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OPTIMISING BUSINESS PROCESSES THROUGH ERP POST-IMPLEMENTATION MODIFICATIONS: AN EXPLORATORY CASE STUDY

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Abstract

While ERP systems can improve the efficiency, effectiveness and flexibility of business processes, there exists a relationship between post-implementation modifications and the optimisation of business processes. This relationship has not been adequately researched. By drawing on the post-implementation experience of an Australian oil company, we report a series of modifications that were conducted on their ERP system, and empirically classify them via propositions according to our proposed theory-driven model: ERP PIM. The model and empirical evidence together provide a theoretical foundation for research into the impact of ERP post-implementation modifications and their influence on business process optimisation. This is considered important for achieving competitive advantage. The applicability of our model as a useful managerial tool for analysing various modifications and understanding their impact on business process optimisation is offered.

Keywords: Business process optimisation; ERP capability; post-implementation modifications; maintenance, upgrades and enhancements

1 INTRODUCTION

Enterprise Resource Planning (ERP) systems are packaged suites of application software, capable of fully integrating business processes, and are adopted for enterprise management and business process integration and optimisation (Grabski, Leech, & Schmidt, 2011). Once implemented, these systems require post implementation modifications to maintain, update, and further align the system with the organisation's functions and strategies (Ng, 2001). Post-implementation modifications include all forms of maintenance, enhancements and upgrades (Cao, Nicolaou, & Bhattacharya, 2010; Ng, Gable, & Chan, 2002). Given the importance that ERP systems play in supporting business operations suggests that the impacts of post-implementation modification initiatives need to be closely examined. There is however a gap in the literature regarding this, as the impacts of ERP post-modifications is rarely studied.

As part of an ongoing study, we recently reported (citation withheld) the development of a conceptual model of ERP post-implementation modifications – the ERP-PIM model. In this paper, we report an empirical evaluation of the ERP-PIM model based on an exploratory case study conducted in an Australian energy company referred to as COIL. From the case, we provide a rich description of what and how ERP post-implementation modifications are undertaken; and how these modifications enhanced ERP capabilities leading to business process optimisation. We conclude that ERP post-implementation modification initiatives are influenced by organisational motivation and organisational learning. We also find that business process optimisation is largely dependent on ERP capability enhanced via modifications. Our study thus makes contribution to both theory and practice by providing richer knowledge of how ERP post-implementation modifications influence business process optimisation. This paper also makes a methodological contribution to IS research as we provide a detailed application of a critical realist ontology and methodology for ERP research.

The paper is structured as follows: First, the relevant background literature is reviewed. Next, the model and the theoretical underpinnings of the model and propositions are presented; this is followed by a discussion of the case study. The model and propositions are evaluated from the analysis of the data and conclusions are drawn.

2 BACKGROUND LITERATURE

The effects of ERP systems on an organisation's performance are largely dependent on how the systems are implemented, utilised, maintained and managed (Nicolaou & Bhattacharya, 2008). ERP systems are maintained and managed through the release of modifications provided by the respective ERP vendor. The term modification in our research refers to maintenance, enhancements and/or upgrades. Since modifications may not influence organisational performance and may be costly and time consuming to perform, post-implementation modifications are selectively implemented by organisations (Cao et al., 2010; Kraemmergaard, Ngewnyama, & Keller, 2012; Law, Chen, & Wu, 2010; Ng & Gable, 2010; Otieno, 2010; Worrell, 2007).

In the academic and practitioner literature, ERP post-implementation modifications have received scant attention in comparison with adoption and implementation issues (Law et al. 2010). Several ERP post-implementation studies acknowledge that modifications can take different forms (Ng and Gable 2010), vary in their impact on organisations (Ng et al. 2002), and are likely to be driven by different organisational motives (Ng 2001). However the literature into ERP post implementation modifications generally refers to maintenance. In fact, an ERP maintenance taxonomy was developed to characterise such changes and additions, and also to differentiate ERP maintenance from traditional software maintenance (Ng et al. 2001). We contend maintenance is only one facet of post implementation modifications and in itself is not sufficient to gain valuable insights into all forms of post-implementation changes undertaken by organisations. Additionally, from our review of the maintenance literature, we find no reference to the impacts of maintenance modifications on business processes, nor has the literature addressed how organisations undertake such maintenance to support organisational needs (Nah et al. 2001; Ng 2001; Ng et al. 2002). In particular, no studies have

considered the influence of post-implementation modifications on business process optimisation. This is surprising given that organisations' distinctive capabilities are embedded in their business processes, which an ERP system embodies. We argue that various forms of modifications are capable of influencing and enhancing the interconnected business processes the system supports, thus maximising the benefits attained from the ERP and ultimately influencing organisational performance (Hawking, Stein, & Foster, 2004). In our research we focus on a variety of modifications; including maintenance, enhancements and upgrade activities. We propose a theory-driven model to categorise ERP post-implementation modifications to explain their influence on business process effectiveness, efficiency and flexibility in essence business process optimisation.

