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ICT in Business

Improving the effectiveness of ERP systems in organizations through the practical integration of business process models

An in-depth case study at a 3PL.

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Content

1 Background

In this study we look at a medium-sized (300 employee's) 3PL in the Netherlands who has recently made the transition to an organisation wide ERP-system. The implementation has been a struggle as the organisation hast to adapt to the limitations on flexibility the system offers. Although the organization recognized the potential of the implementation of an organization wide ERP-system, so far it has not been able to reach this potential. This research will use a process-based view to look at the current state of the ERP integration that provides new insights on the performance of the ERP-system and the overall organization.

At the start of the transition, the 3PL bought a software package that provides an ERP- package tailored for logistics companies. The organization started the transition to the ERP-system in January 2011. The logistics industry is considered to be a very competitive environment in which customers hold great bargaining power and decision times are crucial. To be able to completely tailor to the needs of their customers, the company adapted and fitted ERP-software to deliver the required speed and flexibility their customers demanded. As a result of the high competition and bargaining power of the customer base, profit margins are minimal and pressure for a quick improvement is very high.

Within the next two years problems occurred during the implementation of the ERP-system. The software supplier of the ERP system was not able to adopt the software to new patches since the version of the software used by the logistics company had grown apart from the standard software provided by the supplier. While the software provider is helping the implementation, improvements would only be made if it aided multiple customers of the ERP-vendor instead of just the 3PL.

The logistics company decided to switch strategies as the management felt the required progress with the ERP was too slow. Instead of adapting the software package to the desired needs of the customer it would rather use the standard version of the software. Using the standard version of the ERP system would ensure the patches to the software would be easily applicable. However the standardisation of the ERP system would also require a change in the internal workflow processes of the organization.

One critical asset the ERP system missed are analysing or reporting tools to measure the performance of the organisation except financial measures. No documentation exists on the business processes after the implementation of the ERP system. Together with the software supplier every 3 months a new release is used to fix bugs and issues that have occurred at the 3PL company. A close relationship with the supplier ensures that problems the 3PL supplier has with the software are quickly communicated and addressed through a bucket list and a new version of the software every 2-3 months. Cooperation between the two parties determines the priorities of the various fixes.

The main struggle for the organization still is to ensure customer wishes on special price agreements and flexibility are maintained while standardizing internal processes. This standardization process also includes merging certain business units now handled separate at the different locations. There is a clear desire and need for centralization of different departments like planning, resource management and IT.

After 2 years of adaptation, modification and a certain degree of standardisation management at the 3PL concludes that the ERP system is working, but is not improving operational performance. Efficiency increase is realized at the finance department but has decreased in the overall operations of the 3PL. This paper will examine, construct and explain how a practical integration of business rules in process models is used to ensure the ERP system is able to deliver on its promise. This research tells the story of a practical approach to overcome an inherent problem SME's face when implementing an ERP system.

2 Literature Review

2.1.1 The promise of the ERP System

ERP systems generally offer a promise to an organisation. Both in theory as in practice the general notion of operational efficiency accompanies ERP systems and drives organizations to adopt an ERP system. A number of studies exist that elaborate on the impact of ERP systems on organizations. Most of these studies are focused on larger organisations as the adoption of ERP systems in this market is close to saturation (Uwizeyemungu, 2012). The research on ERP systems and their role in SME organizations is fairly limited (Haddara, 2011) and lacks practical examples.

A reason for the limitation on research is that the positive impact of an ERP system in small organizations is much less visible, due to the often less clear relationships and causal links at the micro-economic level. (Quiescenti, 2006) This makes it harder for case studies to show profounding effects of ERP implementations on organizational performance of SME's. The barrier for adoption of ERP systems by SME organizations is no longer acquiring the ERP system, but the adoption of the system to fit the business processes. In small organizations, the costs for adoption are generally high as specific business processes are often part of the core strengths of SME organizations. (Muscatello, 2003) Adoption costs are not easily linked to a certain department as they are often a result of the customization of a specific business process and the support he ERP system offers this particular business process.

