Cognitive Mapping (FCM): The basis of the FCM approach [25], [43] involves creating a directed graph from a matrix of fuzzy weights, derived from a matrix of interconnections

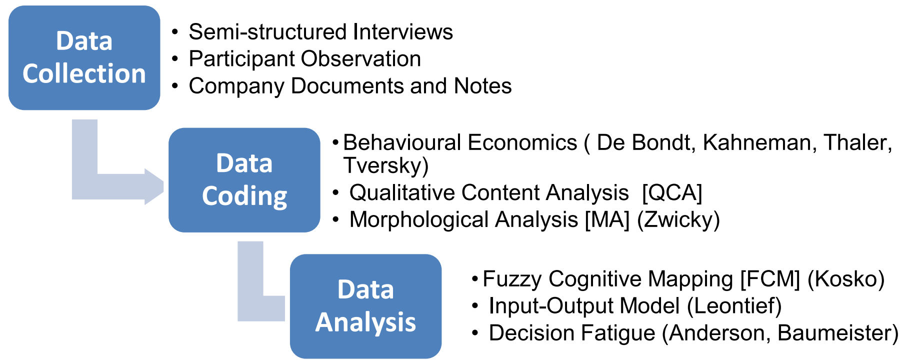

Fig. 1. Research Design.

to produce a "map." For a given pairwise combination of factors, each combination is assigned a fuzzy weighting using a range of positive to negative values. Given the weightings provided are essentially "causal connections," hence, a causal (cognitive) mapping, this approach allows for the exploration of changes to causal states over time for a given initial scenario (vector). Each scenario defines a causal state or "situation," which can be fed into the FCM in order to explore and observe how causal connections behave—providing an in-depth understanding of the cognitive dimension of decision-making behaviors. In real terms, each scenario is effectively an *n* by *n* vector of rank equivalency to the fuzzy weight matrix, *W* (generated as a result of the pairwise comparison across all factors identified).

Each starting vector is an enumeration of expert knowledge/decision-making encoded into numerical fuzzy values per factor. The resulting weight matrix and vector are then algorithmically computed according to the expression given in (1), where computed values for each node (hence, system factor) can then be plotted against each iterative step. As the results converge and the RMS error norm of each fuzzy factor tends toward a stabilized value, the computation ceases and a directed graph can, therefore, be calculated as a result of matrix manipulation. The following equation explains the aforementioned:

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

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*) used in this research is the hyperbolic, tanh(*x*). 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 $1 \times n$ row vector with the values of all concepts, $C_1, C_2, \ldots, C_n$ for *n* concepts or nodes in the FCM, while the former is a $n \times n$ 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 authors aim to use the FCM method to explore the identified human and organizational decision-making factors found as a result of the MA-FAR approach for Alpha. The aim is to explore the decision behaviors, relationships, and thus, the implicit "energy" dynamic between each of the factors.

2) IO Embodied Energy Model: To model/map the human and organizational factors in terms of the "energy" involved in these decisions, the authors apply the IO econometric approach of Wassily Leontief [29]. This approach is regularly used in the field of econometrics, and more specifically, energy economics to account for energy flows and aggregations of inputs to outputs in a system. The IO approach is matrix-based method, used to relate and measure interdependences between different aspects of an economy. The essence of this concept lies in identifying and relating a set of outputs (from one industry sector) as a set of inputs (to another industry sector) that ultimately provide a method for measuring (economy-wide) impacts of a given (sectorial economic) activity. The parentheses in the preceding sentence pinpoint the rationale for adopting this method for the remaining analysis within this research, namely, that a decision that is required (output) affects and influences (the demand) the variables that feed into it. The authors wish to point out that this technique is much akin to other linear programming methods such as the analytic hierarchy process but does not involve any further quantification or prioritization of decision-making factors. Furthermore, the intention is not to use the IO model to forecast or assess the impact of decisions that have been made but to add to the descriptive and narrative nature of understanding the decision requirements/demands involved in the given case in a multiobjective, qualitative manner. The model is defined as follows:

$$x = (I - A)^{-1} d \tag{2}$$

where *A* is a matrix of given economic outputs, *x* is a vector of total output, *d* is a vector of final economic demand, and *I* is the diagonal identity matrix.

The IO approach outputs in terms of decision demands are then considered through the concept of decision fatigue/ego depletion [1], [2] to assess the behavioral impact of such decisions and evaluated through an "embodied energy" audit of all aspects of the decision-making analysis. Embodied energy is normatively defined as the summary of energy that is needed in order to produce a given set of goods or services embodied directly in the asset itself. As such, this concept has been used as a basis for determining the "energies" of an asset or process across its lifecycle, from genesis to obsolescence. This involves determining all (input) materials, production factors, and associated resources. Hence, following Treloar [50], the authors present an explanation of the embodied energy of the decisions in the case context, as an energy path, which is the sum of the FCM of causal behavioral interrelationships; the IO model of decision demands; and the depletion of senior management's self-control and decision-making capacity.

IV. Case Study: IS Investment in Alpha, Inc.

Alpha, Inc., is a manufacturing SME. Its organizational structure comprises three directors, six managers, and approaching 150 operational employees (i.e., shop-floor workers). All directors are apprentice-trained engineers, and none had university or significant management-level development. The company follows a hierarchical structure: employees report to managers, who report to directors, and they report to the MD. Alpha, Inc., used to follow financial methods and tools for investment appraisal. For instance, Alpha had applied cash flow projections and sensitivity analysis to make decisions regarding computer numerically controlled (CNC) equipment. However, after investing in production planning and control (PPC) and shop floor data collection (SFDC) systems, they realized that the methods and tools used were not fit for purpose. These systems were underpinned by intangible and nonfinancial benefits, risks, and costs that could not be assessed using their traditional appraisal methods. The new and inexperienced management team of Alpha, Inc., being unfamiliar with methods and tools that pay attention to human and organizational factors in IT/IS investment appraisal, decided to use a simplistic cost-benefit analysis (CBA).

Alpha initially appeared unconcerned with the limitations associated with the traditional investment appraisal approaches but later concern grew, as their interest in the investment opportunity increased. This concern was well founded, as they had previous experience and were accustomed to the traditional appraisal approaches, good and bad.

The decision to buy the PPC/SFDC system was not successful. In a later stage, it was realized that the systems did not fit with their business strategy and jobbing processes. To address these issues, it was decided to build internally an ERP system that would fit with their strategy, needs, and processes. Furthermore, the senior management team believed that the ERP, being internally developed, would be better supported by staff, and also be a unique resource that would help Alpha achieve a competitive advantage. To justify the investment in the new system, Alpha invested time to brief the employees on the necessity of the investment for the company. The senior management team believed that the previous methods used had not paid sufficient attention to human and organizational issues, which were indeed highlighted by employees during their briefings on the benefits of the new system. These aspects were not incorporated in their traditional appraisal methods, including their CBA. Apart from identifying and confirming the benefits previously thought by the senior managers as important, the employees indicated the expected costs of the system could be greater than originally predicted by the CBA. The new cost category was incorporated in a revised CBA. Therefore, Alpha could not be based solely on CBA to account for the financial implications of the project, and was based on the employees' previous experience. The decision to proceed with developing the system was, hence, an "act of faith," since the new dimensions could not be easily measured by "hard"/financial indicators. Having faith in the success of the project was based on the following aspects, which could not be quantified, and hence, included in the previously adopted traditional financial appraisal methods and tools.