3 THE ERP-PIM MODEL

Our theory-driven model, referred to as ERP-PIM is founded on three major theoretical perspectives: organisational motivation, organisational learning and the resource-based view of the firm. Arguments for the use of these viewpoints are presented.

In the literature, no study has sought to understand what motivates organisations to undertake ERP modifications. Organisational motivation refers to high-level objectives of an organisation to initiate a particular project (Smith et al. 2008). This definition is supported by Rahim, Shanks, and Johnston (2011) who suggest the existence of different types of motivations for IT projects. From the broader ERP implementation literature, we find two types of motivation for ERP systems: business and technical (Markus & Tanis, 2000). Business motivation refers to an organisational intention to gain benefits related to customer satisfaction and overall productivity (Themistocleous, Irani, & O'keefe, 2001; Tomblin, 2010). A technical motivation is an organisational intention to attain benefits drawing on the technical capabilities within the system. In this research we focus on technical and a business motivation. By utilising an organisation motivation perspective, we will have a better understanding why organisations undertake or do not choose to undertake specific modifications.

Organisational learning concerns the active use of data in guiding organisational behaviour (Edmondson & Moingeon, 1998), and focuses on the efficient application of captured and assimilated knowledge to achieve positive influences on organisations' IT infrastructure and business experience (Kane & Alavi, 2007; Tomblin, 2010). Several studies have proposed that different organisational learning types are invoked when organisations maintain and/or improve their ERP systems (Kraemmerand, Møller, & Boer, 2003; Yamin & Sinkovics, 2007). March (1991) argues that improving firm performance involves a trade-off between exploration and exploitation organisational learning, defining exploration as discovery and innovation, and exploitation as refinement and extension of existing competencies. An organisational learning perspective will help us understand the attributes of post-implementation modifications.

We propose that ERP post-implementation modifications are not only influenced by organisational motivations both business and technical, but also by the exploitation and exploration organisational learning theory. Therefore both the organisational motivation and organisational learning perspectives are major foci of our model. The ERP-PIM model is expressed in two parts:

Part 1: a typology of ERP post-implementation modification initiatives which include: maintenance, technical upgrade, enhancement and functional upgrade

Part 2: three sets of propositions explaining how the various modifications influence ERP capability thus influencing business process efficiency, effectiveness and flexibility

3.1 Typology of ERP post- implementation modifications

We present the typology in Figure 1 below.

ORGANISATIONAL MOTIVATION	ORGANISATIONAL LEARNING: *Exploitation*	ORGANISATIONAL LEARNING: *Exploration*
Technical	Cell A **Maintenance**	Cell B **Technical upgrade**
Business	Cell C **Enhancement**	Cell D **Functional upgrade**

Figure 1: Typology of ERP post-implementation modifications

As shown in Figure 1, the typology depicts four cells: Cell A, maintenance, Cell B, technical upgrade, Cell C, enhancement, and Cell D, Functional upgrade. Organisational motivation is presented on the left hand side while organisational learning is placed at the top of the typology. In the following section we discuss how each of the four cells is theoretically underpinned.

Maintenance (Cell A): maintenance modifications are characterised by a technical motivation and an exploitation organisational learning approach. We argue that maintenance modifications are not intended to provide or develop new technical capability but reflect technical adjustments made in the ERP system which typically include support packages or patches, on-going system support, help desk support and bug fixes (Ng 2001;Worrell 2007). Maintenance modifications characterize exploitation organisational learning because they are undertaken as routine activities to stabilise and maintain an efficient system (Law et al. 2010). In addition, maintenance modifications can facilitate better utilisation of the technical capability of an ERP system but are unlikely to influence business processes. Therefore where maintenance modifications are driven by technical considerations, they demonstrate a technical motivation and an exploitation learning approach.

Technical upgrade (Cell B): technical upgrade modifications are characterised by a technical motivation and an exploration learning approach. A technical upgrade may involve the implementation of key emerging and established technologies such as moving an implemented system onto the latest technology platform, without implementing new functionality or changing user behaviour or business processes (Greenbaum 2009). Organisations embark on a technical upgrade of their ERP system when there is a desire for an enhanced technical infrastructure to further support their operations. As the underlying motive is to update the technical infrastructure, we argue that technical upgrades are guided by a technical motivation. In the organisational learning context, technical upgrades represent a form of exploration. This is because they involve the implementation of key emerging technologies (Ng & Chang, 2009), which organisations may choose to explore.

Enhancement (Cell C): enhancement modifications are characterised by a business motivation and an exploitation organisational learning approach. Enhancements facilitate enhanced business objectives and strategies. We argue that with enhancement modifications, organisations will seek the inclusion of new business functionality within their ERP modification initiatives and will request bolt-on functionalities, new modules, design and implementation of customizations. This view of inclusion as a characteristic of an enhancement type of ERP modification is consistent with suggestions that an enhancive modification should be based on the measure to which it contributes to business objectives such as when accommodating business growth, and improving data use (Nicolaou and Bhattacharya 2006). Enhancement modifications appear not to be technically motivated as the existing technical platform forms the basis for the new functionality. In organisational learning context, enhancement modifications are similar to maintenance modifications, where they exemplify refinements and better use of ERP capability, and are considered to be a form of exploitation learning.

