The Propagation of Technology Management Taxonomies for Evaluating Investments in Information Systems

ZAHIR IRANI AND PETER E.D. LOVE

DR. ZAHIR IRANI is a Senior Lecturer in Information Systems in the Department of Information Systems and Computing, Brunel University (UK). Having worked for several years as a project manager, he retains close links with industry, is a nonexecutive director of a leading blue-chip company, and consults with organizations such as Shell Petroleum, Glaxo Wellcome, BMW (UK), and Adidas. Dr. Irani also evaluates European Commission (EC) *ESPRIT* research proposals that are submitted as part of the fifth framework. He serves as a nonexecutive member of an international academic advisory group for MCB University Press, and is a member of the editorial board of Butterworth Heinemann/Computer Weekly—Professional Information Systems Text Books series.

Dr. Irani leads a multidisciplinary funded research group investigating information systems evaluation and integration, where he also supervises a number of Ph.D. students. He is a Visiting Scholar at the University of Salford (UK) and a Visiting Professor at Deakin University (Australia). Dr. Zahir Irani is the Editor in Chief of the *Journal of Logistics and Information Management,* has coauthored a teaching textbook on information systems evaluation, and has written over 100 internationally refereed papers. He has presented at conferences worldwide, and is internationally known for his scholarly work in the area of information systems evaluation. Dr. Irani is on the editorial advisor board of several journals, as well as being co- and minitrack chair to international conferences. He has guest-edited special issues of journals, including *IEEE Transactions, European Journal of Information Systems, International Journal of Technology Management,* and *Information Systems Journal.* Dr. Irani has received numerous grants and awards from national and international funding bodies, including the Engineering and Physical Sciences Research Council (EPSRC), the Royal Academy of Engineering, the Australian Research Council (ARC), the Defence Evaluation Research Agency (DERA), and the European Commission (EC). Further biographical details can be found at: http://www.brunel.ac.uk/~csstzni.

PETER E.D. LOVE is an Associate Professor and Director of the Australian Agile Construction Initiative. He has coauthored two books, written over 100 internationally refereed journals and spoken at conferences worldwide in the areas of quality and IT/IS project management. Evidence of his work can be found in numerous international journals, such as *International Journal of Production Economics,* and *International Journal of Information Management.* In addition, he has guest-edited special issue

Financial support was provided by the Engineering and Physical Sciences Research Council (EPSRC; Ref: [GR/M95066] and [GR/R08025]) and the Australian Research Council.

Journal of Management Information Systems / Winter 2000–2001, Vol. 17, No. 3, pp. 161–177.

0742–1222 / 2001 $9.50 + 0.00.

international journals on themes such as "Multimedia Technology," "Electronic and Internet Commerce," and "Supporting Supply Chains through IT/IS." Professor Love evaluates grant proposals submitted to the Engineering and Physical Sciences Research Council (EPSRC) in the UK. His research in the area of IT/IS has been recognized by the Department of Building and Real Estate at Hong Kong Polytechnic University, as he has been invited on several occasions to attend the department as a Visiting Professor. He also serves on the editorial advisory boards of several international journals and conference scientific technical committees.

ABSTRACT: The management of Information Technology (IT) and Information Systems (IS) is considered a complex exercise by academics and practitioners alike. The reason for this is that there are ubiquitous portfolios of tangible and intangible benefits that are offered to an organization following the adoption of IT/IS that, in turn, all need managing to ensure realization. Organizations also have to take into account the direct and often larger indirect costs that are typically associated with IT/IS deployments. To provide managers with a critical insight into the management of new technology, this paper uses a case study research strategy to examine the technology management experiences of a leading U.K. manufacturing organization during its adoption of a vendor-supplied Manufacturing Resource Planning (MRPII) information system. Following the lack of attention given to human and organizational technology management factors while implementing MRPII, the vendor-based information system was later abandoned and deemed a failure. In addressing those technology management factors that were later identified as important, it was found that key employees were able to overcome a number of organizational barriers and develop and implement a bespoke MRPII system that significantly improved the organization's competitive position. Technology management taxonomies that contributed to the *failure* and later *successful* implementation of MRPII are identified and discussed. The organization's experiences in solving the problems associated with the implementation of their IS offers a learning opportunity for those companies that are seeking a competitive advantage through technology management.

KEY WORDS AND PHRASES: benefits, costs, evaluation, investment, MRPII, taxonomies, technology management.

THE ADOPTION OF INFORMATION TECHNOLOGY (IT) and Information Systems (IS) remains a lengthy, time-consuming and complex process, so issues associated with its management would appear to be of paramount importance. Yet many companies appear to approach the whole management of technology in an unstructured or ad hoc manner throughout the systems' lifecycle. However, with capital investments in IT/IS such as Material Requirements Planning (MRPII), or its enhanced extension Enterprise Resource Planning (ERP) predicted to increase from $21.02 billion in 1998 to $72.63 billion in 2001, issues associated with technology management are appearing on management's agenda [11].