1) Feedback and learning on previous implementations had been considered.
2) The system would alleviate previous issues with information asymmetry and silos between units and enable seamless flow of information across Alpha, creating thereby a culture of collaboration—it would enable BPR.
3) Human and organizational issues have been reflected upon after the failure of the PPC/SFDC.

V. Analysis of IS Investment Decisions in Alpha

A. Structuring the Context of Alpha, Inc.

The authors adopted a BE lens to examine IS evaluation decisions in Alpha. Table I compares the primary attributes of BE with the factors derived from applying QCA in Alpha.

Following MA [55], a morphological field of behavioral decision-making factors was composed, based upon coded data response groupings across factors of "Employee Commitment," "Cultural Change," "Training and Education," and "Management Commitment." This field comprises a cumulative complexity of 70 possible scenario combinations (see Table II). By applying FAR [40], this field was reduced down to 15 factors (a 21% reduction in the field complexity through the removal of redundant or self-similar factors).

The MA-FAR analysis identified the following human and organizational factors.

1) Anchoring Effect (AE): This is generally defined as providing reasons to relate unconnected events together, based upon a biased view of the world. In the case of Alpha, it is translated as management's previous experience in making successful investment decisions.

Alpha followed a mature approach to decision making using a traditional CBA model to justify investments in machine tools. This was the norm and an approach in which there was institutional confidence. CBA underpinned the first large-scale IT/IS investment, that is, the purchase of a vendor-packaged approach. The management team, led by the MD and his passionate but autocratic leadership style maintained the status quo in the investment decision process. Others felt too overwhelmed to propose alternatives. The MD felt positive outcomes could only ever be achieved if the idea and execution originated from him; or, at least, that was a widespread view across the company. This was further reinforced by perceived "successful" investment in past projects using a CBA approach. Therefore, leaving the MD to question the need to consider alternatives, while the same people making the investment decision were those who carried out the postimplementation review (PIR), not unnaturally always concluded that there was "never a bad investment decision."

TABLE I
BE ATTRIBUTES DURING IT/IS INVESTMENT APPRAISAL IN ALPHA (BASED UPON [47] AND [51])

Behavioral Finance Facet	Description	Impact in Alpha, Inc.	Evidence found within Alpha, Inc.
Agency Friction	Inter-relationship between investor and facilitating investment agent or body	High	Conflictual relationship within the management team and amongst team and employees
Anchoring Effect	Providing reasons to relate unconnected events, based upon a biased view of the world	Medium	Management's previous experience with successful investment decisions
Asset Segregation	Separation of assets into individual costs, risks and benefits	Low	Sole adoption of CBA and traditional financial appraisal methods
Availability Error	Psychological comparison with known phenomena	Medium	Management's previous experience with successful investment decisions
Biased Expectations	An overconfidence in predicting uncertain outcomes	Low	The faith of the MD on the benefits of the investment
Confirmation Bias	Bias towards results/behaviors which confirm predetermined outcomes and ignoring all others	Low	Sole adoption of CBA and traditional financial appraisal methods
Decision Framing	Contextualizing positive/negative aspects of a decision (leading to Confirmation Bias)	N/A	None found
Endowment Effect	Emotional attachment to a an entity for no rational reason	Medium	Sole adoption of CBA and traditional financial appraisal methods
Equity Premium Puzzle	Relative risk aversion between equity and fixed investments	N/A	None found
Feedback Loops	Tendency to feedback outputs into inputs	Low	Feedback from appraisal methods and the SFDC
Hindsight Bias	Bias towards historical experiences	Medium	Management's previous experience with successful investment decisions
Information Cascades	Dissemination of unattributed statements ("rumors")	Low	Politics and culture regarding governing and responsibility attribution
Loss Aversion	Viewing loss as opposed to risk (i.e. risk-seeking in the domain of losses and risk-averse in the domain of gains).	Medium	Need to maintain previously gained employee support and trust
Mean Regression	Aversion to extremes in favor of averaged behavior	Low	Insufficient innovative behavior and guidance from externals
Mental Accounting	Subdivision of losses and gains "mentally" by investors (i.e. non-consolidation of profit and loss)	Low	Asset-driven mentality and worldview
Myopic Loss Aversion	Loss aversion exhibiting a disproportionately high sensitivity to investment loss over short timescales	N/A	None found
Rational Expectations Hypothesis	The overweighting of historical over current experiences	Low	Management's previous experience with successful investment decisions
Reference Dependence	A non-consolidated acceptance/rejection of investment gain or loss based upon a fixed reference value or objective	Medium	Over-dependence on capital for the ERP system
Representativeness Heuristics	A preference for paying a premium for an investment which may have below average performance or outcome	N/A	None found
Status Quo Bias	Confirmation Bias within a group or social context	Low	Insufficient ownership and responsibility attribution to employees

TABLE II
MORPHOLOGICAL FIELD (BASED ON [55]) OF BEHAVIORAL FACTORS IDENTIFIED IN ALPHA

Employee Commitment	Cultural Change	Training and Education	Management Commitment
Status quo bias	Confirmation bias Reference dependence Agency friction Availability error Biased expectations Anchoring effect Endowment effect	Hindsight bias Feedback loops	Information cascades Mental accounting Loss aversion Asset segregation Mean regression

2) Agency Friction (AF): This is defined as the interrelationship between investor and facilitating investment agent or body. In Alpha, it is translated as conflictual relationship within the management team and amongst team and employees, especially at shop floor.

The MD was always pushing the company forward. The passion and dominance of the MD created organizational "energy" to propel the company forward toward a strategic vision. The management team appeared to be "weaker" apprentice-trained engineers (again with little or no management experience). In some respects, they were considered by shop-floor workers to have been promoted beyond their ability. As a result, there were numerous points of friction, specifically between the directors, who were shareholders needing financial return and performance, and the management team that was capable but lacking motivation and the management experience required to deliver the ambition of the company. The shop-floor operatives had limited respect and confidence in the (middle) management capability, yet did respect the directors, largely because the directors were considered to be (first and foremost) proven engineers having built up the company from humble origins.

The dominating personality of the MD often resulted in the opinions of others being quickly dismissed. Decisions were often taken independent of the senior managers that ultimately led to a culture where managers were not consulted and left with a feeling of having to be supportive of all decisions, as they felt that they had limited influence to explore alternatives. The consequence of a single point of influence underpinned by an autocratic leadership style was that there was decisive decision making but with no sense of collective buy-in.