Functional upgrade (Cell D): functional upgrade modifications are characterised by a business motivation and an exploration organisational learning approach. We argue that a functional upgrade is generally undertaken to extend the business process functions of an existing ERP system, and to gain new business functionality on a new technical platform. It is thus more complex than a technical upgrade and involves the adoption of new business processes as well as automation of previously un-automated processes (Greenbaum, 2009). This view is consistent with Fryling (2010) who state that functional upgrades reflect business expansion and strategy change. Thus, we argue that functional upgrades are driven by a business motivation and initiated as part of a line-of-business initiative, thus enriching both the business and IT functions of the ERP system. In organisational learning context, functional upgrade modifications represent new knowledge development, strategies and technologies (Greenbaum, 2009; Nah & Delgado, 2006); characteristics which typify exploration learning.

The second part of the ERP-PIM model is grounded in the resource-based view (RBV) of the firm. RBV is used as the theoretical basis for understanding the impact that ERP post-implementation modifications have on business process optimisation.

3.2 Business Process Optimisation - A Resource-Based View (RBV)

Although some studies have reported the impact of ERP implementations on business processes (Karimi, Somers, & Bhattacherjee, 2007; Uwizeyemungu & Raymond, 2010), post-implementation modifications and their impact on business process optimisation (BPO) have not been investigated in the ERP literature. Business processes are a sequence of activities for the creation of goods and services by the conversion of input to output, and consist of physical and information flows, which can be affected by IT systems (Dutta and Roy 2004). Thus, business process optimisation is as an approach aimed at improving business processes by elevating efficiency and effectiveness of the processes within and across organisations (Hammer & Champy, 1993)

In this paper we adopt a resource based view (RBV) when understanding the impact that ERP modifications have on business process optimisation. This approach permits a process-oriented assessment of the value of modifications where the effect of an organisation's resources on business processes can be measured (Porter and Millar 1985; Wade and Hulland 2004). RBV, championed by Barney (1991), and refined by Mata et al. (1995), suggest that organisations compete with one another based on their resources, where a firm's resources include assets and capabilities utilised in implementing strategies. Assets are defined as anything tangible or intangible that can be used in creating or offering products; while capabilities are explained as repeatable patterns of actions that are used to create and offer products to the market (Amit & Schoemaker, 1993; Wade & Hulland, 2004). In this context, an ERP system is considered to be an organisational resource, and ERP capability is understood as routines within an ERP system, that enables the system to deliver functions and services to organisations (Karimi et al. 2007b).

Seeking the impact of ERP systems on business processes from an RBV perspective, Karimi et al. (2007) found that three capabilities could influence either business process efficiency, effectiveness and/or flexibility. These three capabilities are defined as: i) automational - ERP capability to integrate and derive value by substituting capital asset for labour and reducing cost, leading to process efficiency; ii) informational - ERP capability to collect, store, process and disseminate information, leading to process effectiveness; and iii) transformational - ERP capability to facilitate and support process innovation and transformation, leading to process flexibility (Karimi et al. 2007b; Mooney et al. 1996; Uwizeyemungu and Raymond 2012). In this research, we seek to assess the extent to which these capabilities optimise business processes in terms of efficiency, effectiveness and/or flexibility.

The three measures of business process optimisation (BPO); business process efficiency, business process effectiveness, and business process flexibility are briefly defined in Table 1.

BPO	Definition	Measures
Business Process Efficiency	The conversion of input to output in the shortest time possible with the lowest utilisation of resources (Trischler 1996)	Reduction in operational cost; Reduction in input/output ratio, Reduction in error correction work (Karimi et al. 2007a; Lee et al. 2011)
Business Process effectiveness	The satisfaction of one or more business objectives while meeting or exceeding the recipient stakeholder's needs (Trischler 1996)	Better and timely access to corporate data; Higher levels of enterprise-wide data integration (Karimi et al., 2007a)
Business Process Flexibility	The ability to adjust quickly and easily to changes in internal constraints or stakeholder requirements (Trischler 1996)	New ways to customise processes (Karimi et al. 2007a; Lee et al. 2011)

Table 1: Definitions and measures of business process optimisation (Trischler 1996)

Due to the diversity of various modifications, it is expected that not all modification initiatives are likely to impact on business processes. However to correctly establish the influence that various modifications have on ERP capability, and their flow on effect to business process optimisation, a set of three propositions have been developed.

3.2.1 Propositions influencing business process optimisation

The ERP-PIM model, shown in Figure 2, demonstrates the link between the modifications, via ERP capability, through to the propositions and their influence on business processes.

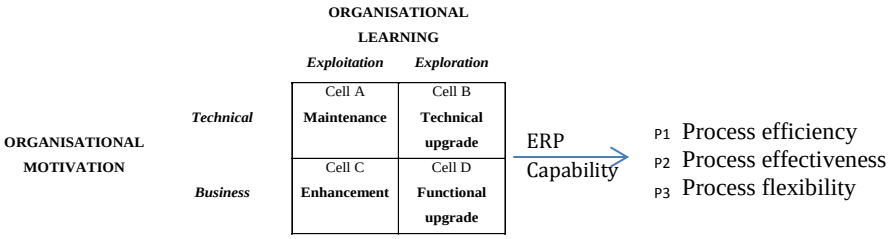

Figure 2 ERP-PIM model: linking ERP modifications with business process optimisation

The three sets of propositions are identified: Proposition 1 explains business process efficiency, Proposition 2 explains process effectiveness and Proposition 3 explains process flexibility.