The effective management of technology needs to be viewed as a structured iterative business process, which offers organizational learning during the lifecycle of the technology. This feedback is necessary so as to offer businesses the opportunity

to learn from their experiences, or mistakes. Technology management should be seen as a business process that facilitates the development of a comprehensive and robust technocentric infrastructure, consequently enhancing the delivery of accurate, timely, and appropriate services within an organization, which in turn increases the economic vitality of the business. There remains, however, a so called "technology management gap" within many businesses, which may result in a competitive advantage being jeopardized. Remenyi et al. [18] propose that technology management (when viewed from an evaluation perspective) may not be deployed in an effective manner in many businesses, and thus initiators of the new technology often become distanced from the development process. In addition, developers may lose sight of the business focus and as a result not deliver what was originally proposed and justified. Similarly, Irani et al. [14] suggest that technology management policies and procedures based on the use of traditional appraisal techniques have worked well for decisions concerning manufacturing capital equipment replacement, but are myopic for the appraisal of complex IT/IS such as MRPII or ERP. The reason for this is that the human and organizational implications associated with adopting new technology (and its management) are often overlooked, or simply ignored. Yet such factors can significantly impact the success or failure of IT/IS investments [5, 6, 13, 17, 20, 22].

Clearly, efficient and effective technology management has the scope to impact companies in a positive or negative way during the technology's lifecycle (i.e., feasibility, justification, requirements definition/engineering, system design, details design, test and preoperation, implementation, operation, maintenance, and post-implementation audit/evaluation). Furthermore, the multiple paths associated with technology management can often yield considerably different outcomes.

This paper uses a case study to describe the experiences of a leading UK manufacturing organization that managed its technology through what were internally considered traditional approaches, that is, basing its investment justification for implementing a MRPII system around traditional appraisal processes. Such prescriptive methods, however, were unable to capture and accommodate the human and organizational dimensions of the investment, and as a result the vendor system was later abandoned and deemed a failure. Recognizing the need for an integrated IS that captures the idiosyncrasies of the organization and softer implications of the investment, key employees were able to later overcome human and organizational barriers and approach the adoption and management of MRPII from a new perspective. Technology management (human and organizational) taxonomies that contributed to the successful evaluation and implementation of a MRPII system are identified and discussed by the authors. In doing so, this paper makes a contribution to the normative literature by describing how different approaches to the technology management process can yield different organizational outcomes. Two fundamentally different approaches of technology management are presented and discussed. As a result, the findings presented in the paper provide a learning opportunity for those companies that are seeking a competitive advantage through the effective management of new technology.

Research Methodology

PREVIOUS RESEARCH SUGGESTS THAT AN ORGANIZATION'S FAILURE with IT/IS is primarily attributable to not meeting user expectations, which underlines the significance of the soft human and organizational issues involved with IT/IS evaluation [19]. With this in mind, there was a need for a research methodology that would involve and enfranchise an organization and their staff, so that the theory and knowledge surrounding decision-making and the investment justification process of MRPII could be derived to develop effective technology management taxonomies. Considering the originality of this research, a case study strategy was adopted [8, 9, 23]. The case used for the research was not systematically sampled, so it is not possible to generalize the findings to a wider population of small to medium enterprises (SMEs) with similar characteristics found within the manufacturing industry.

Data Collection

The data collection procedure has followed the major prescriptions in doing fieldwork research [1, 4, 7, 23]. A variety of secondary data sources were used to collect data with regard to the development of technology management taxonomies for evaluating MRPII investments, such as internal reports, budget reports, and filed accounts. A variety of data have been used to derive the findings presented in this paper, which include interviews, observations, illustrative materials (e.g., newsletters and other publications that form part of the case study organization's history) and past project management documentation. The authors have extensive industrial experience in the manufacturing industry and have used this experience, together with a predefined interview protocol, to determine the data needed for the research.

Interviews

Interviews were conducted with the Managing Director (MD), Production Director (PD), Production Manager (PM), and Shop Floor employees. The duration of each interview was approximately 40 minutes, where every interview was conducted on a "one-to-one" basis so as to stimulate conversation and break down any barriers that may have existed between the interviewer and interviewee. Furthermore, all interviews took place away from the normal office environment and resulting disruptions. (Interviews were conducted in the company's boardroom.)

