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AND BUSINESS PROCESS CHANGE:
ON THE INTEGRATED DESIGN AND EVALUATION OF
BUSINESS PROCESSES AND INFORMATION SYSTEMS***

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**LEGACY INFORMATION SYSTEMS
AND BUSINESS PROCESS CHANGE**

FOCUS ISSUE ON LEGACY INFORMATION SYSTEMS AND BUSINESS PROCESS CHANGE: ON THE INTEGRATED DESIGN AND EVALUATION OF BUSINESS PROCESSES AND INFORMATION SYSTEMS

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ABSTRACT

The role of information systems in influencing and enabling organisational design is widely acknowledged. Yet limited attention is paid to the theoretical legitimacy and conceptual basis of IS-enabled organisational change i.e., business engineering. In this paper we review business engineering's reference disciplines critically: process-based organisational design, IS development, and IS evaluation. Findings from a case study of business engineering provide empirical support to the theoretical analysis. Synthesis of the conclusions of the review and the case study lead to a number of propositions and potential avenues for further research into the theoretically attractive and practically important field of aligning the design of organisational structures with the design of Information Systems intended to support them.

Keywords: Business engineering, IS development, IS evaluation, process orientation, organisational design, case study

I. BUSINESS ENGINEERING AS A RESEARCH FIELD

It is a cliché that most contemporary organisations operate within complex social, political, economical, and technological settings [Scott Morton, 1991], characterised by such phenomena as the globalisation of national economies,

reduced barriers to market entry, intensification of competition, greater customer expectations, and the rise of a post-industrial Information Society [Castells, 1996]. Against this backdrop, widespread attention is paid, both by researchers and practitioners, to developing methods, techniques, and tools that help enterprises achieve change. Such change management approaches include business process re-engineering (BPR) [Hammer, 1990; Davenport & Short, 1990; Venkatraman, 1991], continuous process improvement (CPI) [Harrington, 1991], and others.

Most modern change management approaches differentiate from their older counterparts by their focus on the business process as the fundamental unit of analysis in organisational design. According to the perspective they advocate, organisations should not be analysed in terms of the functions into which they can be decomposed or in terms of the products they produce, but in terms of the key business processes that they perform. Processes are defined as dynamic orderings of work activities across time and place, with a beginning, an end, and clearly identified inputs and outputs.

A second characteristic of recent change management approaches is the heavy importance they generally place on the role of Information Systems (IS) in enabling change. For example, Davenport [1993] asserts that *'by virtue of its power and popularity, no single business resource is better positioned than information technology to bring about radical improvement in business processes'*. Many other researchers (for example, [Galliers, 1993]; [Grover et al., 1994]; [Raymond et al., 1995]; [Fielder et al., 1995]; [Fuglseth & Gronhaug, 1997]) address the critical role of IS in enabling process changes in contemporary organisations.

The reasons for heavy emphasis on information systems are not difficult to understand. During the last two decades, developments in computer hardware and software created new opportunities for organisations to collect and analyse data, convert them into useful information, and utilise this information as a strategic resource able to bring competitive advantages. This change gave rise to

new methods of conducting business that were unthinkable only a few years ago; for example, electronic commerce [Kalakota & Whinston, 1996; Bakos, 1998].

As a result, organisations made large investments in information systems [Willcocks, 1992], but not all businesses were able to enjoy commensurate financial returns. Indeed, the proliferation of IS coincided with lower macroeconomic figures of productivity and profitability in both the manufacturing and service sectors [Roach, 1991]. Brynjolfsson [1993] has used the term 'IT productivity paradox' to describe the alleged inability of IS to deliver in practice the benefits they promise in theory.

To explain this paradox, some researchers point out that IS was mainly used to automate existing processes rather than as an opportunity for business process change [Hammer & Champy, 1993]. Because business processes are seldom structured with the possibilities of new technologies in mind, the full potential of IS is not always realised. Even worse, other researchers argue that most organisations never designed their business processes at all. Rather, existing processes evolved over time [Hansen, 1994]. Due to this ad hoc evolution, many processes are far from being streamlined, cost effective, or aligned with the over-all organisational goals and strategy.

These observations spawned significant amounts of research to address the alignment of business process change and information technology introduction in organisations. In the context of this paper, the term '*business engineering*', introduced by Meel and Sol [1996], will be used to refer to this dual design strategy. Business engineering is defined here as the integral, concurrent design of organisational processes and the information systems to support them.

The aim of this paper is to examine critically the theoretical legitimacy and conceptual basis of business engineering. Although both IS researchers and management science scholars devoted significant amounts of work in the areas that form the basis of the field, we are aware of no studies that explicitly synthesise findings from the 'reference disciplines' of business engineering to establish a sound foundation and a research agenda for the field. In the following sections, we review the state-of-the-art in these reference disciplines, which we

take to include process-based organisational design, IS development, and IS evaluation (Figure 1). Findings from a case study are presented to support the findings of the theoretical review. We conclude the paper by synthesising our results into a conceptual basis for business engineering. Finally, we articulate a number of avenues for future business engineering research.