ERP systems can be defined and described through different definitions. A key feature of an ERP systems is that it provides a single database system that supports core activities as manufacturing, human resources and finance. (Su, 2010) The definition for ERP systems used in this research paper is given by Wallace and Kremzar (Wallace, 2001):

''An enterprise-wide set of management tools that balances demand and supply, containing the ability to link customers and suppliers into a complete supply chain, employing proven business processes for decision making, and providing high degrees of cross-functional integration among sales, marketing, manufacturing, operations, logistics, purchasing, finance, new product development, and human resources, thereby enabling people to run their business with high levels of customer service and productivity, and simultaneously lower costs and inventories; and providing the foundation for effective ecommerce."

The promise of any ERP system is to improve organizational performance.

Any ERP system will try to uphold this promise of improving performance by providing an entire business with a suite of software modules covering all activities of the business. The primary role of an ERP system is to support business activities. It attempts to integrate all departments and functions across a company onto a single computer system that can serve all those different departments' particular needs. (Klaus, 2000) An ERP system is able to provide quick decision-making opportunities based on current data throughout the organisation and improves communication with customers. (Hitt, 2002)

Figure 1 shows a number of technical and business reasons summed by Markus and Tanis for adopting an ERP system. (Markus, 2000). The table provides adoption reasons form a technical and a business perspective for small companies and large companies.

Figure 1 Reasons for Adopting Enterprise Systems

TABLE 10.1 Reasons for Adopting Enterprise Systems

	Small Companies/ Simple Structures	Large Companies/ Complex Structures
Technical reasons	• Solve Y2K and similar problems • Integrate applications cross-functionally • Replace hard-to-maintain interfaces • Reduce software maintenance burden through outsourcing • Eliminate redundant data entry and concomitant errors and difficulty analyzing data • Improve IT architecture • Ease technology capacity constraints • Decrease computer operating costs	Most small/simple company reasons plus • Consolidate multiple different systems of the same type (e.g., general ledger packages)
Business reasons	• Accommodate business growth • Acquire multilanguage and multicurrency IT support • Improve informal and/or inefficient business processes • Clean up data and records through standardization • Reduce business operating and administrative expenses • Reduce inventory carrying costs and stockouts • Eliminate delays and errors in filling customers' orders for merged businesses	Most small/simple company reasons plus • Provide integrated IT support • Standardize different numbering, naming, and coding schemes • Standardize procedures across different locations • Present a single face to the customer • Acquire worldwide "available to promise" capability • Streamline financial consolidations • Improve companywide decision support

The promise of organizational performance is mostly embedded in the business reasons for adoption. Critically in improving organizational performance is the functionality of an ERP system to improve informal and ineffective business processes. However as such systems are usually off-the-shelf software packages, their implementation involves a process of customizing the generic package and aligning it with the specific needs of the enterprise. (Ehie, 2005) These specific needs are not always well documented in organisations, especially in SME's. Organizations in practice struggle to effectively capture business processes and rules that define these business needs. As a result ERP implementation costs are generally high for SME's and ERP systems often fail to reach their potential.

2.1.2 Implementation approach and performance of an ERP system

Adoption of ERP systems can be classified through three different implementation approaches. Organizations generally will adhere to one of the following implementation approaches for their ERP project: The comprehensive approach is an implementation on a large scale and involves the implementation of the full functionality of the ERP system. Middle-road implementations generally imply that a selection of core ERP modules is implemented. The Vanilla implementation approach only implements core ERP functionality on a small scale. (Parr, 2000)

Five characteristics are defined that describe the implementation of the ERP system. These characteristics include the physical scope, the Business Process Reengineering (BPR) scope, the technical scope, the module implementation strategy and resource allocation Interesting to note is that the BPR scope is considered to be one of the five characteristics of an ERP implementation. The inclusion of the BPR scope as one of the five major characteristics of an ERP implementation illustrates the effect ERP systems will have on the internal business processes of an organisation. The scope to which the organisation changes internal business processes should therefore be related to the type of implementation of the ERP system. A vanilla approach is often chosen to minimise the impact of the ERP system on business processes and thereby reduce the necessity to make changes in processes. (Parr, 2000)