The authors acted as a neutral medium through which questions and answers were transmitted and therefore endeavored to eliminate bias. Essentially, bias in interviews occurs when the interviewer tries to adjust the wording of the question to fit the respondent or records only selected portions of the respondent's answers. Most often, however, interviewer bias results from the use of probes. These are follow-up questions and are typically used by interviewers to get respondents to elaborate on ambiguous or incomplete answers [21]. Bearing this in mind, in trying to clarify the respondent's answers the interviewers were careful not to introduce any ideas that

might form part of the respondent's subsequent answer. Furthermore, the interviewers were also mindful of the feedback respondents gained from their verbal and nonverbal responses. Thus the interviewer avoided giving overt signals such as smiling and nodding approvingly when a respondent failed to answer a question. It was decided that such actions could lead to respondents withholding responses to later questions. The interviewees reviewed the reports from the interviews and their views were invited to ensure the accuracy of the reports.

Case Study Validity

The use of interviews, documentary sources, and observations indicates that internal validity needed to be addressed. Interviews, in particular, were used to identify technology management "failure" and "success" factors related to MRPII implementation, which had been discovered through examining the interviews. Each interview was tape-recorded and subsequently transcribed. These were given to each person that had been interviewed to check and to resolve any discrepancies that may have arisen and eliminate any interviewer bias. Bearing in mind the array of evidence that was accumulated, great care was undertaken by the authors to ensure that the data collected converged on similar facts [15].

Case Study

THE CASE STUDY PRESENTED IN THIS SECTION describes the experiences of a SME UK manufacturing organization that adopted a vendor-based MRPII system, which subsequently "failed" to satisfy user requirements. The reason for this failure is attributed to a lack of consideration of human and organizational benefits and costs implications during the evaluation process [19]. Acknowledging the problems with the system, functional managers later developed and implemented a bespoke MRPII system, which took into account financial, human, and organizational cost and benefits. As a result, the system has proven to be very successful, as the organization was cited in the UK's top 100 for its best practices.

Background

The case study organization (which shall be referred to as Company V) is a precision subcontract job shop with about 150 employees and a turnover of just under £5 million. It produces a wide variety of made-to-order parts, products, and assemblies, for a large number of customers, in diverse industries. Essentially, Company V sells time and expertise using many different conventional and computer-controlled machines. Company V has a make-to-order inventory policy, with most component parts having a very low level of standardization and thus few common components. To produce these differing and often complex parts, a highly flexible production capability is required. This implies versatile manufacturing equipment, flexible employees, and a

genuine need to maximize the utilization of technology, to continuously improve and innovate, and to remain competitive in manufacture. Typical components and assemblies within a jobbing shop environment tend to be diverse and have uncomplicated Bills of Material (BOM) and product structures. Furthermore, they are nearly always made to specifications supplied by the Original Equipment Manufacturer (OEM).

Orders for individual products tend to be small and their timing depends on the fluctuating needs of customers, who often use the company to "off-load" capacity. Therefore, close communications and the integrity of information between Company V and its customers are necessary for responsive change. The company boasts of its agility and information management, and as such manufacturing lead times are short, which ensures that throughput production flow is maximized. Therefore, if there are changes in the requirements of customers or the marketplace then Company V is able to respond in an effective manner by retooling or reequipping their production facility.

Company V's management team is lean, with few functional divisions. The following personnel report directly to the managing director: a sales and marketing director, a finance director, an administrative/general director (to whom the purchasing, human resource, and IT/IS functions report), and a manufacturing director. On the shop floor, supervisors manage several self-directed work teams who comprise of 7 to 15 staff members, such as machine operators, assemblers, material handlers, receivers, and shippers.

Case Findings and Analysis

THE "SUCCESS" OF COMPANY V'S PREVIOUS INVESTMENTS helped give them the encouragement and motivation they needed to introduce a computerized Production Planning and Control (PPC) system. The measure of "success" used by Company V was the removal of "procedural pain"—that is, if it was not considered painful to carry out the new computerized procedure, the project was considered a success. When asked to further elaborate on the issue of procedural pain, the measures of laborious, repetitive, boring, and time-consuming were all identified. However, it should be noted that these are all nontraditional "subjective" intangible and nonfinancial measures, but according to Hyde [12], traditional criteria for judging IT project success are no longer correct and should be replaced by measures that reflect new approaches to system development and management.

Unlike other "smaller" investments, the driving force behind the PPC project was the managing director, who ultimately sanctioned all investment decisions. When asked to evaluate the perceived impact of the proposed PPC system, the managing director replied:

> The scope of benefits from investing in IT appeared enormous, and only restricted by my imagination. . . . I was the main visionary leader and could see the long-term strategic implications of my decision to invest. I was sure the benefits would far outweigh the costs.

There appeared, however, to be other factors "driving" this investment, with the managing director stating:

> We were under significant pressure by our customers to offer year on year cost reductions. . . . So, there were risks associated with not utilizing new technology to provide a competitive advantage.