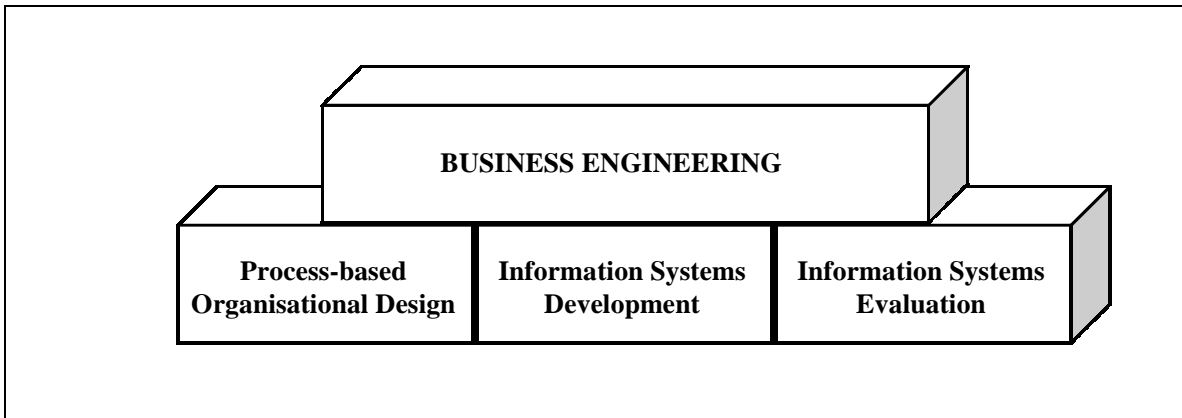


Figure 1. Reference Disciplines of Business Engineering

II. PROCESS-BASED ORGANISATIONAL DESIGN

Fuelled by an increasing demand for organisational change, the 1990's witnessed the development of many methodologies, techniques, and tools to support organisational design projects. Kettinger et al. [1997] present a detailed review and critical appraisal of such methods. This appraisal shows that, although information systems are usually viewed as a critical enabler of process change, the integration of IS design, development, and evaluation into business process change methods generally failed to attract enough attention by management researchers.

Many researchers (for example [Keen, 1991]; [Scott-Morton, 1991]; [Galliers, 1993]; [Davenport, 1993]; [Grover et al., 1994]; [Fielder et al., 1995]) argue against the notion of introducing IS in organisations for the automation of

existing processes within the boundaries of traditional functional areas. Instead, they contend that IS should be introduced for business process transformation [Venkatraman, 1991]. The underlying basis for this proposition is simple: while automation of existing processes may increase the speed at which they are executed, it is based on the questionable assumption that these processes are satisfactory [Fielder et al., 1995]. Such an approach can have considerable drawbacks: Harrington [1991] asserts that automating an inefficient process will simply produce a 'faster mess'. Business engineering takes a step back and looks at ways in which business goals can be supported by redesigning the existing process while at the same time considering how information systems can support the new process [Galliers, 1993]. By approaching business design and IS design in such a integrated fashion, process-based organisational analysis can take advantage of the improved co-ordination, communication, and information manipulation capabilities of Information Systems [Keen, 1991; O'Brien, 1993].

Although the benefits of aligning the design of business processes with the design of their corresponding information systems should be apparent in theory, such integrated design strategies have rarely been the case in practice. Business analysts and IS professionals traditionally had distinct roles within organisations, each equipped with their own tools, techniques, skills, and even terminology [Earl, 1994]. There appears to be very limited support for predicting the consequences that changes in one organisational facet (business processes or information systems) will have on the other [MacArthur et al., 1994]. Most business process change methodologies seem to reinforce this distinction by either concentrating exclusively on the business process level (earlier methods, for example Davenport's [1993] framework shown in Figure 2) or by failing to realise the complexity of IS design and development (later methods, for example Kettinger et al.'s [1997] framework shown in Figure 3).

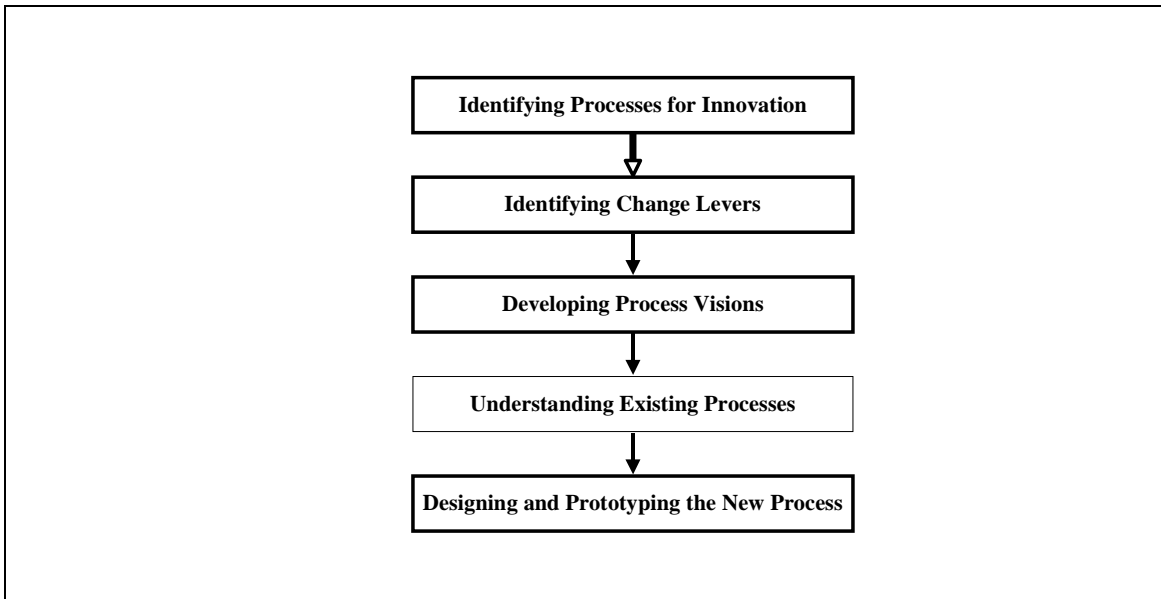


Figure 2. Davenport's BPR Framework [1993]