Proposition 1: Business process efficiency

Most organisations wish to attain business process efficiency when they implement an ERP system (Gunasekaran and McGaughey 2007; Nicolaou and Bhattacharya 2008). Thus, after implementing an ERP system, organisations continue to undertake modifications that are designed to increase automational and integrative ERP capability (Harris and Davenport 2006; Karimi et al. 2007b).

We argue that technically motivated modifications may only correct and update the ERP system, but are unlikely to have any impact on automational and integrative efficiency-related ERP capability (Nah, Faja, & Cata, 2001). This is because technically motivated modifications do not include new or improved functions that increase efficiency-related capability. Additionally, technically motivated modifications, though able to ensure a stable well performing system and even present a new technical platform and new user interfaces, are not directed at improved integration of business. Thus, they are unlikely to improve business process efficiency. This argument supports Proposition 1a.

Proposition 1a: *Maintenance and Technical Upgrade modifications (Cells A & B) have no impact on process efficiency.*

Business motivated modifications, which are accompanied by new business functions and capabilities, may initiate changes that improve automational and integrative ERP capability. We argue that only modifications that include new business functionality may provide capabilities for more cost-effective business operations (Ng 2006). However, it may be the case that not all business motivated modifications will likely to improve such cut costing and efficiency related capabilities. This argument supports Proposition 1b and 1c.

Proposition 1b: *Enhancement and Functional Upgrade modifications (Cells C and D) that increase automational ERP capability improve process efficiency.*
Proposition 1c: *Enhancement and Functional Upgrade modifications (Cells C and D) that do not increase automational ERP capability do not improve process efficiency.*

Proposition 2: Business process effectiveness

Operational effectiveness from ERP systems goes beyond cost and time savings; it includes increased resource utilisation, improved decision making, reduced waste, increased responsiveness, and improved product or service quality (Beheshti and Beheshti 2010; Karimi et al. 2007b). As such, it appears that only modifications that present advances in information and communication technologies and/or business processes are likely to increase informational effects required to attain business process effectiveness.

Harris and Davenport (2006) suggest that organisations can commit resources to tailoring the ERP system to optimise business processes and achieve effectiveness. However, unlike the explorative technically motivated modifications (technical upgrade), which at the least provide new user interfaces, the exploitative technically motivated modifications (maintenance) do not deliver new features or new technology capabilities, and are unlikely to improve informational ERP capability. For instance, though maintenance modifications may eradicate bugs, they are incapable of delivering technologies/functionalities that enhance ERP-based process effectiveness. Hence we propose:

Proposition 2a: *Maintenance modifications (Cell A) have no impact on process effectiveness*

Unlike maintenance modifications, technical upgrades are expected to impact business process effectiveness. This is because new user interface, better reporting structures and add-on products supported by new versions are able to facilitate increased use of information (Kremers and Dissel 2000; Ng 2006), thereby improving informational ERP capability. As such, technical upgrades are not only focused on the internal functioning of the ERP system within organisation to deliver process efficiency, but also on the ability of the firm to process and disseminate information. Likewise, business motivated modifications, which are undertaken in response to business needs and aimed at attaining a greater fit between the organisation and the ERP system, have the potential to deliver capabilities that enhance ERP capability for resource utilisation and increased responsiveness (Karimi et al. 2007b). With faster and more efficient technology platform delivered by technical upgrades, and additional functions for improved business processes delivered by enhancements and functional upgrades, an organisation may gain not only automational ERP benefits for process efficiency, but also informational benefits for process effectiveness. However, it may be the case that not all technical upgrade and business motivated modifications will likely to improve such information capabilities. Therefore, we propose:

Proposition 2b: *Technical Upgrade, Enhancement, and Functional Upgrade modifications (Cells B, C and D) that increase informational ERP capability improve process effectiveness*
Proposition 2c: *Technical Upgrade, Enhancement, and Functional Upgrade modifications (Cells B, C and D) that do not increase informational ERP capability do not improve process effectiveness*

Proposition 3: Business process flexibility

For an ERP system to be a source of competitive advantage, it must deliver much more than operational efficiency and operational effectiveness; it must also be designed innovatively, be unique and allow differentiation from competitors (Beard and Sumner 2004; Seddon 2005). The capability of

an ERP system to facilitate innovation and differentiation is described as ERP's transformative effect (Karimi et al. 2007a; Karimi et al. 2007b; Uwizeyemungu and Raymond 2012). Following Beard and Sumner (2004), we argue that an ERP system is a source of competitive advantage only if it is valuable, rare, inimitable and non-substitutable. Beard and Sumner (2004), and Ng and Chang (2009) discuss how that rarity can only come from the implementation of upgrades in a faster and more economical fashion than competitors. Inimitability, Kalling (2003) argues, proceeds from efforts to iteratively develop the system as it is used to ensure that it always meets operational needs. As the system becomes better aligned with operational needs, it is likely that the system will become unique and increasingly difficult to imitate (Ragowsky and Gefen 2008).