The reason why Company V lacked a formal justification process was because they had not previously invested in projects that were outside the scope of traditional appraisal techniques. In particular, major strategic benefits such as perceived market leadership, leadership in new technology, and promotion of an "open business culture" were not readily convertible in financial terms. Previous investments in Computer Numerically Controlled (CNC) equipment had been financed through loan agreements where cash flow projections and sensitivity analysis had been used to assess the impact and risk of the investment. Clearly, in such cases the focus is on direct financial benefits and costs, whereas the PPC system was viewed as providing a portfolio of benefits and costs, which were not easily accommodated within those appraisal techniques traditionally used by Company V.

Company V soon discovered that the accountancy frameworks that it has considerable experience in using were not suitable for investments with intangible and nonfinancial benefits and indirect costs, as they provided inappropriate information for rigorous evaluation. A new and inexperienced management team (which was unaware of the latest appraisal techniques, which could take into account qualitative costs and benefits) used a simplistic Cost/Benefit Analysis (CBA). Management's use of CBA allowed the listing of perceived project benefits and costs, but no assignments of financial values were made to the PPC implications identified. This was due to the complexity, subjectivity, and time-consuming nature of identifying and assigning arbitrary values to the intangible and nonfinancial benefits and costs associated with the PPC investment. Table 1 presents a taxonomy of strategic benefits identified as part of Company V's CBA, with Tables 2 and 3 presenting tactical and operational benefits, respectively. The interdependent nature of these taxonomies is also depicted in Figure 1.

In considering the proposed taxonomies of benefits identified in the tables, Harris [10] describes how investment decisions typically fall into three categories, these being strategic, tactical, and operational. Regarding the costs considered as part of Company V's CBA, they only identified direct financial costs, such as:

- uninterruptable power supply
- file servers, terminals, and printing facilities
- backup tape streamer
- key vendor software modules
- relational database software
- additional networking software
- consultancy support (partially grant funded)
- network wiring, junctions, and connectors

Table 1. Taxonomy of Strategic Production Planning and Control Benefits

Classification of MRPII Benefits	Financial	Non-Financial	Partly/Totally Intangible
Strategic Benefits			
Improved Growth and Success	X	X	X
Leader in New Technology			X
Improved Market Share	X		
Market Leadership	X	X	X
Enhanced Competitive Advantage	X	X	X

Table 2. Taxonomy of Tactical Production Planning and Control Benefits

Classification of MRPII Benefits	Financial	Non-Financial	Partly/Totally Intangible
Tactical Benefits			
Improved Flexibility	X	X	X
Improved Response to Changes		X	
Improved Product Quality	X	X	X
Improved Teamwork			X
Promotes Open Culture			X
Improved Integration with other business Functions			X
Increased Plant Efficiency	X		
Reduced Delivery Lead-times		X	
Reduced Lead-times		X	
Improved Capacity Planning	X	X	X
Improved Data Management		X	X
Improved Manufacturing Control		X	X
Improved Accuracy of Decisions	X	X	X

- installation and maintenance
- "in-house" customizing time
- reengineering of business processes to suit software
- running costs: electricity insurance premium rises
- consumables (e.g., toner cartridges disks, paper)
- database software course
- database user group fees
- hardware and software performance required to process types
- data volumes of transactions
- functions that are over and above a given user's immediate requirement (e.g., mandatory security facilities)
- balancing developmental costs against maintenance costs
- network architecture and associated hubs, routers, and gateways

Table 3. Taxonomy of Operational Production Planning and Control Benefits

Classification of MRPII Benefits	Financial	Non-Financial	Partly/Totally Intangible
Operational Benefits			
Reduced Raw Material Inventory	X		
Reduced Levels of WIP		X	
Reduced Labor Costs	X		
Reduced Manufacturing Costs	X		
Increased Throughput	X		