STAGE	ACTIVITIES				
S ₁ ENVISION	S ₁ A ₁	S ₁ A ₂	S ₁ A ₃	S ₁ A ₄	
	Establish Management Commitment and Vision	Discover Reengineering Opportunities	Identify IT Levers	Select Process	
S ₂ INITIATE	S ₂ A ₁	S ₂ A ₂	S ₂ A ₃	S ₂ A ₄	S ₂ A ₅
	Inform Stakeholders	Organise Reengineering Teams	Conduct Project Planning	Determine External Process Customer Requirements	Set Performance Goals
S ₃ DIAGNOSE	S ₃ A ₁	S ₃ A ₂			
	Document Existing Process	Analyse Existing Process			
S ₄ REDESIGN	S ₄ A ₁	S ₄ A ₂	S ₄ A ₃	S ₄ A ₄	
	Define and Analyse New Process Concepts	Prototype and Detailed Design of a New Process	Design Human Resource Structure	Analyse and Design Information Systems	
S ₅ RECONSTRUCT	S ₅ A ₁	S ₅ A ₂	S ₅ A ₃	S ₅ A ₄	
	Reorganise	Implement Information Systems	Train Users	Process Cut-Over	
S ₆ EVALUATE	S ₆ A ₁	S ₆ A ₂			
	Evaluate Process Performance	Link to Continuous Improvement Programs			

Figure 3. Kettinger et al.'s [1997] BPR Framework

IS design and development is typically a complicated endeavour which usually becomes a complex organisational project of its own. The challenge for business engineering is to bring process design and IS design together without adding to the already high complexity of each task alone. One way to achieve unity is to incorporate high-level IS design into business process design projects and leave the technical details of IS implementation to be managed in the aftermath of process change decisions. Such an approach has two advantages:

1. it ensures that a focus on the alignment of organisational and IS structures is always maintained, thereby allowing business managers to assess the organisational impact of structural and informational changes in an integrated fashion.

2. it drives the complexity of designing detailed IS structures out of the process change endeavour, thereby allowing decision-makers to concentrate on organisational rather than technical factors when designing and evaluating changes. As argued later in this paper, such an approach also presents significant advantages for the IS specialist.

III. INFORMATION SYSTEMS DEVELOPMENT

The proliferation of information systems naturally resulted in increasingly complex systems being built to support core business activities. To assist in achieving maximum efficiency in building and using such systems, enormous intellectual investment was made in structured methodological approaches to IS development (e.g., the Structured Systems Analysis and Design Methodology [Downs et al., 1992]). The aim of such approaches is to provide a systematic, stepwise development framework to structure the development process and ultimately lead to 'better' information systems. The components of most structured IS development methods collectively comprise the Systems Development Life Cycle (SDLC) [Avison, 1997]. A typical archetype of the SDLC is illustrated in Figure 4 [Turban et al., 1996]. The definitions of the various steps

in the SDLC show the close relationship, yet practical incompatibility, between existing approaches for process-based organisational design and IS development.

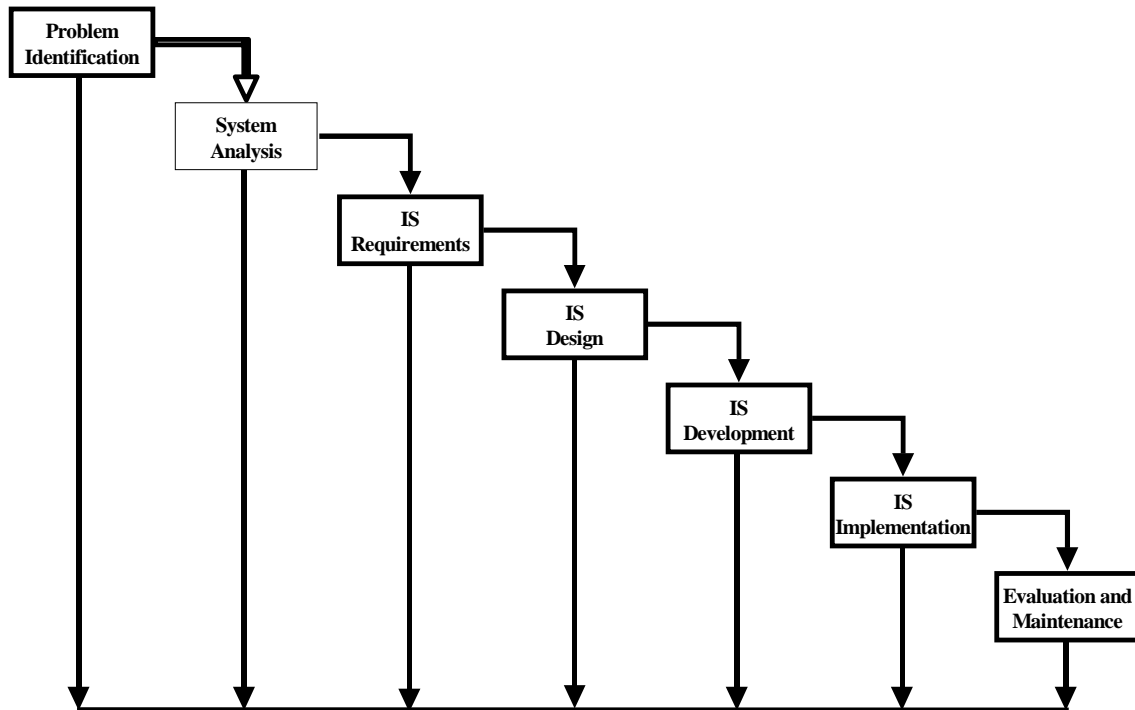


Figure 4. The System Development Life Cycle [Turban et al., 1996]