We argue that technically motivated modifications, which are concerned with correcting, adapting, updating and enhancing the technology platform of the ERP system, may have no direct effect on transformational ERP capability. Likewise, enhancement modifications, which provide new business functions for old technology platforms, may not permit innovation and differentiation because they are fundamentally the original technology with some new operational features, but are unlikely to deliver any substantial improvement in transformative capability.

Proposition 3a:	*Maintenance, Technical Upgrade, and Enhancement modifications (Cells A, B, and C) have no impact on process flexibility.*

We argue that functional upgrades are able to improve business process flexibility. This is because it presents both new technology and new business functions, and permits improved utilisation of data for product/service innovation and differentiation, as well as improved transformational capability for better customer and supplier relationships (Khoo, Robey, & Rao, 2011; Ng & Chang, 2009). However, it is not expected that all explorative business motivated modifications will improve transformational capability. Hence we propose

Proposition 3b:	*Functional Upgrade modifications (Cell D) that increase transformational ERP capability improve process flexibility.*
Proposition 3c:	*Functional Upgrade modifications (Cell D) that do not increase transformational ERP capability do not improve process flexibility.*

The approach used to empirically evaluate the three sets of propositions discussed above is now discussed in the following sections.

4 RESEARCH METHOD

4.1 Justification of Research Approach

With no existing framework to explain the association between ERP modifications and business process optimisation, our study represents a theory-building endeavour; conducted from a critical realist ontological perspective. The study attends to how and why ERP post-implementation modifications influence business process optimisation, and can be described as an information systems (IS) evaluation research (Carlsson, 2009). A realist IS evaluation research seeks to explain rather than predict and aims to develop and test theories grounded in practice (Carlsson, 2003; Dobson, Myles, & Jackson, 2007). As an essential step in critical realism studies, our research focuses on potential causal mechanisms which could generate events, rather than descriptions of empirical events themselves.

4.2 Operationalizing Critical Realism

A key aspect of critical realism is the use of a retroductive research strategy (Mingers, Mutch, & Willcocks, 2013). Retroduction is described as a process of building hypothetical models of structures and mechanisms that are assumed to produce empirical phenomena (Bhaskar, 1998). With retroduction, in order to explain observable phenomena and the regularities that obtain between them, researchers must attempt to discover appropriate mechanisms and the contexts in which they operate

(Blaikie, 2009). As such, our retroductive argument begins with an accepted phenomenon (business process optimisation: efficiency, effectiveness and flexibility), and is followed by questions of mechanisms that facilitate optimisation from ERP post-implementation modifications. From our analysis of the literature, we find ERP capability to be our generative mechanism for business process efficiency, effectiveness and flexibility. Our goal is to understand why ERP post-implementation modifications work, through an understanding of action mechanisms and the study of contextual conditioning. As such, we have conceptualised (ERP-PIM model) an initial context- IS initiative-mechanism-outcome pattern configuration, in form of propositions stating the conditions under which ERP post-implementation would deliver business process efficiency, effectiveness and flexibility. Hence, we do not just inspect outcomes, rather we analyse them to discover if the proposed mechanism/context theories are confirmed (Carlsson, 2012). Through this process, we create a "middle range" theory that provides an analytical framework to interpret similarities and differences between types of ERP post-implementation initiatives. Thus we define the context of our study as organisational motivation and learning; mechanism, as ERP capability enabled by post-implementation modifications; and outcomes as business process efficiency effectiveness and flexibility.

4.3 Data Collection and Analysis Approach

While the critical realist study can be conducted using a mix of quantitative and qualitative data, we have adopted a case study approach because it is ideal for capturing context (Carlsson, 2009). Context is particularly important for this study as we argue that post-implementation modifications to ERP systems take different forms and are undertaken within various organisational motivation and organisational learning contexts. A case study approach also suits our goal to explore in 'what' ways ERP post-implementation modifications can be classified, and 'how' these modifications influence business process performance; Yin (2009) suggests that such questions are better addressed using qualitative methods. A single case approach was chosen here to enable us capture several instances of post-implementation modifications and capture similarities and differences these instances within the dynamic context of a single organisation. Each instance is considered as an appropriate unit of analysis for our model. Data was collected from multiple sources including face-to-face conversations, telephone interviews, e-mail communications, and company documents. In-depth interviews were undertaken with two key informants: a senior IT executive, and a business development executive, both with over 30 years of experience within the organisation. A coding scheme was developed based on the interview questions that focused on capturing the features of organisational motivation, organisational learning, and business process efficiency, effectiveness and flexibility. Propositions were evaluated using pattern matching (Yin, 2009), and enabled us to compare the capabilities predicted in our model with those identified from the case study data. The interviewees granted access to relevant company documents; this facilitated the corroboration of information provided during interviews.