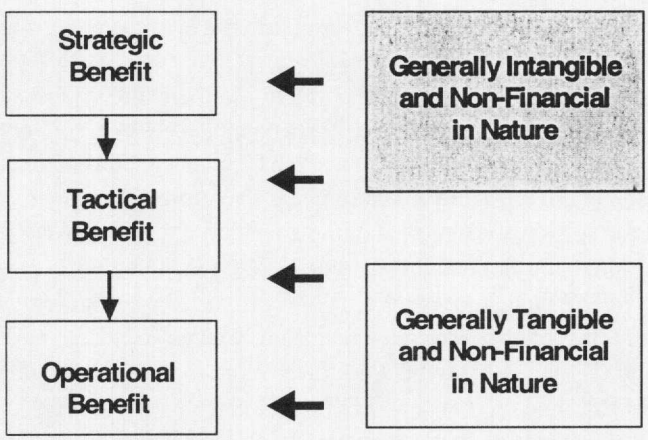

Figure 1. Nature of Strategic, Tactical, and Operational Benefits

As Company V was unable to calculate accurately the financial returns achievable, an "act of faith" decision to invest was made. The basis for this investment strategy, although ad hoc, was that the company was unable to calculate accurately the scope and magnitude of the investments' benefits. In particular, the far-reaching implications of the intangible and nonfinancial benefits (together with the indirect costs that later appeared), added to the complexity and further justified the investment strategy. Interestingly enough, the British CIMA/IProdE [2] suggests that some benefits of IT/IS cannot be quantified, and stated that "an act of faith that such systems are necessary may be required." Therefore, it would appear that the British CIMA/IProdE advocates the adoption of an ad hoc justification strategy. Yet Kaplan [16] states that if companies invest in projects whose financial returns are unknown, or below their cost of capital, there is a chance they could become insolvent.

During the implementation of the core PPC module, it became evident that the vendor-supplied system required the data to fulfill its (the software's) needs, rather than fitting the way Company V operated. It is noteworthy that Cox and Clark [3] reported similar findings. Such circumstances had sought to be avoided by Company V, as the "major" reengineering of business processes just to satisfy the software was considered expensive, non-value-adding, and time-consuming, as well as causing

disruptions to production performance. Furthermore, these implications appeared as significant cost factors that had not been acknowledged within their CBA. The reengineering of processes, however, presented themselves as unavoidable, to achieve the necessary functionality for the effective use of the PPC system.

Employee resistance and a culture based on reactive isolation added to the implementation problems. People openly blamed the IS when things went wrong. The production director was regularly confronted with "work-to lists" that usually had much data that seemed meaningless. He was ready to dismiss the system and go back to the old manual way of PPC. However, the production director was eventually convinced by the software selection and implementation team that computerized PPC was the only way forward if the company were to expand in the future. The team explained that the difficulties being experienced were attributable to the lack of a suitable reporting structure and data format and that the system needed time to "settle down."

It appeared that Company V's biggest problem was their core vendor-supplied PPC module, which worked extremely well if kept supplied with a continuous flow of "clean data." Nonetheless, if there was any "hitch" in data recording or accuracy, the system became highly unstable and unreliable. Therefore, the need to alleviate this problem led the software selection and implementation team to investigate the purchase of a vendor shop floor data collection (SFDC) module. Furthermore, the purchase of the SFDC module seemed a natural progression toward achieving "full" MRPII integration, which received the managing director's endorsement.

It was found that the operational workforce did not receive an orientation on the importance of PPC and on how the SFDC could make a contribution to the performance of the PPC function. In hindsight, however, the software selection and implementation team regretted not educating the workforce. This was particularly painful to the team because management considered this lack of education and training as a barrier to the program being accepted at an operational level. Skepticism and the implications of misuse resulted in "unreliable" data, which brought "noise" into the Master Production Schedule (MPS). Such issues later resulted in inaccurate customer delivery lead times being quoted, falls in productivity, and the loss of a customer base. These factors had a significant impact on the perceived success of the IS and were not acknowledged as implementation issues during the systems evaluation.

At this point the managing director (project champion) turned his attention to a new project, appearing to have either lost interest, due to the lack of success, or being driven by other organizational improvement initiatives. Responsibility for the implementation process was delegated to others, hoping that the by then well-established production director would take up the challenge. He had not been a key member of the software selection and implementation team, but had, rather, operated as an honoree, advising on technical issues when consulted. The production director therefore expected to take the lead in his role as head of the production department. He did not welcome the responsibility for ensuring project success of a half-implemented system, on which he had been given little opportunity for significant input. Still, he acknowledged the contribution that the PPC system was making (and could further make) toward the streamlining of the production function. In light of difficulties, the

software selection and implementation team suddenly changed, from supporting to trying to apportion blame.

Many of the problems that the real-time shop floor data collection intended to alleviate appeared to be further complicated by the SFDC module, which, as the production director claimed, was because:

> We had not sat down in the first place and formalized our systems. . . . People were not informed of the impact the system would make on their job function(s) . . . nobody on the shop floor bought into ensuring the success of the system. They needed educating, not disciplining.

Furthermore, it appeared that at this point, the software selection and implementation team reached a stalemate. No clear direction could be decided, as there was no focused leadership within the team. Furthermore, the PPC software appeared to be dictating the need for a number of dedicated experts, to analyze, manipulate, and control the production function. This was not welcomed by the majority of the management team, who were trying to develop a corporate culture based on openness, through promoting the concepts of flexible, empowered teamwork. Thus the adoption of such a system clearly did not have the operational support necessary for its successful operation. Consequently, management, who were supported by the software selection and implementation team, advocated the development of a bespoke system, more suited to the idiosyncrasies of Company V's processes, and their by now perceived unique needs as a subcontract jobbing shop.