3) Confirmation Bias (CB): This is generally defined as bias toward results/behaviors; and as such, behaviors that confirm predetermined outcomes ignoring all others. In the case of Alpha, this is translated as reliance upon CBA and nonholistic accounting of intangible factors.

The organization had a proven approach to the justification of investments that had traditionally been capital purchases with tangible efficiency returns—specifically, the use of CBA to justify the investment in CNC machine tools that produced a productivity gain that could be easily financially quantified. Such an approach was less suited to more intangible investment decisions, such as the purchase or development of an IS. Embedded bias occurred, as the investment decision was emotionally driven and motivated by the MD while also being *ex post* evaluated by the investment sponsor. As a result, there was little independence in the reflective evaluation process as the MD appeared unable to self-criticize previous decisions. Consequently, there was a biased "embedded success" in all decision making that was taken by the MD. The converse implication of this approach was that any decision(s) not taken by the MD were considered to have been total failures; all decisions were positive if the single reference point for previous decisions originated from the MD.

4) Endowment Effect (EE): This is generally defined as emotional attachment to an entity for no rational reason. In Alpha, this can be translated as an overreliance on CBA and cost-accounting methods.

A track record and perceived success resulting in endowed confidence when using a CBA approach was clear. Applying CBA to IT/IS decision making appeared to be a proxy for an autocratic leadership style (over the management team), and a paternalistic leadership style over a contingent of the operational workforce. As a result, there was a combination of dominance and confidence from different community groups; specifically the management team was dominated and the operational workforce offered confidence to the MD. Other such examples can be cited, such as when the company was invited to showcase itself among larger original equipment manufacturers (OEM), which was accepted by the MD, although the cost was exorbitant. However, the enticement and (endowed) self-justification was overwhelming and led by the MD. The financial cost was clear but the benefits and outcomes were opaque (in the sense that other investment decisions were made using CBA) but the characteristics of the leadership style were clear and evident in the decision-making process. It would appear that over successive years and notwithstanding the organizational structure, there was a single point of failure/success that gravitated around the MD.

5) Feedback Loops (FL): This is generally defined as a tendency to feedback outputs into inputs. In terms of the case context in this paper, this can be translated as the application of an ISE approach to implementation of the SFDC module.

The company took an isolated approach to all investment decisions. It did not link the inputs from one investment decision with another. Hence, the last decision was always "right" and so suggested the preceding decision was correct also as long as the process remained consistent. There was clear contextual evidence of using previous decisions perceived successful as the basis of providing institutional confidence to support future decision making. This institutional confidence was underpinned by a biased and flawed approach to evaluation. Together with the organizational culture, the management team felt unable to challenge the MD about past investment decisions and the PIR process, as a basis for a review in process.

6) Loss Aversion (LA): This is generally defined as viewing loss of an entity/asset, as opposed to the risk of an entity/asset (i.e., seeking risk in losses and being averse to risk in gaining domains) [47], [51]. In the case of Alpha, they did not to lose previously gained employee trust and commitment.

The organizational culture was one where the workforce either came through a developed apprentice scheme, or were long-standing employees of an OEM that had undergone a redundancy process. Notwithstanding the size of the company and its decision-making process and regardless of individual views, there was evidence of high levels of affiliation and personal endowment to the organization. Consequently, there was little churn of staff because of the personal investment (in tenure) over a long period of time with the company. While the management and operational workforce may not have always appreciated the autocratic undertone of the decision making by the MD, they did appreciate the progressive approach of the company. There was evidence that clarity of direction, a personal endowment to the organization generated over longitudinal service mitigated the autocratic leadership style of the MD. Personal energy invested by staff resulted in organizational momentum, thus aversion to loss was not an option (in terms of moving to a competitor organization that may have been more inclusive in terms of the decision-making approach, but have less clarity of direction).

7) Reference Dependence (RD): This is generally defined as an either accepting or rejecting gains by an investment on the grounds of a fixed reference value or objective [47], [51]. In Alpha, it means overdependence on capital and funds for the ERP system.

The institutional strategy was, in many respects, mimicking large OEMs. While this may be fit for purpose within larger companies, it often does not suit smaller businesses. The best practices adopted by larger inspirational sector leaders, in some respects, constrained the company's own flexibility and growth that required a responsive infrastructure typical of subcontractors. Strategy that did not necessarily have a direct financial return drove the business forward. Interestingly, the MD later distanced himself from being the original instigator. Such reversals were motivated by later considered *common sense* rather than pressure from colleagues. This led to a lack of group consensus on decision reference points. Thus, the level of technology acceptance and adoption was a new and moderating factor, which was limited not by imagination but by delivery capability.

8) Status Quo Bias (SQB): This is generally defined as CB within a group or social context [47], [51]. In Alpha, it meant insufficient ownership and responsibility attribution to employees.

The institution was driven by strong CB, where the MD was always keen to be a trend setter rather than a follower, and therefore, often punched above his weight both within and outside his company (he modeled his organization not against his peers or similar-sized companies, but large Japanese companies). In this respect, there was a bias toward strong, clear (if not transparent) decision making, as such decisions were not always underpinned by robust data but rather by emotion and intuition. However, the intuition aspect was often biased as it was self-perpetuated and based upon a sense of predetermined previous successes. The MD was influenced by noncompetitive "gurus" and sector leaders (regarding academics and noncompetitive people as offering value while discrediting the success of other organizations of a similar size and shape).

B. Causality of Behavioral Decisions in Alpha, Inc.

The authors used the output of MA-FAR into an FCM model to explore the decision behaviors, relationships, and thus, the implicit "energy" dynamic between each of the MA-FAR factors.

A pairwise combination of the eight factors highlighted in the previous section was carried out through a facilitated focus group session with the case company participants. As a result of carrying out this pairwise mapping, fuzzy causal weights were assigned on a scale between –1 and 1 in increments of 0.25, where a value of –1 signifies a very negative causal relationship, 0 signifies a neutral or nonexistent causal relationship and 1 signifies a very strong causal relationship (the remaining interstitial values are, hence, gradations between these). The first author conducted the assignment of weights. To ensure reliability, an independent coder also conducted weight assignment. The convergence (agreement) of the coders was then checked. When there was a disagreement, a further discussion between the coders took place until agreement (convergence) was reached [6], [36]. Table III gives the developed weight matrix for the causal relationships between the identified factors.

Fig. 2 shows the resulting direct graph representation of Table III.