When analyzing and identifying business processes and business rules during an ERP implementation it is crucial to adhere to the made agreements on the implementation approach. The larger the impact of the ERP implementation, it becomes more crucial to ensure that the current and future business processes and rules fit the chosen ERP implementation. When measuring improvements in organizational performance it is reasonable to expect improvement sooner in small scale ERP implementations. On the other hand it is also logical to assume that organizational efficiency benefits are larger for full-scale implementations, although this may take longer to show.

2.2 Proposed methodology from a business process perspective

2.2.1 Business rules to define business logic

As stated before specific processes are often part of the core strength of SME's. (Muscatello, 2003) This finding underlines the importance of specific process understanding within an SME and an ERP system. As a result adoption costs of ERP systems at SME's are generally much higher than buying the software. The specific business processes require room to customize the ERP system to be able to cope with the specific business processes of a small SME. It is harder to reach a high efficiency through the usage of an ERP system if an organization does not possess standardized business processes. The case study in this paper demonstrates that the need for business process understanding inside the organization is a necessity to obtain performance improvement.

A business rule is "a statement that defines or constrains some aspect of the business". (Gottesdiener, 1997) It makes business structure or policies explicit. Business rules are a good fit for areas where it is preferred to have individual services for customers(customer-specific) or have many inter-related decisions. (Bajec, 2000.) Specific business processes possess business logic.

In general we can state that a task in a business process is specific when the business object on which the task applies is explicitly described. A business rule consists of logic applicable on certain business objects. Therefore we can state that the specification of a task in a business process model defines the place a business rule can be triggered.

Business rules exist in every organization, but are often not explicitly stated or documented in the organizations business process description. In this case business rules are implicitly available either as human expertise or hidden in software code.

The accessible business rule framework generally adopts the same definition of a business rule as stated above but extends it by distinguishing between constraint, invariant, derivation and

classification. This research acknowledges that making business rules explicit allows organizations to understand the rules it is currently operating under. Externalizing the rules removes them from people's heads and out of application code and puts them on the table. This provides insight into the behaviour of employees as well as applications. (Rouvellou, 2000.)

A further distinction on different types of business rules can also be made on the perspective from which the rule is viewed. Operational rules are seen as expressions of business rules from a business process perspective. A rule can either be **descriptive**, in which case it is a validation of a current organisations informational entity or **prescriptive**, the business rule prescribes action during the occurrence of some business event. (Kardasis, 2004) Using nested business rules any combination of the above mentioned rule types can be combined. To perform a certain task a validation of a business object and an event both need to take place. Logical operators can be used to allow nesting of business rules.

ERP systems have always struggled to cope with specific business processes as an ERP system is generally developed as a standardizing solution. Software developers build ERP systems as a tool for generating operational efficiency through standardization. The high costs of adoption are a result of this unbalance between the ERP software developed with standard processes in mind while being used to support very specific business processes in SME's. Capturing and understanding the reasons that make the business processes specific could potentially reduce the high costs that occur during the adoption phase of an ERP implementation.

2.2.2 Abstraction of the business through business process models

Business process modelling is an approach for visually depicting the ways an organization conducts its business. It defines the operations of the organization through entities, activities and enablers and their relationships. (Curtis, 1992) By modelling the business processes of an organization it gains insight and understanding in the ways a company conducts business. Furthermore it becomes easier to see the impact of changes in business processes on the entire model.