The Development of a Bespoke MRPII System

DRIVEN BY THE NEED[1] TO DEVELOP AN INTEGRATED IS that would acknowledge the idiosyncrasies of Company V, key employees set about developing their own business solution. This investment was partially financed by two government-sponsored schemes. The development of bespoke software was perceived to give Company V a new opportunity to gain operational support for the successful implementation of MRPII. It would appear that human and organizational issues played a crucial part in the decision-making process to develop a bespoke software system. The decision by Company V to develop its own software was seen as a significant turnaround by many within the organization, and indeed it contradicted the managing director's initial justification for purchasing vendor software.

The majority of benefits originally envisaged as deliverables from implementing vendor software, such as those that were identified in Tables 1 through 3, appeared to have still remained relevant. However, the scope of costs associated with developing a bespoke MRPII system was considered greater than originally detailed. Therefore, as part of a revised CBA, Company V significantly increased its estimate of the costs it perceived would be incurred during the development, implementation, and operation of bespoke MRPII software. These new costs were in addition to the already realized direct costs that had been incurred during the earlier purchase of vendor software and complement those social subsystem costs reported by Ryan and Harrison

[19]. Tables 4 and 5 identify the taxonomy of costs that have been classified as indirect organizational and human costs, respectively.

Acknowledging failure through loss of confidence and user participation, Company V decided to abandon the use of the vendor SFDC module due to the disappointing results obtained. This decision was made because of:

- poor data reliability
- swipe hardware terminal problems
- lack of employee support and discipline to consistently use the bar code system
- lack of interest in continuing the implementation process
- misalignment between the strategic direction of the vendor and the organization
- falls in productivity
- lack of clear project focus, leadership, and deliverables

Essentially, the company went back to basics and drew on their experiences. It was decided by the managing director to enlist the support of a consultancy company, as help was needed to facilitate the design, development, and implementation process. Before such processes commenced, Company V reassessed its strategic direction, organizational strengths, and weaknesses, and revised its business plan and developed a project strategy. Company V then began a series of intensive strategic education sessions and workshop training days. All functional managers were educated on the importance of MRPII, and on the impact that the investment would make to their job function(s). A simplified course was also developed for shop floor stakeholders. This course not only addressed the educational issues associated with MRPII but also looked at the practical implications of such a system on their job function(s). In doing so, it clearly differentiated education from training. The subject and teaching media used varied, using as much imagination as possible. Teamwork was promoted, with all employees being mixed and grouped together. They were filmed and reviewed playing games, using Legos® and jigsaw puzzles, all with meaning for throughput production flow, communication, Just in Time (JIT) inventory management, and Total Quality Management (TQM). The workshop exercises appeared to be well received, and helped to win over skeptics. In parallel with the workshop training and education sessions, an information system design and development team was assembled.

Where necessary, employees (subject to their acceptance) were sent on external training courses to develop new technical skills. In addition, students on industrial placements were temporarily employed to develop software. Students were placed at Company V for a period of six months or one year. During their placement each student was supervised by a member of staff from a university (implicitly resulting in technical academic support). This recruitment policy helped to keep system development costs down, thus reducing the need for expensive contract engineers. An additional benefit of having students on the project was to maintain a constant stream of innovation, inspiration, and motivation. However, closer supervision was needed to retain project focus than would have been needed if only general company employees performed the work. During the development of their bespoke IS, Company V schematically mapped out their entire business process using flowchart tools. In do-

Table 4. Taxonomy of Indirect Human Costs

Classification of Indirect Human Costs	MRPII Cost Factors
Management/Staff Resource	Integrating computerized production planning and control into work practices.
Management Time	Devising, approving and amending IT and manufacturing strategies.
Cost of ownership: System Support	Vendor support/trouble shooting costs.
Management Effort and Dedication	Exploring the potential of the system. Linking and integrating new systems together, e.g., CAM, DNC, CIM.
Employee Time	Detailing, approving and amending the computerization of product BOMs.
Employee Training	Being trained to manipulate vendor software and training others.
Employee Motivation	Interest in computerized production planning and control reduces as time passes.
Changes in Salaries	Pay increases based on improved employee flexibility.
Software Disposal	The removal of all software prior to disposal.
Staff Turnover	Increases in interview costs, induction costs, training costs based in the need for skilled human resource.

Table 5. Taxonomy of Indirect Organizational Costs

Classification of Indirect Organizational Costs	MRPII Cost Factor
Productivity Losses	Developing and adapting to new systems, procedures, and guidelines.
Strains on Resource	Maximizing the potential of the new technology through integrating information flows and increasing information availability.
Business Process Reengineering	The redesign of organizational functions, processes, and reporting structures.
Hardware Disposal	The removal of all hardware prior to environmentally friendly disposal.
Organizational Restructuring	Covert resistance to change.

ing so, a top-level analysis of Company V's key business processes was performed, identifying processes and their order of occurrence.