Probably the first remark to be made about IS development is the inherently complex nature of designing and implementing information systems, especially when they are critical to the organisation and to its success in the marketplace. For business engineering, this complexity implies that it may not be effective, or even feasible, to integrate IS development within business process change as many of the process change methods advocate (e.g., Kettinger et al.'s [1997] framework). This point reinforces our earlier argument for incorporating only the high-level organisational impacts of IS in business process design and leaving the low-level technical implementation details for later.

A second observation about SDLC-based IS development methods is that they perpetuate the distinction between the business and the IS domain. Most structured approaches to IS development begin with an implicit assumption that

the business domain issues are resolved and the system is to work in a stable and well-defined business environment, where the only issue is to identify the 'correct' requirements for the new IS [Paul, 1993]. As a result, not enough attention is generally being paid to investigating the interactions of the IS to be developed with the business processes it will naturally affect. Wolstenholme et al. [1993] described such approaches to IS development as 'reductionist'. These authors argue that as information systems pass through the various stages of their development life cycles, there is a natural and acceptable tendency for them to be defined in greater and greater detail. Such a top-down approach to IS development may be necessary to ensure the decomposition of a complex problem into smaller, more manageable tasks, but it can pose a potential danger to the effectiveness of the final system. As system development proceeds, the focus is steadily moving away from high-level organisational issues towards more detailed sub-problems concerned with the IS itself. Such a paradigm for IS development necessarily separates and treats business processes and information systems in isolation. At no later point in the system development life cycle are these organisational facets re-united in order to identify possible redundancies or sub-optimal designs arising from this artificial separation.

Finally, SDLC-based approaches tend to view IS evaluation as a post-implementation activity, addressed only in the last step of the system development life cycle. Although clearly important, such an assessment comes too late to have any real impact on the development process and can only benefit future versions of the information system. What may be needed is an explicit focus on the pre-implementation (*ex ante*) evaluation of the information system (for example, within the problem identification or system analysis stages). Such an evaluation should abstract away from technical details and focus on justifying the need for, and the costs and benefits associated with, the development of a system in terms of its impact on business processes and organisational performance.

IV. INFORMATION SYSTEMS EVALUATION

The use of methodological approaches for IS development undoubtedly contributed to the creation of more flexible information systems. However, many systems still fail to fulfil the needs of their users and the organisations that adopt them (characteristic and well-publicised examples of IS failures can be found in Glass [1998]). IS failure can translate to huge financial losses due to the large capital investments most organisations make in information technology. By 1991, UK company expenditure on IS was exceeding £10 billion per year, equivalent to an average of over 1.2% of annual turnover [Willcocks, 1992]. At the same time, research studies suggested that at least 20% of this expenditure was wasted and between 30% and 40% of IS projects realised no net benefits, however measured [Willcocks & Lester, 1991].

As a result of these cautionary figures, IS specialists and business managers historically expressed increasing concerns regarding their ability to evaluate their investments in information systems prior to committing organisational resources to them [Raymond et al., 1995]. IS evaluation is important for many reasons:

1. Organisations need to justify their investments in IS, because of the large percentage of capital consumed by these investments and the need to prioritise among heterogeneous investment proposals competing for scarce organisational resources.
2. Managers need a better understanding of the impact of IS on organisational performance. Such understanding can help an organisation utilise resources better and improve its position vis-à-vis its competitors [Clemons, 1991].
3. Failure of such understanding may have disastrous consequences such as inappropriate resource allocation and competitive disadvantage [Farbey et al., 1993].
4. Viewed in systems terms, evaluation provides the basic feedback function to managers as well as forming a fundamental component of the organisational learning process [Smithson & Hirschheim, 1998].

5. Evaluation provides the benchmarks of what is to be achieved by the IS investment. These benchmarks can later be used to provide a measure of the actual implementation success of IS projects [Farbey et al., 1992].

The evaluation of an IS investment may be carried out in virtually every step in the system's life cycle. In the earlier stages (before project approval), evaluation is concerned with setting targets and predicting outcomes in terms of costs, benefits, and potential risks. This phase of evaluation is usually referred to as ex ante evaluation. In the later stages, when the system has been operational for some time, ex post evaluation may be carried out to ensure that planned benefits are being realised and to identify any unforeseen benefits or costs that need to be managed [Kumar, 1990]. Since our stated objective is to study IS evaluation in the context of business engineering, this research focuses on ex ante IS evaluation problems. Therefore, the term 'IS evaluation' within this paper is used to refer to ex ante investment appraisal.

Ex ante IS evaluation has long been considered a difficult and elusive domain. Many reasons are offered to explain the difficulties in evaluating IS investments. Table 1, based on data from [Willcocks, 1992]; [Farbey et al., 1993]; [Lederer & Prasad, 1993]; and [Brown, 1994], summarises some of the most commonly cited difficulties.