Computing the reachability matrix for this initial FCM is based upon

$$R = A + A^2 + A^3 \tag{3}$$

where *A* is the reachability of the fuzzy matrix, W_{ij} and where for the purposes of this research $A = W_{ij}$. The calculation of *R* shows that the strength of the local causal relationships (column sum) occurs as: CB ≥ EE ≥ LA ≥ RD ≥ AE ≥ FL ≥ AF ≥ SQB; while the strength of the global causal relationships (row sum) occurs as: AE ≥ EE ≥ CB ≥ FL ≥ RD ≥ LA ≥ SQB ≥ AF. This highlights that CB is locally influential among all other nodes, while SQB is less so; and conversely, AE is globally influential across the entire cognitive map, while AF is less so.

We now turn to applying a given scenario vector—hence, system model—to the FCM. This scenario describes a situation where there is a greater focus given to sales promotion forecasting, and hence, where there is less of a focus on collaborative planning, time-series analysis, and prior information—and more emphasis on supply/demand, direct intervention, and experience factors, respectively. This is as a result of computing the output of (1) to a given scenario vector, which represents each of the FCM factors in turn. This is represented by the vector

$$[0.000 - 0.500\, 1.000\, 1.000\, 0.250 - 1.000\, 1.000]. \tag{4}$$

By calculating the output of the matrix computation given in (1) where the weight matrix W_{ij} is that of Table III and the initial vector C_i^t is (4), the resulting FCM weight matrix was computed—hence, Table IV highlights the reachability of each FCM. Fig. 3 shows the resulting FCM results per node.

Computing the reachability matrix using (3), shows that the strength of the local causal relationships occur as: AF ≥ RD ≥ CB ≥ FL ≥ EE ≥ AE ≥ SQB ≥ LA; while the strength of the global causal relationships occur as AE, LA, SQB ≥ EE ≥ FL ≥ CB ≥ AF ≥ RD. Hence, as before, this highlights that AF is locally influential among all other nodes, while LA is less so; and conversely AE, LA, and SQB are all equally globally influential across the entire cognitive map, while RD is less so.

The results of the FCM nodal values in Fig. 3, shows a lead–lag relationship between RD, LA, CB, and EE factors, which is mediated by the growth and decay response of factor AF. Grouped together these causal factors broadly identify behavioral decision making, which is biased in some respects in response to the working relationship between senior management and shop-floor workers (and vice versa). The SQB factor alternates between strongly negative causal and strongly positive causal responses—which are mirrored by factor FL to some extent. Hence, both of these factors identify with ownership of and relationship to the investment decisions taken by Alpha.

An interpretation of this is that biases in the decision-making processes were opposing the very organizational relationships that they were rooted in. This suggests that such manufac-

TABLE III
FUZZY WEIGHT MATRIX OF HUMAN AND ORGANIZATIONAL DECISION FACTORS IN ALPHA, INC.

	AE	*AF*	*CB*	*EE*	*FL*	*LA*	*RD*	*SQB*	Σ
AE	0.000	1.000	1.000	1.000	−1.000	1.000	1.000	0.000	**4.000**
AF	−1.000	0.000	−1.000	−0.250	0.000	−1.000	0.000	0.000	**−3.250**
CB	1.000	−1.000	0.000	1.000	0.000	0.000	1.000	−1.000	**1.000**
EE	0.000	0.000	1.000	0.000	1.000	1.000	1.000	0.000	**4.000**
FL	0.000	0.000	1.000	1.000	0.000	0.000	−1.000	0.750	**1.750**
LA	1.000	0.000	0.000	−1.000	0.000	0.000	0.000	−1.000	**−1.000**
RD	−1.000	0.000	1.000	0.000	0.250	1.000	0.000	−0.250	**1.000**
SQB	−1.000	−0.250	0.000	0.250	0.250	0.000	0.000	0.000	**−0.750**
Σ	**−1.000**	**−0.250**	**3.000**	**2.000**	**0.500**	**2.000**	**2.000**	**−1.500**	

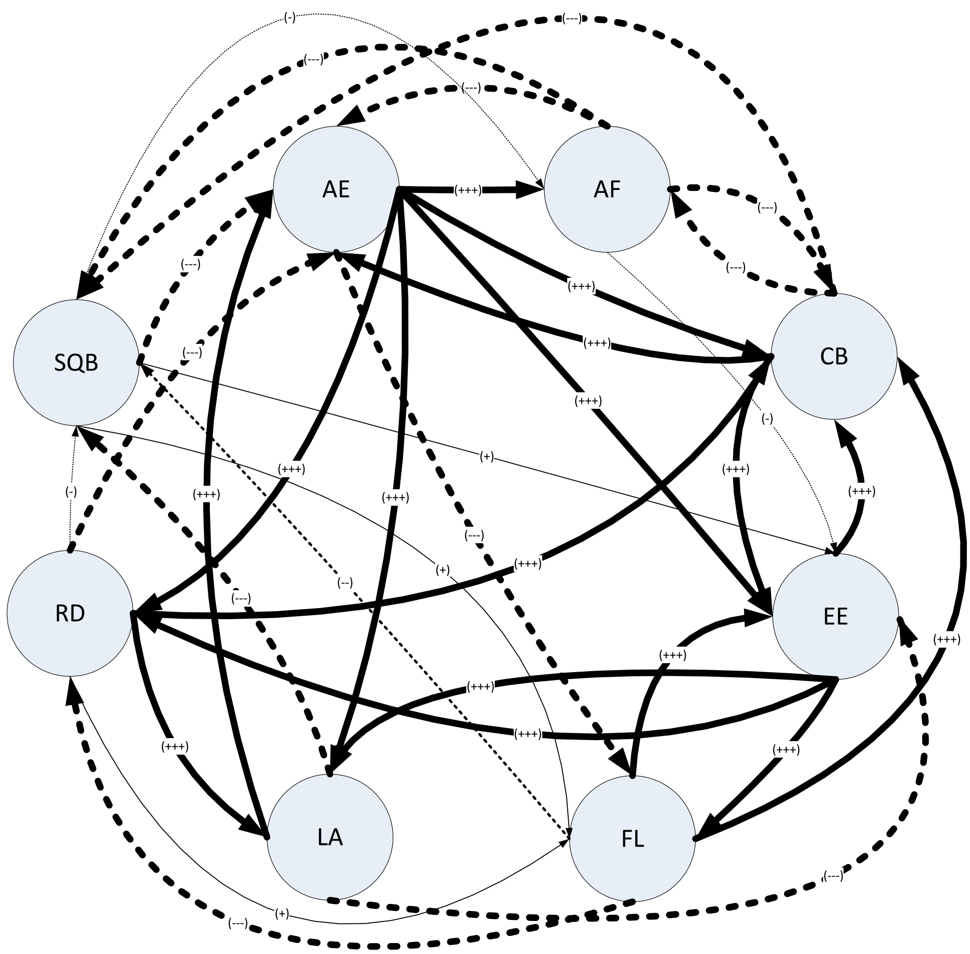

Fig. 2. FCM of the human and organizational decision-making factors in the ERP implementation context.

turing investment decisions were more reliant upon the very assumption-based factors, which the management team was seeking to avoid, but which were heavily related to the working relationships within which the decision makers were rooted. In order to put this further into context, by comparing both the initial FCM and the scenario FCM matrix in Table IV, this highlights that factor AE appears to be a common driving factor across both cognitive maps; while factors LA, SQB, and EE, respectively, have high levels of reachability (i.e., globally influential among nodes). This further supports the assertion that there was a high degree of influence on the decision-making process based upon a generally positive (although perhaps misplaced) assumption that future decisions would be as successful as prior decisions, in the face of a lack of ownership of the investment decisions by the company as a whole.