This enabled processes to be reengineered and facilitated the removal of non–value-adding activities before any systems were computerized. This approach to reengineering

was considerably different from earlier attempts in that previous processes appeared to be generic and were based around the functionality of the vendor-supplied software. The reengineering of business processes before bespoke system development allowed for the software being developed to be modeled on best practice jobbing shop activities. It was at this point that the expertise of the consultancy company and academic institutions proved invaluable.

Technology Management Factors: Key Learning Issues

AS A RESULT OF THE CASE STUDY FINDINGS, a number of technology management factors have been identified as having an impact on the failure/success of Company V's adoption of MRPII. These factors are presented in Table 6, where their contribution is identified toward the implementation of vendor software and the later development of a bespoke system.

The inability of traditional modes of financial analysis to justify IT/IS investments (which have strategic implications) has led a growing number of practitioners in calling for a moratorium on their use. The reason for this is that traditional approaches are considered to offer narrow levels of analysis, through their prescriptive focus on operational implications of the investment. This is further complicated, with many managers becoming preoccupied with financial appraisal insofar as practical strategic considerations have been overlooked and in some cases ignored. This inevitably results in many strategically important projects failing to "pass" the financial justification stage of the evaluation process. Consequently, companies are often forced to adopt a myopic approach to IT/IS project justification. This is further complicated where the information system is modular and the system is purchased in stages, the implications being that the appraisal methods only consider the benefits and costs associated with the module being evaluated and are unable to account for benefits that the entire system brings.

Conclusions

THE INCREASED SCOPE OF NEW TECHNOLOGY has not only provided organizations with enablers for change but also prompted companies to reassess the way they evaluate, manage, and exploit technology. The empirical results reported in this paper have identified a case where traditional modes of investment appraisal were inappropriate when accounting for the implications of the investment, and as a result, did not support the efficient and effective deployment of new technology. Therefore, the strategy adopted by the case study when evaluating the MRPII investment was an "act of faith," and thus ad hoc in nature. This subsequently resulted in the system being considered a "failure," as human and organizational factors were neglected during the evaluation and technology management process. The main reason for Company V's ad hoc approach to investment decision-making was that many of the benefits resulting from their investment were considered intangible and nonfinancial. Consequently,

Table 6. Comparative Review of Technology Management Processes

Technology Management Factors	Vendor Software	Bespoke Software
Investment Strategy	Act of Faith	Educated Decision Without Financial Quantitative Analysis
Formal Project Management	No	Yes
Company Culture	Closed	Open
Concept Justification to Workforce	No	Yes
Workforce Educated/Trained	No	Yes
Management Educated/Trained	No	Yes
Appraisal Technique	Cost/Benefit Analysis	Cost/Benefit Analysis
Consultancy Support	No	Yes
Academic Involvement	No	Industrial Placement of Students
Continuous Project Evaluation	No	Monthly Management Review Meetings
Investment Integrated in Business Plan	No	Yes
Classification of Benefits	Strategic, Tactical, and Operational	Strategic, Tactical, and Operational
Nature of Benefits Identified	Financial, Non-financial, and Intangible	Financial, Nonfinancial, and Intangible
Classification of Costs Identified	Direct Costs	Direct and Indirect Costs
Nature of Costs Identified	Financial	Financial and Intangible
Risk Considered	Competitive Risk	Competitive Risk
Implementation Process	Implementation Team	Implementation Team with Contribution from Other Functions
Project Leader	Managing Director	Production Director
Development Scope	Short/Medium Term	Long Term
Human Factors	Not Considered	Addressed Where Possible
Organizational Implications	Not Considered and Not Considered Far-Reaching	Acknowledged as Being Far-Reaching
Implementation Documentation	Ad hoc	Formal Documentation Process
Stakeholder Analysis	No	Yes
Perceived Project Outcome	Failure	Success

they could not be accommodated within traditional evaluation and management frameworks, which had been previously used for the justification of capital manufacturing equipment. The relatively new and inexperienced management team further complicated the justification process, as a result of their lack of knowledge on how to identify and manage IT/IS-related benefits and costs. There are also serious implications connected with the poor project management, which in part was exacerbated by indecisive and inconsistent leadership, thus questioning the appropriate positioning of project managers within the organizational structure. With management under increasing pressure to produce short-term financial savings through improved productivity, managers need to ensure that those projects with long-term strategic focuses were not excluded on the basis of their intangible and nonfinancial benefits. The case study points to the significance of human and organizational factors, and exemplifies the need to take account of such issues within any robust evaluation criteria, thus heightening the significance of the proposed technology management taxonomies.