5 CASE STUDY BACKGROUND: COIL

COIL is a large Australian energy company. Its business value chain incorporates supply, refining, distribution and marketing. With almost 3,500 employees working across Australia COIL generated annual revenue of about AUS $18 billion in 2012. COIL's first implementation of an ERP system was undertaken in 1991. In 1996, SAP R/3 release 3.0D was implemented and this was followed by an upgrade to 4.6C, on which product costing was implemented. In 2008, an upgrade to 4.7 was undertaken. Also in 2008, COIL upgraded their system to SAP ECC6, and this was followed by the installation of enhancement pack 4. For the purpose of this research, the migration by COIL to SAP ECC6 is not considered to be a post-implementation modification. Rather, in line with our definition of post-implementation modifications (Section 1), it is considered to be a new ERP software implementation; while the modifications to the ERP system after COIL migrated to ECC6 are within the scope of this research.

In this paper, four instances of post-implementation modifications at COIL are discussed: instance 1, upgrade from R/3 3.0D to R/3 3.1H; instance 2, upgrade to SAP R/3 4.7 from SAP R/3 4.6; instance 3, implementation of product costing; and instance 4, installation of enhancement pack 4 within SAP ECC6. The instances are presented in the following two steps: first, in order to assess the applicability of our typology, each instance is analysed from the organisational motivation and organisational learning perspective; second, the association between instances, their influence on ERP capability and subsequent influence on business process efficiency, effectiveness and flexibility are presented and the propositions explored. Due to page limitation, only brief summaries of the instances are provided. To further elaborate on our analysis, a table showing how a single instance (instance 3- product costing) was analysed has been included as Appendix A.

5.1 Classifying ERP Post-implementation Initiatives

Instance 1: upgrade to SAP R/3 3.1H

COIL upgraded their R/3 3.0D ERP system to R/3 3.1H in 1998 mainly to keep updated and remain within their maintenance contract with SAP. The following statement by the IT executive reflected this: "*For us, we undertook patching ass a periodic exercise to apply cumulative fixes to our system…Our reason for moving from 3.0D to 3.1H was to prevent being out of support"*. On the other hand, the business executive viewed the upgrade as a means of exploiting the system as stated: *"We quite need to update the system to be able to keep on exploiting the system"*.

Thus, it can be observed that the upgrade 3.1H was undertaken to keep the ERP system in supportable version as recommended by SAP. In addition, the characteristics of the 3.1H upgrade point away from exploration to exploitation as it focused on a continuing use of the system by keeping it updated without a search for new functionalities or capabilities. The upgrade to SAP R/3 3.1H at COIL is therefore classified as an instance of 'maintenance', driven by a technical motivation and undertaken with an exploitation organisational learning approach.

Instance 2: upgrade to SAP R/3 4.7

The key motivation for upgrading from SAP R/3 4.6C to SAP R/3 4.7 was the desire for a new technical infrastructure to facilitate an upgrade to ECC6. This was done because COIL was unable to apply patches and hot-packs to 4.6C due to a problem with the oil-industry specific software product that had been implemented on top of R/3 4.6C. The IT executive and business executive both stated: *"We had to first of all catch up, so we had to bring in all these upgrades, and then we were in a position to look into ECC6.* The IT executive also confirmed: *"We did a double hop with the ECC6 upgrade. An initial upgrade to 4.7 was required, not for any new functionality, but for a new technical platform… we had to apply patches to update our system to the latest and newer level 4.7 to enable the upgrade to ECC6"*.

Therefore the R/3 4.7 upgrade reflects a search for a new and updated technical infrastructure, but no search for new capability or functionality as it was undertaken mainly to obtain a new technical level, with no considerations for additional business functionality. This, though not reflecting a search for new functionality, reflects a search for a new technical capability in form of an updated technical platform capable of supporting the ECC6 upgrade. This particular modification is considered an example of 'Technical upgrade' and depicts a technically motivated exploration organisational learning approach as depicted in Cell B in the typology.

Instance 3: product costing implementation

The motivation for implementing product costing at COIL was primarily to automate their product costing process. The business executive stated: *"6 years ago, we put in product costing... the main purpose was to automate product costing from doing product costing on spreadsheets*". This statement implies a business motivation. There appeared to be no exploration of functionality that resulted in changes to existing processes; however there was a desire to replicate already existing process, typical of exploitation. The IT executive stated: *"We worked with the business to utilise*

absolutely standard SAP functionality for product costing process. Because we haven't fully exploited the system and the functionality present in the system....when we're coming to do implementation, we've looked at achieving what was there previously". The product costing implementation at COIL is classified as an 'enhancement' and is business motivated with exploitation organisational learning approach as depicted in Cell C in the typology.

Instance 4: enhancement pack 4 (EHP4)
A year after the ECC6 implementation, COIL implemented EHP4 to extend the functionality for business operations. The business executive stated: *"the drive for EHP 4 was its usability ...first we teamed up with SAP development and that gave us the ability to review what the functionality was in the enhancement packs to determine whether we wanted to implement it or not…looking at what those enhancement packs have to offer is not easily determined…some of that functionality is very hard to access".* Because the installation of EHP4 involved a review of functionality to further support business operations, the installation was classified as a 'functional upgrade' and is business motivated with an exploration organisational learning approach as depicted in Cell D in the typology.