The list in Table 1 indicates that the major difficulties in IS evaluation relate either to benefit measurement or to the methodological approaches used. Despite this, most of the existing IS evaluation methods focus more on processing the relevant data during the decision-making process rather than generating the data that will drive evaluation [Strassman, 1990]. In other words, they focus on carrying out and managing the process of evaluation and not on the actual measurement of the benefits.

Table 1. The Difficulties of IS Evaluation

<p><i>COST-RELATED REASONS</i></p> <ul style="list-style-type: none"> • Estimating the cost and time to develop new applications is difficult and unreliable. • Human and organisational costs are often neglected during evaluation.
<p><i>BENEFIT-RELATED REASONS</i></p> <ul style="list-style-type: none"> • IS benefits may include intangible, indirect, or strategic advantages that are inherently difficult to express in quantitative (especially monetary) terms. • IS benefits are indirect to business and therefore indistinguishable from other confounding factors (for example, people, processes, and strategy). • Many applications are targeted at achieving second-order effects that are difficult to predict and measure. • Fractional IS savings cannot be aggregated to provide realistic savings on an organisation-wide scale. • The planning horizon (for which benefits <i>must</i> be assessed) may be longer than the forecasting horizon (for which benefits <i>can</i> be assessed). • Organisations may simply be unaware of the potential benefits of innovative new systems.
<p><i>RISK-RELATED REASONS</i></p> <ul style="list-style-type: none"> • The life span of IS is uncertain (due to technological obsolescence and changing requirements). • IS impacts depend on a number of external factors that may lie outside the sphere of organisational control.
<p><i>METHODOLOGY-RELATED REASONS</i></p> <ul style="list-style-type: none"> • Financial and accounting techniques may be inappropriate for assessing IS investments. • Usually IS is part of a wider business reorganisation and hence IS investments cannot be evaluated out of the context of the overall change. • Tasks left out of the IS scope must also be evaluated as they can contribute significantly to overall costs.
<p><i>POLITICAL REASONS</i></p> <ul style="list-style-type: none"> • Project champions tend to underestimate costs and overestimate benefits.

Empirical surveys (for example, [Willcocks & Lester, 1991]; [Farbey et al., 1992]; [Ballantine et al., 1994]) consistently show that most companies use variants of a small number of methods, notably generic financial and accounting

techniques such as return-on-investment and cost-benefit analysis. These methods may be the natural choice for evaluation since they are already in widespread use for evaluating other types of capital expenditure and can, amongst others, allow for direct comparisons between heterogeneous IS and non-IS enabled investments.

However, to use financial methods effectively in evaluating IS investments, we need to articulate ways of generating reliable and objective estimates of the expected impacts of a proposed information system on business performance. Without such data, over-reliance on such methods can lead to an excessively conservative IS portfolio and an associated loss of competitiveness [Whiting et al., 1993]. Despite acknowledging the need for benefit measurement in theory [Bacon, 1992], IS evaluation researchers characteristically avoid addressing it in practice. Of the many IS evaluation methods that exist, only those known as the 'experimental' ones (prototyping and simulation) seem to address the issue of generating data to be used in subsequent evaluations. Prototyping can yield real data on which to estimate a system's potential organisational impact at a relatively early stage of IS development. These data can be used as a basis for decisions to proceed with a full-scale system development. Simulation is mentioned as a promising tool for IS evaluation in a number of studies (e.g., [Giaglis et al., 1999a]; [Giaglis et al., 1999b]). The theoretical advantage of simulation is that it allows experiments to be run with alternative system configurations and thus can provide useful data on which to base investment decisions at a low cost. Moreover, simulation allows for 'what-if' and sensitivity analyses that can help to resolve problems about the robustness of the proposed system in the face of uncertain assumptions.

In a comprehensive review of existing research in IS evaluation is a potential difficulty. Smithson and Hirschheim [1998] identify five levels on which IS evaluation is conducted:

1. the macro level,
2. the sector level,
3. the firm level,

4. the application level, and
5. the stakeholder level.

However, a fundamental unit of IS analysis, the business process, is missing from an otherwise comprehensive review. In view of the recent focus of much IS research on the issues of business process change and business engineering, it seems surprising that only a limited number of researchers addressed IS evaluation at the level of the business process. These researchers include:

1. Ginzberg [1979] who, 20 years ago, wrote: *'Changes to processes are the link between changes to information and organisational outcomes. It is only once we understand how the new system will be used that its value can be estimated. Thus, efforts to quantify benefits should focus on the changes in organisational processes which will result from changes to information systems'*.
2. Farbey et al. [1992] argued for the need to abandon the IS project as the fundamental unit of analysis in IS evaluation and adopt the wider concept of the business process instead. In particular, the authors assert that *'when the information system is part of a wide ranging set of changes ... it is almost impossible to determine the proportion of any benefit which can be said to stem from any component of the change. It is only possible to evaluate the costs and benefits of the whole package of changes'*.
3. Farbey et al. [1998], in the editorial of a recent special issue of the European Journal of Information Systems on IS evaluation, report: *'... a major change we have detected is that the big questions are to do with the value added by transformations in which IS/IT plays, maybe, a crucial role, rather than about putting value on to the IS/IT contribution... The traditional unit of evaluation was the application... In the future ought we to take a more holistic view in considering the change in all its parts?'*

While we are in complete agreement with the above arguments, we are aware of no IS evaluation method that actually advocates such a perspective for

appraising the benefits of an information system by measuring the impact of changes on the level of the business processes that the IS is intended to support.