Acknowledgments: The authors thank the case study company for its participation in this study. Without the cooperation and support of management and employees the research could not have been undertaken. The authors are also grateful to the five anonymous referees for their helpful and constructive comments, which helped improve this manuscript.

NOTE

1. The previously formed software selection and implementation team took the initiative to implement bespoke MRPII development. They perceived that the company would be more satisfied with the results of their "own" system, rather than the implementation of "rigid" vendor software.

REFERENCES

1. Bonoma, T.V. Case research in marketing: opportunities, problems, and a process. *Journal of Marketing Research, 12* (1985), 199–208.

2. British CIMA/IProdE. *Justifying Investments in Advanced Manufacturing Projects.* London: Kogan Page, 1987.

3. Cox, J.F., and Clark, S.L. Problems in implementing and operating a manufacturing resource planning information system. *Journal of Management Information Systems, 1,* 1 (1984), 81–101.

4. Dane, F.C. *Research Methods.* Pacific Grove, CA: Brooks-Cole, 1990.

5. Ezingeard J.-N.; Irani, Z.; and Race, P. Assessing the value and cost implications of manufacturing information and data systems: an empirical study. *European Journal of Information Systems, 7,* 4, (1999), 252–260.

6. Farbey, B.; Land, F.; and Targett, D. *IT Investment: A Study of Methods and Practices.* Kent, UK: Management Today/Butterworth-Heinemann Ltd., 1993.

7. Fiedler, J. *Field Research: A Manual for Logistics and Management of Scientific Studies in Natural Settings.* San Francisco: Jossey-Bass, 1978.

8. Galliers, R.D. Choosing information systems research approaches. In R.D. Galliers (ed.), *Information Systems Research—Issues, Methods and Practice Guidelines.* Oxford, UK: Blackwell Scientific, 1992, pp. 144–162.

9. Hakim, C. *Research Design: Strategies and Choice in the Design of Social Research.* London: Allen and Unwin, 1987.

10. Harris, S. *Human Communication and Information Systems.* Oxford, UK: NCC Blackwell, 1996.

11. Heald, K., and Kelly, K. ARM research predicts EPR market will reach $72.63 billion by 2002, *ARM Research,* November 2d, 1998.

12. Hyde, A. Failure?—who says? *The Computer Bulletin,* July 26–29, 2000.

13. Irani, Z.; Ezingeard, J.-N.; and Grieve, R.J. Integrating the costs of an IT/IS infrastructure into the investment decision making process. *The International Journal of Technological Innovation, Entrepreneurship and Technology Management (Technovation), 17,* 11–12 (1997), 695–706.

14. Irani, Z.; Love, P.E.D.; and Hides, M.T. *Investment Evaluation of New Technology: Integrating IT/IS Cost Management into a Model,* Association for Information System, 2000 Americas Conference on Information Systems (AMCIS 2000), CD Proceedings, August 10–13, 2000, Long Beach, CA.

15. Jick, T.D. Mixing qualitative and quantitative methods: triangulation in accumulation. *Administrative Science Quarterly, 24,* 602–611, 1979.

16. Kaplan, R.S. Financial justification for the factory of the future. Working Paper, Harvard Business School, 1985.

17. Khalifa, G.; Irani, Z.; and Baldwin, L.P. IT Evaluation Methods: Drivers and Consequences, Association for Information System, 2000 Americas Conference on Information Systems (AMCIS2000), CD Proceedings, August 10–13, 2000, Long Beach, CA.

18. Remenyi, D.; Money, A.; Sherwood-Smith, M.; and Irani, Z. *The Effective Measurement and Management of IT Costs and Benefits,* Professional Information Systems Text Books series, 2d ed., Kent, UK: Butterworth Heinemann/Computer Weekly, 2000.

19. Ryan, S.D., and Harrison, D.A. Considering social subsystem costs and benefits in IT investment decisions: A view from the field of anticipated payoffs, *Journal of Management Information Systems, 16,* 4 (2000), 11–40.

20. Serafeimidis, V., and Smithson, S. Information Systems Evaluation in Practice: a case study of organisational change. *Journal of Information Technology, 15,* 2 (2000), 93–105.

21. Shaughnessy, J.J., and Zechmeister, E.B. *Research Methods in Psychology,* 3d ed. Boston: McGraw-Hill, 1994.

22. Voss, C.A. Managing advanced manufacturing technology, *International Journal of Operations and Production Management, 6,* 5 (1986), 4–7.

23. Yin, R.K. *Case Study Research: Design and Methods.* Applied Social Research Methods Series, vol. 5. London: Sage Publications, 1994.