The four instances of ERP post-implementation modification initiatives, discussed above, are classified into either Cell A, B, C or D. This is depicted in Figure 3.

		ORGANISATIONAL LEARNING	
		Exploitation	***Exploration***
ORGANISATIONAL MOTIVATION	***Technical***	Cell A **Maintenance** *Instance 1: Upgrade to R/3 v3.1H*	Cell B **Technical upgrade** *Instance 2: Upgrade to R/3 v4.7*
	Business	Cell C **Enhancement** *Instance 3:Product costing*	Cell D **Functional upgrade** *Instance 4: Enhancement pack 4*

Figure 3: Classifying instances of post-implementation modifications at COIL

As shown in Figure 3, all four instances could be linked to the typology: Instance 1 a maintenance activity; instance 2 a technical upgrade; instance 3 an enhancement and instance 4 a functional upgrade. In the following section, each modification instance is analysed in terms of each set of propositions.

5.2 Analyses of Propositions

Instance 1: upgrade from SAP R/3 3.0D to SAP R/3 3.1H
The upgrade to 3.1H at COIL is classified as an instance of 'maintenance'. With an aim only to update the existing system, this upgrade did not impact on business processes in terms of efficiency, effectiveness or flexibility. This is consistent with our argument that *maintenance* post-implementation modifications deliver no new functionality or technical infrastructure, and are therefore incapable of delivering or improving the ERP system's capability. As maintenance post-implementation modifications do not improve any ERP capability, organisations are unlikely to gain business process efficiency, effectiveness or flexibility from such modifications. Our finding confirms that the maintenance post-implementation modification had no impact on ERP-based process optimisation supporting propositions 1a, 2a, and 3a.

Instance 2: upgrade from SAP R/3 4.6C to SAP R/3 4.7
The upgrade to 4.7 at COIL is classified as an instance of 'technical upgrade'. The sole purpose for the upgrade to 4.7 from 4.6C was to gain a new platform so that the upgrade to SAP ECC6 could be made offering the newer architecture. Although the 4.7 upgrade provided a new technical infrastructure, it did not impact business processes and as such did not increase ERP capability to further automate business processes. This is consistent with our argument in proposition 1c where *technical upgrade* post-implementation modifications that deliver no automational ERP capability are

reasoned to be incapable of improving business process efficiency. In other words, *technical upgrade* post-implementation modifications are only expected to improve automational ERP capability, and as such organisations are only likely to gain business process efficiency, and not effectiveness or flexibility from such modifications. Our finding also confirms that the technical upgrade post-implementation modification had no impact on ERP-based process effectiveness and flexibility supporting propositions 2a, and 3a.

Instance 3: implementation of product costing into R/3 4.7

The implementation of product costing at COIL has been classified as an instance of 'enhancement'. The business executive suggested that better valuation of inventory was a key value gained: *"Since product costing implementation, we can interrogate the system to know what exactly our inventory position is at a point in time… from a dollars perspective, that was something we had no opportunity to do prior to that...it has cut down the month end manual calculations, so the big spike of the work at the end of the month has gone away and ongoing work throughout the month has also gone away"*. In a similar assertion, the IT executive commented: *"the outstanding benefit as of right now is to know what our inventory valuation is… it cuts down manual rework and people having to do stuff outside the system…now we're able to track inventory anytime, as it goes through in real-time…it has cut down part of the process, just by doing this in real-time".*

Both business and IT executive reveal how business process efficiency was improved as a result of the product costing implementation; time spent doing manual reworks were eliminated as several parts of the process were reduced. Business process efficiency appears to have proceeded from an increased automational ERP capability; as opposed to the previously manual inventory valuation process, COIL had automated their product costing process to increase its efficiency. In addition, informational ERP capability was also increased; better supply and availability of information, enhancing timely decision making. By being able to track inventory at any time as a result of an increased availability of information, COIL gained improved business process effectiveness. Both efficiency and effectiveness gained from the product costing implementation provide partial support for our propositions.

Propositions 1b and 2b, which suggests that enhancement post-implementation modifications that improve automational and informational ERP capability will improve business process efficiency and effectiveness were supported at COIL; the product costing implementation both increased automational and informational ERP capability. As such, product costing improved business process efficiency and business process effectiveness. Findings were also consistent with proposition 3a; product costing did not impact transformational ERP capability, and as such had no impact on business process flexibility.

Instance 4: installation of EHP4 into ECC6

EHP4 has been classified as an instance of 'functional upgrade'. Propositions 1c, 2c and 3c suggest that modifications that do not increase automational, informational and transformational ERP capability are incapable of improving business process efficiency, effectiveness and flexibility. In the case of EHP4, no ERP capability had been activated as a result of the installation. This is because EHP4 modification was undertaken with no business process considerations in mind. The IT executive stated: "*we have only installed EHP4…to date, we have not implemented any technical usages, we are looking at a few functionalities at the moment, but we haven't implemented anything". This statement confirms that* COIL did not activate any of the new functions that came with 4.7 that would improve their business processes. In fact the business executive confirmed: "*Now there is a pushback amongst the business regarding the benefits of the ERP system…because there is a lot of additional functionalities around…but we haven't exactly enhanced the system to get the additional functionalities"*. EHP 4 installation provides support for propositions 1c, 2c, and 3c as it did not increase any ERP capability, and was incapable of improving business process optimisation.