We argue that a change in perspective is needed to understand and maximise the value of IS in organisations. We need to adopt process change as a mediating factor between the IS initiative and economic return. Such thinking could trigger a radically different perspective in the way IS investments are viewed and analysed within an organisation. For example, organisations would not anymore expect an IS investment in itself to provide economic returns for the company and would recognise that only changes in a business process can yield such benefits. The role of information systems is to make a new process design possible [Ward et al., 1996].

To illustrate how the approach of adopting process change as the analytic lens for studying the alignment of business and IT designs may be applied in practice, the next section reviews the results of a case study of business engineering. In Section VI, we combine the lessons of this empirical evidence with the findings of the theoretical review into a number of conclusions and future business engineering research directions.

V. BUSINESS ENGINEERING IN PRACTICE: LESSONS FROM A CASE STUDY

The case is typical of inter-organisational business engineering: two organisations jointly attempting to improve their performance and achieve an edge over their competitors by means of process change and IS introduction. The two organisations were the national subsidiary of a multinational pharmaceuticals company and a small enterprise acting as a regional distributor of the multinational's products. The project was aimed at assessing the potential of redesigning the trading communications scheme between the two companies and evaluating the possibility of introducing Electronic Data Interchange (EDI) applications to support the redesigned processes of customer order fulfillment.

The purpose of our analysis here is to concentrate on the study results and the

lessons they can offer regarding business engineering, rather than reporting in detail the case study process and analysis. A more detailed discussion of the case is presented in Giaglis et al. [1999b]. A short description of the case background follows.

CASE BACKGROUND

Due to the special nature of the health care and pharmaceuticals market and the urgency of most customer demands, each customer order submitted to the two companies had to be fulfilled within very strict time limits. However, it was observed that the targets set by the two companies were virtually never met in practice. Preliminary discussions did not result in any definite proposals for solutions. However, the two companies agreed that the problems seemed to arise from inefficiencies in the ordering process and from the inability to maintain an optimal level of product inventory to support order fulfillment. The communication and information exchange scheme between the two companies was deemed to be cumbersome and inflexible. Since these inefficiencies represented a major source of customer dissatisfaction it was decided that a more in-depth study of the problem should be sought and the possibility of introducing electronic communications (by means of an EDI infrastructure) along the value chain should be examined.

ASSESSING THE BENEFITS OF EDI

It has been argued that one of the main reasons explaining the reluctance of organisations to adopt EDI and other similar electronic commerce applications on a great scale may be the significant amount of organisational change required. Indeed, such applications are described as bearing a close resemblance to radical BPR efforts [Kalakota & Whinston, 1996]. Such a radical change will necessarily pose a fundamental question to managers and decision-makers: can the benefits achieved by employing EDI outweigh the costs needed for setting up and maintaining the necessary infrastructure and applications? Such applications may account for significant expenditure, especially for small and medium firms: hardware, software, telecommunications, training, and

business re-organisation, to name a few. Although these costs are relatively easy to estimate as long as a specific business scenario is envisaged, intangible benefits assessment is usually problematic, albeit very significant, for a complete business case to be made. In line with the previous analysis, business process simulation was employed to assist in identifying the problems of existing process designs, to formulate appropriate solutions based on EDI applications, and to realise the expected impacts of these solutions on key business performance indicators.

The underlying notion behind this argument is simple and follows naturally from the analysis of the previous sections. EDI investments do not usually constitute an end in themselves, but are generally part of a wider business reorganisation in which they play a specific role (significant or otherwise). In such cases, it is important that the investment in the wider business change is evaluated and not the IT investment alone. In other words, it makes sense to concentrate our efforts on the wider business processes that surround the EDI investment and study the impact of EDI using the business process as the fundamental unit of analysis. Business Process Simulation (BPS) offers a theoretically attractive mechanism for this approach.

STUDY AIMS AND OBJECTIVES

The case study aimed at

1. examining in detail the existing process of customer order fulfilment,
2. proposing alternative processes by which the problems of the existing process could be alleviated, and
3. evaluating the potential of introducing EDI applications to facilitate the communication between the two companies.

STUDY DESIGN AND IMPLEMENTATION

Interviews with key process participants (management and employees) of both companies were conducted to capture the process essence and decompose the order fulfillment process into its component activities. The knowledge elicited by the interviews was used to define the boundaries of the process and the

models to be developed. An initial static model (flowchart) was developed to depict the activities within the process and was then calibrated with quantitative data to drive the simulations. The resulting dynamic model was validated and run. The results of the simulation runs were analysed, only to confirm that existing process performance was far from producing results within the stated management objectives. Based on the results of the as-is modelling phase, alternative process configurations were developed and discussed with both companies for acceptance and feasibility. Alternative process scenarios were then developed and modeled. The results from these prospective to-be process designs were compared with the as-is model to evaluate the impact of changes on key performance indicators. A more detailed discussion on the case study implementation and results can be found in Giaglis et al. [1999b].

STUDY FINDINGS

Simulation provided valuable insight into the ability of the proposed solutions to alleviate the problems faced by the two companies. Some results were surprising: contrary to what was expected, the adoption of EDI by itself did not result in the lead-time savings for order fulfilment initially envisaged by the two companies. However, simulation made it possible to realise that, if combined with the technology introduction, other (non EDI-dependent) structural process changes could provide a solution to the inefficiencies of the process.