These dynamic causal interrelationships provide a rich picture into the behavioral drivers of the ISE scenario and show the determining features of the decisions as a result. However, the authors suggest that in order to gain further insight into how these relationships affect and impinge upon individual and orga-

TABLE IV
COMPARISON OF INITIAL AND SCENARIO FCM

ISE Decision factors (fuzzy nodes)	Locally influential (East-West, FCM matrix row)		Globally influential (North-South, FCM matrix column)	
	Initial R	Scenario R	Initial R	Scenario R
AE	3.000	2.513	14.000	21.000
AF	1.797	6.513	−3.203	−7.000
CB	11.000	5.562	7.000	−7.000
EE	8.125	5.012	12.000	−0.509
FL	2.656	5.550	6.734	−6.288
LA	8.000	1.632	1.000	21.000
RD	8.000	5.973	5.125	−7.000
SQB	−0.469	2.450	−0.547	21.000
$\bar{x}$	5.264	4.400	5.264	4.400
Σ	3.756	1.768	5.596	13.014

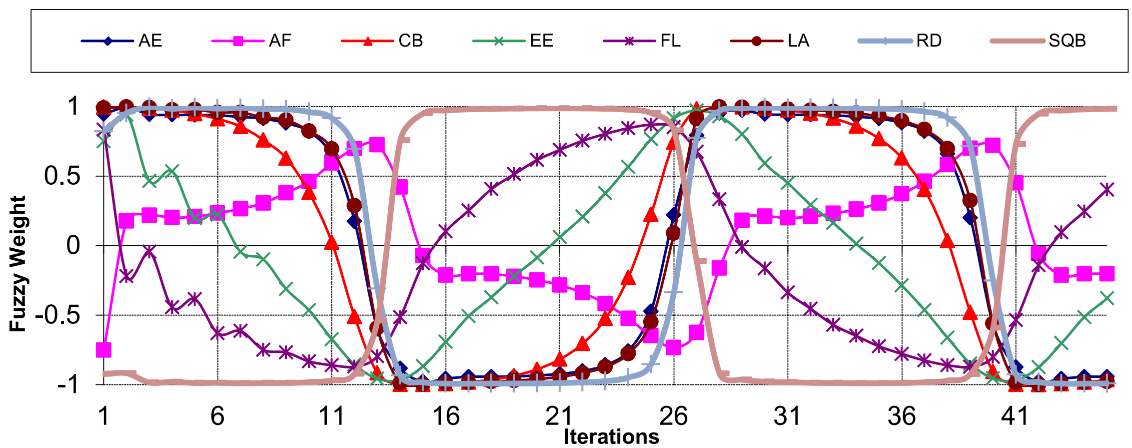

Fig. 3. FCM results.

nizational behaviors requires extending this analysis by carrying out an econometric, energy auditing-based exploration of these relationships. This is further explained in the next section.

C. Embodied Energy of Organizational Decisions in Alpha, Inc.

Following the IO econometric approach [7], [29], the authors take the relevant matrices from the FCM (causal model) as follows in order to compute the IO demand using (2).

1) The "economic" transactions (matrix, A) is the fuzzy weight matrix W.
2) The "direct requirements" of supply (vector, d) is the scenario vector, C_t.
3) The "total requirements" of demand (vector, x) will be the computed vector of required outputs.

Noting that the rank of the identity matrix, I, has to be same as the rank of the matrix of transactions, A (i.e., the fuzzy weight matrix, W), the researchers computed the IO of the decisions encoded in the FCM through the matrix manipulation of (2). By subsequently also noting that the inverse of the threshold function given in (1) would need to be applied to scale the demand vector, x, to the fuzzy interval [–1, 1], vector x was calculated for both the initial and scenario-based FCMs and the

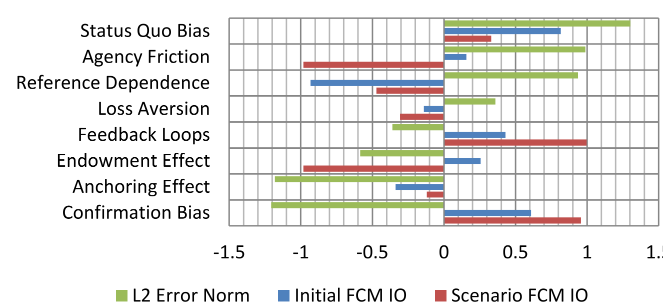

Fig. 4. IO model output and error norm for Alpha causal mapping.

L2 error norm computed as

$$l = \sqrt{x_k^2 + \cdots x_n^2} \tag{5}$$

where values x_k are the individual elements of the demand vector, x computed from (5), for $k = 1, \ldots, n$ and n is the rank of x. The resulting errors and values for the IO responses were calculated and standardized to the standard deviation of the initial and scenario FCM nodal data from which a graph of the distribution of IO values could be produced as in Fig. 4.

Fig. 4 highlights the "demand" of behavioral decision factors that underlie the causal interrelationships coded through the fuzzy cognitive map. As such, it can be seen for the initial

FCM that RD, reference dependence, has a high negative demand (−0.93148), which is mitigated by a high positive demand at the opposite end of the spectrum, by SQB (0.81577). This underscores the predetermination by Alpha management to base its future investment decisions upon "reference successes" at the cost of a lack of ownership of the decision-making process overall by the firm. The scenario FCM identifies different demands, however, where both EE and AF have high negative demand (−0.982); while FLs have high positive demand (0.9967). This explains the investment decision process in terms of a preference for utilizing nonholistic appraisal techniques such as CBA as outcomes from previous decisions, as inputs to future decisions: to the detriment of the working relationship between management and shop-floor workers.

The authors now wish to view these IO aspects of decision demand, through the lens of two contemporary perspectives on how such decision demands are handled by individuals.

First, the authors rehearse the findings from the data that show that the MD of Alpha was, to all intents and purposes, seeking to make all judgement decisions himself with reference to aspects of prior experience and knowledge (hence, anchoring, referencing, and confirming biases of previous investment successes). Although the authors have represented these elements based upon notions of causal, behavioral, and demand aspects, they now wish to reframe these by stating that the MD suffered a case of "ego depletion" [2]. Baumeister [2] contended that decisions affect self-control and vice versa. As such, the authors of this paper propose that the MD of Alpha was indeed faced with a conflict of both self-control and self-regulation given the IO results data as shown previously (i.e., the sets of behavioral demands were evenly matched, given the kurtosis and skewness of the data in Fig. 4 tend toward a standard distribution).