5.3 Observations

We make the following observations: First, Propositions P1a, P1b, and P1c, predicting business process efficiency, were supported for Cells A, B, C and D. No business process efficiency was predicted for Cell A; this was observed for Cell A. Only modifications which improved automational ERP capability were predicted to deliver business process efficiency; this was observed for Cells B, C and D. Instance 3 enhanced automational ERP capability and improved business process efficiency; Instance 4 did not improve automational ERP capability, and did not improve efficiency. Second, Propositions P2a, P2b, and P2c, which predict business process effectiveness was supported for Cells A, C and D. No business process effectiveness was predicted for Cells A and B; this was observed. For Cell C and D, only modifications which improved informational ERP capability were predicted to deliver business process effectiveness; this was also observed for both instance 3 and 4. Third, Propositions P3a, P3b, and P3c, which predict business process flexibility was fully supported for Cells A, B, C and D. No business process flexibility was predicted for Cells A, B and C; this too was observed for instances 2, 3 and 4. For Cell D, only modifications that improved transformational ERP capability were predicted to deliver business process flexibility. This was observed for instance 4 which did not increase transformational ERP capability and in turn did not have any impact of flexibility.

Drawing on this evidence, we suggest that there exists a broad support for the applicability of the ERP-PIM model.

6 CONCLUSION

In this paper, we have reported an initial evaluation of a theory-driven model that links ERP post-implementation modifications with business process optimisation; efficiency, effectiveness and flexibility via ERP capability. Results from our single case study in a large Australian energy company therefore provide some support for the model. This initial validation of the ERP-PIM model contributes to theory and practice by enriching the ERP literature and extending the applicability of specific organisation theories (organisational motivation and organisational learning) to the ERP post-implementation context. Improved understanding facilitated by the model creates a foundation for theory development in future ERP post-implementation research. Our study also presents a methodological contribution to ERP research; we have provided insights into the application of critical realism ontology and methodology for assessing ERP post-implementation modifications. Our use of critical realism particularly highlights ERP capability as the generative mechanism for business process optimisation from ERP post-implementation modifications. The practical contribution of the evaluated model to organisations is a method for classifying ERP post-implementation modifications. In addition, we anticipate that the model will provide better understanding of how business process efficiency, effectiveness and flexibility may be achieved from a post-implementation modification initiative. For instance, knowledge that business process optimisation is dependent on three specific ERP capabilities enhanced by post-implementation modifications. Particularly for senior managers, the model could serve as a tool for guiding post-implementation modification initiatives to enhance ERP capability. As an ERP system embodies organisations' business processes, increasing ERP capability enhances business process optimisation, an important area for achieving competitive advantage.

In deriving the ERP-PIM model and conceptualising the typology categories, we did not make any explicit assumptions about unique characteristics associated with a particular industry segment or organisation size. In other words, the derivation process of the model was influenced by neither industry characteristics nor organisation size. Therefore the model, at a conceptual level, should be applicable to any kind of organisation.

The ERP-PIM model and associated propositions are currently being validated through a multiple case study approach to further reflect post-implementation experiences. With such a study, comparisons can be made amongst organisations and propositions can be further investigated.

Appendix A: An example of how data was analysed for each instance of post-implementation modification

Constructs	Sub-construct	Indicators	Evidence (Instance3-product costing)
Organisational Motivation	Technical Motivation	Bugs, Keeping updated, Correction, Ongoing system support, Replace disparate systems, Better architecture, Integrate applications cross-functionally	-
	Business Motivation	New functionality Business improvement	*"6 years ago, we put in product costing...from doing product costing on spreadsheet, the main purpose was to automate product costing"*
Organisational Learning	Exploitation Learning	Decreased variation in processes; Elaborating on existing ideas, technologies, strategies and knowledge; Clearly-defined, short term objectives and immediate targets; Risk-aversion	*"Because we haven't fully exploited the system and the functionality present in the system....with implementation, we've looked at achieving what was there previously"*
	Exploration Learning	Increased variation in processes; Extensive search/ Innovation, experimenting with new ideas, technologies, strategies and knowledge; High risk;	
Business process optimisation	Efficiency	Reduction in operational cost ; Reduction in input/output ratio Reduction in error correction work	*"it cuts down the manual rework of people having to do stuff outside the system"*
	Effectiveness	Better and timely access to corporate data; Higher levels of enterprise-wide data integration; Increased throughput	*"we can now interrogate the system to know what exactly our inventory position is at a point in time. From a dollars perspective, we had no opportunity to do that before"*
	Flexibility	Process/product/service innovation and differentiation; New ways to customise processes, process agility	-

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