Further to the simulation analysis, the process scenarios were scrutinised to develop a detailed understanding of implementation challenges and transform hypotheses into detailed implementation plans. The requirements of each option regarding technology, people, and skills were assessed and a formal cost-benefit analysis was conducted to evaluate the proposed investments. Based on the results of the analyses, detailed recommendations for change and implementation plans were proposed.

LESSONS FROM THE CASE STUDY

Simulation proved to be a valuable mechanism for realising the business value of EDI and evaluating the investments in business terms. Both companies

were able to see for themselves and assess the costs and benefits associated with various proposed options. This hands-on experience helped the two firms overcome their doubts about adopting EDI. It built their confidence in the technology, without the risk and cost of developing prototype applications and disrupting their businesses operations.

It was further appreciated how simulation proved that the adoption of EDI alone would only marginally improve the performance of the process, contrary to what was initially expected. Management was able to identify, propose, and experiment with other options that would complement the EDI investment to achieve the desired results. Thus, the case study provides empirical evidence to support the argument that modelling businesses at the process level can provide an efficient mechanism for allowing organisations to assess the business value of IS investments and align IS with their operating structures.

VI. A SYNTHESIS OF THEORETICAL AND EMPIRICAL FINDINGS

The purpose of this section is to summarise the conclusions reached earlier through reviewing the existing state-of-the-art in process-based organisational design, IS development, and IS evaluation. By synthesising these conclusions with the findings of the case study, it is possible to deduce a number of theoretical propositions for business engineering. These propositions can, in turn, form the basis for articulating potential avenues for further research.

PROCESS-BASED ORGANISATIONAL DESIGN

It seems to be widely accepted that the adoption of a process-based view of organisations can deliver significant benefits to the study and redesign of organisational structures. Further to representing the 'natural' way of describing work [Earl, 1994], processes lend themselves better to analysis and measurement. While there is no way of measuring or improving a static hierarchical structure in any absolute sense [Davenport, 1993], processes are amenable to measurement in a variety of dimensions (cost, time, and output quality, to name but a few). A process-based model, as demonstrated in the

simulation case study, can provide the basis of informed analysis and decision-making in a manner that would be extremely difficult (if not impossible) to achieve in a functional, divisional, or product-based analysis.

The importance of information systems as an enabler of organisational change, coupled with the recursive relationships between IS and business processes, necessitate that processes and systems are considered and designed together. Although theoretically attractive, such an integrated perspective is far from easy to achieve in practice, and existing methodologies for business process change generally fail to address this issue satisfactorily. The challenge for business engineering is to bring process design and IS design together without adding to the high complexity of each task alone.

A potential strategy for addressing this need would involve incorporating high-level IS design and IS evaluation into business process design, and leaving the technical details of IS implementation to be addressed in the aftermath of business engineering decisions. Such an approach was followed in the case study where the EDI applications were defined in general terms (only to the level of detail necessary for the model development and analysis) without the need for specific reference to implementation-dependent technical details. This approach allowed for aligning IS designs with process designs without adding an unnecessary degree of complexity to the whole exercise.

Table 2 summarises the findings from the review of the process-based organisational design literature.

IS DEVELOPMENT

The design and implementation of information systems is generally a complex and laborious exercise for most contemporary organisations. It may not be desirable (or even feasible) to incorporate such design into business process change in its entirety. A strategy where IS design is treated along two dimensions (one concerning the organisational impact of IS, and the other concerning the technical implementation details) may be more appropriate. The case study discussed above addressed only the first dimension, while the technical

Table 2. Findings from the Process-based Organisational Design (POD) Domain

<p>POD.1. There is a need to integrate the design of organisational processes and Information Systems (business engineering).</p>
<p>POD.2. Adopting a horizontal, process perspective may facilitate more efficient analysis and design strategies.</p>
<p>POD.3. Existing business process change methodologies fail to address the balance between the need for and the complexity of IS design.</p>
<p>POD.4. It may be desirable to integrate high-level (organisational) IS design into business process design, and leave low-level (technical) IS design out of scope of business engineering.</p>

implementation details need only be addressed in a subsequent IS project. What is even more important is that implementation details need only be developed for the solution chosen and not for every alternative information system design that was considered during the business engineering endeavour.

Such a two-tier approach to business engineering acknowledges that although most existing IS development methods begin by stressing the importance of understanding the real-world operation that the IS will support, they quickly become absorbed in the definition of individual functions and detailed requirements ('reductionism'). Such a paradigm for IS development necessarily separates and treats business processes and information systems in isolation, despite the fact that they are in reality closely inter-related.

Furthermore, existing IS development methodologies pay only limited attention to the *ex ante* evaluation of Information Systems, at least as far as their organisational impacts are concerned. What may be needed is a reverse of the process of progressively decomposing the problem of IS development into smaller, more technical, tasks. Instead, when the system is evaluated, the high-level real-world picture should be reconstructed to ensure that the overall impact of the information system on the business processes is evaluated [Wolstenholme et al., 1993]. The simulation approach followed in the case study accommodated this requirement effectively. It enabled EDI application impact assessment on the

whole spectrum of business processes affected instead of only examining the immediate environment of the IS that would have probably been the focus of most IS development methods.

Table 3 summarises the findings from the review of the IS development domain. It is worth pointing to the similarity of findings with those reported in Table 2 from the process-based organisational design domain, all pointing to the need for improved IS evaluation in the context of business engineering.