Second, the complexity of making decisions under conditions of cost benefit can also lead to increasingly difficult value choices—hence, selection difficulty. Anderson [1] highlighted this as "decision avoidance," which is based upon a combination of a rational-emotional response to scenarios where executive decision function is routinely required. In this respect, the authors, thus, also contend that while there was no "inaction inertia" within the firm, there was some tradeoff between effort versus accuracy by applying a tailored evaluation of the new IS in Alpha. The attentional focus of the firm overall was set to be outward-, rather than inward-, facing (which led to the ongoing conflict with the status quo, leading to AF effects as noted earlier). There was also clearly a preference for uncertainty in some sense, as the application of a trusted approach was done blindly—with the caveat that the firm had not made such a manufacturing decision before and that this technique was the most suitable in the absence of any other experience (hence, the endowment effect of the CBA). Perhaps significantly, based upon the perspective that Anderson [1] provided, the authors also propose that, in this particular case, Alpha and the MD suffered from anticipatory negative decision framing and counterfactual thinking—all of which contributed to a reference dependence on the funds and resources committed to the ERP project. Needless to say, there was perhaps an emotional decision-making response to investment in technology based upon a depletion of self-control and self-regulation energy, which clouded rational decisions based upon a decision strategy.

Following an "embodied energy" audit of all aspects of the decision-making analysis [43], the authors proposed that the embodied energy of the decision process within Alpha, was driven by individual decision makers (such as the MD), which had a negative impact upon the decision that was made to invest in technology as a result of a focus on past decisions. This focus was primarily driven by a combination of decision biases in the form of a range of behavioral factors: AF (disagreement between senior management and shop-floor workers); AE (propensity to focus upon previous successful investment decisions); LA (avoiding wanting to lose the trust of employees); CB (reliance upon specific cost accounting methods to support a predetermined outcome); and feedback loops (applying a prior evaluation model to a new investment scenario and hoping to achieve similar results). Consequently, the authors contend that Alpha, in some shape or form, furthermore underwent a form of ego depletion wherein management—as well as the rest of the firm—succumbed to a form of (investment appraisal) decision fatigue. This fatigue was the result of feedback loop behavior where prior decisions and tools were being endowed with a greater prominence than they should have been. Thus, an increase in emotional attachment to CBA and a reduction in self-regulation by the rest of the firm and management team (aversion to SQB, as shown in the FCM and IO models). Hence, in a general sense, decision-making biases perpetuated the process for investing in manufacturing IS in contrast to the lack of decision-making ownership and responsibility displayed by Alpha management to the shop-floor workers.

VI. Conclusion

This paper has sought to explore the domain of IT/IS investment decision making through the lens of behavioral economics and an associated energy accounting (equilibrium) method. In doing so, it has leveraged the lenses of behavioral economics, causality, IO equilibrium, and the general notion of depletion of executive energy function to study the "embodied energy" of the IT/IS decisions in manufacturing focusing on human and organizational factors. The following was found.

1) Individual biases in the decision-making processes were opposing the very organizational relationships that they were rooted in. Investment decisions were more reliant upon the assumption-based factors, which the management team was seeking to avoid, but which were heavily related to the working relationships within which the decision makers were rooted.
2) The frictional relationship between the management board and shop-floor workers (AF), coupled with management's experience with previous investment decisions (AE, RD) was in direct conflict with the desire to mitigate a loss of employee trust gained over many years (LA).

This paper contributes to the normative literature on ISE by exploring the underlying behavior and energy involved in decision making in ISE focusing on human and organizational factors. It adds to the argument put forward by ISE scholars that human and organizational factors are significant in IS justification in manufacturing [30], [45], [48]. Furthermore, it extends this argument by proposing the aforementioned lenses to study ISE behavior and embodied energy, suggesting that human and organizational factors can lead to a (negative) state of organizational decision-making energy. The consequences to engineering management, therefore, being potentially profound. It illustrates how management fatigue around ISE decision making in manufacturing can be expressed in the form of "ego-depletion" [2] of the key decision maker (i.e., reduction in self-control, self-regulation, and executive function—displayed as excessive self-belief). Organizations, hence, need to be cautious of using self-perpetuating models of investment appraisal where (misplaced) assumptions about intended benefits of the investment may cause a bias by senior management to use (previously) successful appraisal tools and techniques. Essentially, past success is not indication of future outcomes.

Our analysis enables the development of a frame of reference for ISE decision making based on human and organizational factors. The ISE literature has underlined the behavioral issues (e.g., politics and power) [4], [30] and has suggested tactics used to influence the investment from the designation stage to retrying the ERP investment proposal forever aiming at resolving any conflict through the constant repeating of ISE feedback and exploiting possible changes over time in the subjective appraisal of the IT/IS investment in question [4].

The purpose of this research was to show that a process of evaluating causal relationships, decision demands, and associated behaviors uncovers intrinsic richness and depth to the complex nature of management-led investment decisions, in this case, within an engineering management perspective. Hence, this research does not seek to offer any conclusions of a generalizable nature—rather it offers other organizations that are similar in context/process to draw parallels. And, as such, it avoids the identified pitfalls associated with behavioral biases and executive decision making.

This study provides engineering managers with insights on the behavior and embodied energy underlying IT/IS investment decisions. First, managers should be aware of the individual biases and their effects on the IT/IS decision-making process. No matter if they try to avoid these biases by balancing the allocation of resources with a strategic overview of the IT/IS in question, their skill and judgment are dependent on those organizational/working relationships within which biases are rooted. Second, to increase the level of shop-floor trust and support in IT/IS decision making, managers should use their experience with previous investment decisions to inform shop-floor workers about the benefits of investments and replace frictional relationships with support and cooperation. Third, managers should consider diversifying the IT/IS investment methods they use during the decision-making process, base their selection on the investment decision problem [22], [23], and avoid using methods deeply rooted in organizational structures and routines no matter how successful they have been in the past. Perpetual use of particular methods may lead to decision fatigue ("ego-depletion") of the decision maker, influencing negatively the investment decision-making process and outcome. Therefore, by acknowledging and avoiding decision fatigue engineering managers should be able to take better and unbiased decisions towards successful IT/IS investments in manufacturing.

Acknowledgment

The authors would like to thank three anonymous reviewers for their extremely constructive and helpful comments, which helped to improve the presentation of the manuscript considerably, and Prof. R. Sabherwal, Editor-in-Chief, and Prof. P. Love, Editor of the IEEE Transactions on Engineering Management, for the opportunity to revise and resubmit the paper for publication.