Table 3. Findings from the IS Development (ISD) Domain

ISD.1. IS development is a complex process, which may be difficult to integrate fully into business process change exercises.
ISD.2. Existing IS development methods generally adopt a ‘reductionist’ approach, which is incompatible with the high-level goals and objectives of business process change.
ISD.3. Existing IS development methods do not generally pay enough attention to the importance of, and the difficulties associated with, <i>ex ante</i> IS evaluation.
ISD.4. It may be desirable to integrate IS evaluation into business process design, adopting a ‘holistic’, organisational view of information systems.

IS EVALUATION

Smithson and Hirschheim [1998] note that ‘*developments in both the business and organisational context, and the IS context itself, have made IS evaluation even more necessary and, yet, even more difficult*’. IS evaluation is necessary due to the high level of organisational investments in IS, and the need of managers to have a better understanding of the impact of IS on organisational performance. IS evaluation is difficult for many reasons, the primary ones relating either to benefit measurement or to the methodological approaches used.

Benefit assessment is inherently complex due to the very nature of IS benefits, consisting in many cases of difficult-to-measure intangible, indirect, and strategic effects. Despite this difficulty, few IS evaluation methods focus on providing tools for generating numerical data regarding benefits that are necessary for carrying out formal investment appraisals. Since most organisations continue to use generic, financial investment appraisal techniques for assessing the desirability and priority of IS investments, we need to support IS evaluation further by developing techniques and tools for generating estimates of the organisational value of IS. Experimental methods (for example, systems prototyping and simulation) seem to be capable of producing such estimates, as demonstrated in the case study presented in Section V.

Regarding the methodological approaches used, most approaches to IS evaluation use the IS project (or the IS application) as the fundamental unit of analysis for studying evaluation issues. However, contemporary IS are increasingly integrated together, making it even more difficult to disentangle a single system for evaluation. This may render the demarcation of boundaries around individual systems for the purposes of evaluation a meaningless exercise [Smithson & Hirschheim, 1998]. We argue that IS evaluation should be driven by the real-world organisation in which the IS will be applied. We therefore advocate adopting a high-level, organisational perspective of the problem of IS evaluation, and we propose to substitute the IS project with the business process as the fundamental unit of analysis in IS evaluation. Business process modelling approaches, as shown in the case study, can fit this requirement well. Other approaches of similar nature could include upper-CASE tools, workflow management systems, enterprise resource planning applications, and so on.

Table 4 summarises the findings from the review of the IS evaluation domain. Coupled with the findings above, these findings point to the close inter-relationships between the reference disciplines of business engineering, and hence to the legitimacy of business engineering as a field of inquiry.

Table 4. Findings from the IS Evaluation (ISE) Domain

ISE.1.	IS evaluation is important, due to the high investments in IS and the critical role of technology in improving business performance.
ISE.2.	IS evaluation is difficult, mainly due to reasons related to benefit assessment and the methodological approaches used.
ISE.3.	Existing IS evaluation methods focus primarily on the level of the IS project in isolation, without paying explicit attention to the interactions of the IS with the real-world organisation (business processes).
ISE.4.	There exists a need for supporting the data generation phase of evaluation, especially related to benefits assessment. Experimental methods, like simulation, are a promising approach.

VII. FUTURE BUSINESS ENGINEERING RESEARCH

Based on the discussion in Section VI of the limitations of existing approaches to business engineering, we can now articulate a number of avenues for further research that will enable the accumulation of intellectual capital in the area in a focused and targeted manner. Perhaps the most important direction that future research efforts should focus upon relates to the development and empirical validation of methodological approaches to business engineering. Such methodologies should satisfy the requirements identified above, namely adopting a process perspective in analysing organisational structures, integrating high-level IS design within business process design, and leaving the technical details of IS implementation to the software engineering domain experts.

Such methodologies should be complemented by targeted modelling techniques (both for business process modelling and IS modelling) and software tools that would facilitate the methodological steps and support users in carrying out business engineering exercises. Techniques such as IDEF [Mayer et al., 1995] and discrete-event simulation [Giaglis et al., 1999c] seem to lend themselves better to integrated business and IS modelling. However, even these

techniques may need to be modified and/or complemented by others to support business engineering principles.

In the IS development domain, business engineering provides an underlying basis for the development of methods that would overcome the traditional problems of the SDLC paradigm, namely reductionism and lack of focus in *ex ante* evaluation. Existing IS development methods that deviate from the SDLC paradigm, for example Joint Application Development [Kettelhut, 1997], ETHICS [Mumford & Weir, 1979], and Multiview [Avison & Wood-Harper, 1990], are all potential candidates for fitting into the business engineering paradigm.

Similarly, in the IS evaluation domain, further research is required to drive the development of IS-specific evaluation techniques that will complement existing ones by providing data on IS costs and benefits at the level of the business process. Simulation models seem to offer an excellent candidate here, if they can be made to explicitly incorporate both business (structural) and IS-enabled (informational) effects of organisational process redesign. A potential research avenue in this area could be the development of a *design theory* [Walls et al., 1992] of IS evaluation by simulation that would specify both the design process of developing such simulation models, and the design products that this process should generate.

Summarising, we can conclude that business engineering is still a field at youthful state, providing a number of both intellectually stimulating and practically relevant research and application areas. It is only through targeted further research that we can establish a deeper understanding of this inherently interdisciplinary domain, and help bridge the gap between the worlds of management and information technology in contemporary organisations.

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