References

[1] C. J. Anderson, "The psychology of doing nothing: Forms of decision avoidance result from reason and emotion," *Psychol. Bull.*, vol. 129, no. 1, pp. 139–167, 2003.
[2] R. F. Baumeister, "Ego depletion and self-control failure: An energy model of the self 's executive function," *Self Identity*, vol. 1, no. 2, pp. 129–136, 2002.
[3] E. Berghout, M. Nijland, and K. Grant. (2005). Seven ways to get your favoured IT project accepted—Politics in IT evaluation. *Electron. J. Inf. Syst. Eval.* [Online]. *8(1).* Available: www.ejise.com
[4] P. Beynon-Davies, P. Owens, and M. D. Williams, "Information systems evaluation and the information systems development process," *J. Enterprise Inf. Manage.*, vol. 17, no. 4, pp. 276–282, 2004.
[5] M. Bidan, F. Rowe, and D, Truex. "An empirical study of IS architectures in French SMEs: Integration approaches," *Eur. J. Inf. Syst.*, vol. 21, pp. 287–302, 2012.
[6] J. L. Campbell, C. Quincy, J. Osserman, and O. K. Pedersen, "Coding in-depth semistructured interviews problems of unitization and intercoder reliability and agreement," *Sociol. Method Res.*, vol. 42, no. 3, pp. 294–320, 2013.
[7] J. Chandra, S. Schall, "Economic justification of flexible manufacturing systems using the Leontief input-output model," *Eng. Econ.*, vol. 34, no. 1, pp. 27–50, 1988.
[8] C. C. Chen, "Managing ERP implementation failure: A project management perspective," *IEEE Trans. Eng. Manage.*, vol. 56, no. 1, pp. 157–170, Feb. 2009.
[9] T. M. Choi, P. S. Chow, and S. C. Liu, "Implementation of fashion ERP systems in china: Case study of a fashion brand, review and future challenges," *Int. J. Prod. Econ.*, vol. 146, no. 1, 70–81, 2013.
[10] H. Courtney, D. Lovallo, and C. Clarke, "Deciding how to decide," Harvard Business Review, pp. 63–65, Nov. 2013.
[11] M. Crotty, *The Foundations of Social Research*. Newbury Park, CA, USA: Sage, 2003.
[12] R. G. Coyle, R. Crawshay, and L. Sutton. "Futures assessments by field anomaly relaxation," *Futures*, vol. 26, no. 1, pp. 25–43, 1994.
[13] T. H. Davenport and J. D. Brooks, "Enterprise systems and the supply chain," *J. Enter. Inf. Manage.*, vol. 17, no. 1, pp. 8–19, 2004.
[14] K. Davies, "Different stakeholder groups and their perceptions of project success," *Int. J. Project Manage.*, vol. 32, no. 2, 189–202, 2014.
[15] W. F. M. De Bondt and R. H. Thaler, "Does the stock market overreact?" *J. Finance*, vol. 40, no. 3, pp. 793–808, 1985.
[16] S. Devaraj and R. Kohli, "Information technology payoff in the Healthcare industry: a longitudinal study," *J. Manage. Inf. Syst.*, vol. 16, no. 4, pp. 14–68, 2000.
[17] B. Farbey, F. Land, and D. Targett, *How to Assess Your IT investment: A Study of Methods and Practices*. Oxford, U.K.: Butterworth-Heinemann, 1993.
[18] V. Grover and T. Davenport, "General perspectives on knowledge management: Fostering a research agenda," *J. Manage. Inf. Syst.*, vol. 18, no. 1, pp. 5–23, 2001.
[19] G. Guthrie, *Basic Research Methods*. Newbury Park, CA, USA: Sage, 2010.
[20] S. Y. Hung, C. Chen, and K. H. Wang, "Critical success factors for the implementation of integrated healthcare information systems projects: An organizational fit perspective," *Commun. Assoc. Inf. Syst.*, vol. 34, pp. 775–796, 2014.
[21] Z. Irani, "Investment evaluation within project management: An information systems perspective," *J. Oper. Res. Soc.*, vol. 61, no. 6, pp. 917–928, 2010.

[22] Z. Irani and P.E.D. Love, "Developing a frame of reference for ex-ante IT/IS investment evaluation," *Eur. J. Inf. Syst.*, vol. 11, no. 1, pp. 74–82, 2002.

[23] Z. Irani, A. M. Sharif, and P. E. D. Love, "Transforming failure into success through organizational learning: An analysis of a manufacturing information system," *Eur. J. Inf. Syst.*, vol. 10, no. 1, 55–66, 2001.

[24] H. W. Kim, "The effects of switching costs on user resistance to enterprise systems implementation," *IEEE Trans. Eng. Manage.*, vol. 58, no. 3, pp. 266–277, Aug. 2011.

[25] B. Kosko, *Neural Networks and Fuzzy Systems: A Dynamical Approach to Machine Intelligence*. Englewood Cliffs, NJ, USA: Prentice Hall, 1991.

[26] Y. H. Kwak, J. Park, and B. Y. Chung, "Understanding end-users' acceptance of enterprise resource planning (ERP) system in project-based sectors," *IEEE Trans. Eng. Manage.*, vol. 59, no. 2, pp. 471–482, May 2010.

[27] S. Lee, "Integrating positivist and interpretive approaches to organizational research," *Org. Sci.*, vol. 2, no. 4, pp. 342–365, 1991.

[28] F. Lefley and J. Sarkis, "Short-termism and the appraisal of AMT capital projects," *Int. J. Prod. Res*., vol. 35, no. 2, pp. 341–355, 1997.

[29] W. W. Leontief, *Input-Output Economics*. Oxford, UK: Oxford Univ. Press, 1986.

[30] P. E. D. Love, D. J. Edwards, Z. Irani, and D. H. T. Walker, "Project pathogens: The anatomy of omission errors in construction and resource engineering project," *IEEE Trans. Eng. Manage.*, vol. 56, no. 3, pp. 425–435, Aug. 2009.

[31] J. Martinez-Alier, *Ecological Economics: Energy Environment and Society*. Oxford, U.K.: Blackwell, 1990.

[32] P. Mayring, "Qualitative content analysis," *Forum: Qualitative Soc. Res.*, vol. 1, no. 2, pp. 1–80, 2000.

[33] J. R. Muscatello, M.H. Small and I.J. Chen, "Implementing ERP in small and mid-size manufacturing firms," *Int. J. Oper. Prod. Manage.*, vol. 23 no. 8, pp. 850–71, 2003.

[34] N. Parr and G. Shanks, "A taxonomy of ERP implementation approaches," in *Proc. 33rd Hawaii Int. Conf. Syst. Sci.*, Jan. 2002, pp. 2424–2433.

[35] P. Poba-Nzaou and L. Raymond, "Managing ERP system risk in SMEs: A multiple case study," *J. Inf. Technol.*, vol. 26, no. 3, pp. 172–190, 2011.

[36] W. J. Potter and D. Levine-Donnerstein, "Rethinking validity and reliability in content analysis," *J. Appl. Commun. Res.*, vol. 27, pp. 258–284, 1999.

[37] M. Rabin, "Psychology and economics," *J. Econ. Literature*, vol. 36 no. 1, pp. 11–46, 1988.

[38] D. Remenyi, D., and M. Sherwood-Smith, "Maximise information systems value by continuous participative evaluation," *Logist. Inf. Manage.*, vol. 12, no. 1–2, pp. 14 -32, 1999.

[39] T. Ritchey, "Scenario development and risk management using morphological field analysis," in *Proc. 5th Eur. Conf. Inf. Syst.*, 1997, pp. 1053–1059.

[40] R. Rhynne, "Field anomaly relaxation—The arts of usage," *Futures*, vol. 27, no. 6, pp. 657–674, 1995.

[41] P. Senge, A. Kleiner, C. Roberts, R. Ross, and B. Smith, *The Fifth Discipline Fieldbook*. New York, NY, USA: DoubleDay/Currency Books, 1994.

[42] Seufert, G. Von Krogh, and A. Bach, "Towards knowledge networking," *J. Knowl. Manage.*, vol. 3, no. 3, pp. 180–190, 1999.

[43] M. Sharif and Z. Irani, "Exploring fuzzy cognitive mapping for IS evaluation," *Eur. J. Oper. Res.*, vol. 173, no. 3, pp. 1175- 1187, 2006.

[44] D. Silverman, *Interpreting Qualitative Data*. London, U.K.: Sage, 2001.

[45] S. J. Taylor and R. Bogdan, *Introduction to Qualitative Research Methods*, 2nd ed. Hoboken, NJ, USA: Wiley, 1984.

[46] C. J. Stefanou, "A framework for the ex-ante evaluation of ERP software," *Eur. J. Inf. Syst.*, vol. 10, no. 4, pp. 204–215, 2002.

[47] R. Thaler, "The end of behavioral finance," *Financ. Anal. J.*, vol. 55, no. 6, pp. 12–17, Nov./Dec. 1999.

[48] M. Themistocleous, Z. Irani, and P.E.D. Love, "Evaluating the integration of supply chain information systems," *Eur. J. Oper. Res.*, vol. 159, no. 2, pp. 393–405, 2004.

[49] J. Y. L. Thong, "An integrated model of information systems adoption in small businesses," *J. Manage. Inf. Syst.*, vol. 15, no. 4, pp. 187–214, 1999.

[50] G. J. Treloar, "Extracting embodied energy paths from input–output tables: Towards an input–output-based hybrid energy analysis method," *Econ. Syst. Res.*, vol. 9, no. 4, pp. 375–391, 1997.

[51] A. Tversky and D. Kahneman, "Judgment under uncertainty: Heuristics and biases," *Science*, vol. 185, no. 4157, pp. 1124–1131, 1974.

[52] V. Venkatesh, S. A. Brown, and H. Bala, "Bridging the qualitative-quantitative divide: Guidelines for conducting mixed methods research in information systems," *MIS Quart.*, vol. 37, no. 1, pp. 21–54, 2013.

[53] R. J. Yang, Y. Wang, and X. H. Jin, "Stakeholders' attributes, behaviors, and decision-making strategies in construction projects: Importance and correlations in practice," *Project Manage. J.*, vol. 45, no. 3, pp. 74–90, 2014.

[54] R. K. Yin, *Case Study Research: Design and Methods*. Newbury Park, CA, USA: Sage, 1994.

[55] F. Zwicky, *Discovery, Invention, Research —Through the Morphological Approach*. New York, NY, USA: Macmillian, 1969.

Zahir Irani received the B.Eng. (Hons.) and M.Phil., degrees, and the Ph.D. degree in investment evaluation and undertook his leadership development at the Harvard Business School.

He is Dean of Business, Arts and Social Sciences at Brunel University London. Prior to commencing this role, he was seconded to Whitehall, where he was a Senior Policy Advisor in the Cabinet Office. He is a Professor of Operations and Information Management in the Brunel Business School, Brunel University–London, Uxbridge, U.K., which he joined in August 2006 as the Head. Under his leadership, the Brunel Business School received the 2013/14 Times Higher Award-Business School of the Year. Zahir's research interests are multidisciplinary in nature, and developed from early work on the area of evaluating investments in manufacturing information systems to more recent works in transformational government. He then went on to lead one of the world's leading departments of information systems and computing before becoming the Head of the Brunel Business School a few years later. His leadership skills have crafted a progressive Business School, where he helps others achieve their leadership and management potential. He has consulted for a number of public and private sector organizations, which range from U.K. government departments, Shell Petroleum, UK, and BMW, Germany. His work has taken him overseas, where he has undertaken assignments in Saudi Arabia, Bahrain, Dubai, Australia, and Canada.

Amir M. Sharif Amir M. Sharif received the B.Eng. (Hons.) degree in aeronautical engineering from the Department of Mechanical Engineering and Aeronautics, City University, London, U.K., and the Ph.D. degree from the Department of Information Systems and Computing, Brunel University, London, U.K.

He is a Professor and an Acting Head of Brunel Business School, Brunel University–London, Uxbridge, U.K., and a Professor of Operations Management. He is also the Founding Director of the Operations and Supply Chain Systems Research Group. Being the former Director of MBA programs at Brunel Business School, and a past industry practitioner for more than 10 years, he has been involved with the implementation of strategic and operational programmes for a range of multinational organizations across fields as diverse as investment banking, defense, information technology, industrial products, and the public sector. He has worked and consulted for leading international organizations, such as JP Morgan, UBS Investment Bank, BAE Systems, British Gas/Centrica, Invensys, Sony Corporation, the BBC, and many others across a variety of countries including the USA, UK and Japan. As a result, he has expert knowledge in business process redesign, performance, operations and supply chain management, and information systems strategy.

Thanos Papadopoulos received the Diploma (Equivalent to M.Eng.) in computer engineering and informatics from the University of Patras, Greece; the M.Sc. degree in information systems from the Athens University of Economics and Business, Athens, Greece, in 2005, and the Ph.D. degree in information systems from Warwick Business School, Coventry, U.K in 2009.

He is an Associate Professor of Information Systems and the Director of the MBA program at the Sussex School of Business, Management, and Economics, University of Sussex, Brighton, U.K. His research interests include the social and organizational aspects underpinning the deployment of information systems and technology-enabled process improvements within organizations and supply chains. His articles have been published in leading international journals, such as the *British Journal of Management*, the *International Journal of Production Economics*, *Technological Forecasting and Social Change*, the *Journal of Strategic Information Systems*, the *International Journal of Operations and Production Management*, the *Journal of Operational Research Society*, and *Production Planning and Control*.