The importance of business processes has been mentioned in research literature since 1960. During the last decade we have seen the literature of business processes increase and numerous methodologies and tools have been proposed to model business processes. (Aguilar-Saven, 2004) Business processes provide a useful framework to describe how work is accomplished in an organization. Analysing, understanding and improving business processes promises improvement in the general performance of an organization. (Melão, 2001)

Existing research on BPM often is conducted from an information systems perspective. The main purpose of the research from Information Systems literature is to model business processes to be able to support them using information systems. (Melão, 2001) The aim of this research will be the other way around. We will use a business process perspective to look at functionalities the ERP system needs to integrate to model the way the organization conducts its business. The framework proposed in this research will separate the business process logic functionality embedded in ERP systems.

Business process models tend to be very useful to measure effects of changes on an entire system. BPM models provide descriptions that look at overall efficiency, effectiveness and throughput-time as a result of internal changes made. This characteristic is the premise for the field of business process management in which business process modelling is essential. Business process

management is defined as: *Supporting business processes using methods, techniques, and software to design, enact, control, and analyze operational processes involving humans, organizations, applications, documents and other sources of information.* (Van der Aalst, 2003)

In order to analyse and understand systems, a model is constructed according to a particular viewpoint and using a particular modelling technique. The purpose or goal of the model constructed should always lead the choice of viewpoint and technique used to model the business process. (Aguilar-Saven, 2004) When modelling the performance of the organization and the supporting ERP system a business process perspective is used to measure effectiveness and efficiency of the organization.

Phalp states that the choice of process modelling tools, notation and method need to be considered. Both method and notation depend on the desired characteristics of the model. (Phalp, 1998) In this research the most important characteristic the business process model language needs to have is the ability to define and incorporate business rules in the business process model. Furthermore it is important that the notation is widely developed, used and described in the literature.

2.2.3 Full understanding through integration

Business Rules describe business operations in a declarative fashion, while business processes use a procedural form. Studies have shown that both techniques share complementary aspects that allow for the linkage of both techniques. (Zur Muehlen M. M., 2008) Most important is that both techniques share the same purpose: Improving the effectivity and efficiency of daily operations by making business operations analysable and understandable. However organizations in practice struggle to effectively capture business processes and rules. While sharing the same objectives both techniques provide different and unique paths for reaching this objective. Business rules focus on improving effective usage of ERP systems by aligning specific businesses and the supporting ERP

system while business process modelling improves efficiency through standardization and automation of the business.

Research exists on the topic of integrating business rules in current BPM models. Early attempts show how business rules are redefined as ECA (event-condition-action) notations to be fitted in the BPM model. (Knolmayer, 2000) In all previous attempts at integrating business rules and business process modelling the rules are adapted and fitted in the BPM model. (Bajec, 2000.) (Knolmayer, 2000) (Rouvellou, 2000.) (Kovacic, 2004) (van Eijndhoven, 2008) In order to effectively combine the different techniques the focus of researchers has been on improving business rules within process model diagrams. This improvement is mostly notable in the areas of process model maintainability and change management. The usage of business rules in BPM models to achieve process flexibility is addressed in the literature as well and contains critical findings regarding the linkage between ERP systems and the performance of small SME's. (van Eijndhoven, 2008) This indicates the strong need for flexibility at small SME's that does not suit the standardized format of a general ERP system.

Ruopeng & Sadiq distinguish between 2 different BPM approaches. While graph-based process models have their roots in Petri-net theory, rule based process models are used to capture human expertise in business logic rules. Logical rules are used to represent structural, data and or resource dependencies between task executions. Therefore rule-based systems are able to partially specify process definitions allowing rule based systems to model adaptability and flexibility as well as human expertise in process models. (Lu, 2007)

Charfi & Mezini argue that business rules are often defined as activities in a process model. A rule-intensive business process definition contains plenty of activities that model decision-making points in the process. Using business rules in a general process model is especially useful in domains with rule-intensive processes. Business constraints have to be explicitly integrated in the process model by expressing business rules in terms of activities. (Habich, 2010)
Activities in a process are defined as tasks being executed for a specific product by a specific

resource. (Reijers, 2002) The specification of activities fits the characteristics of business rules rather well.

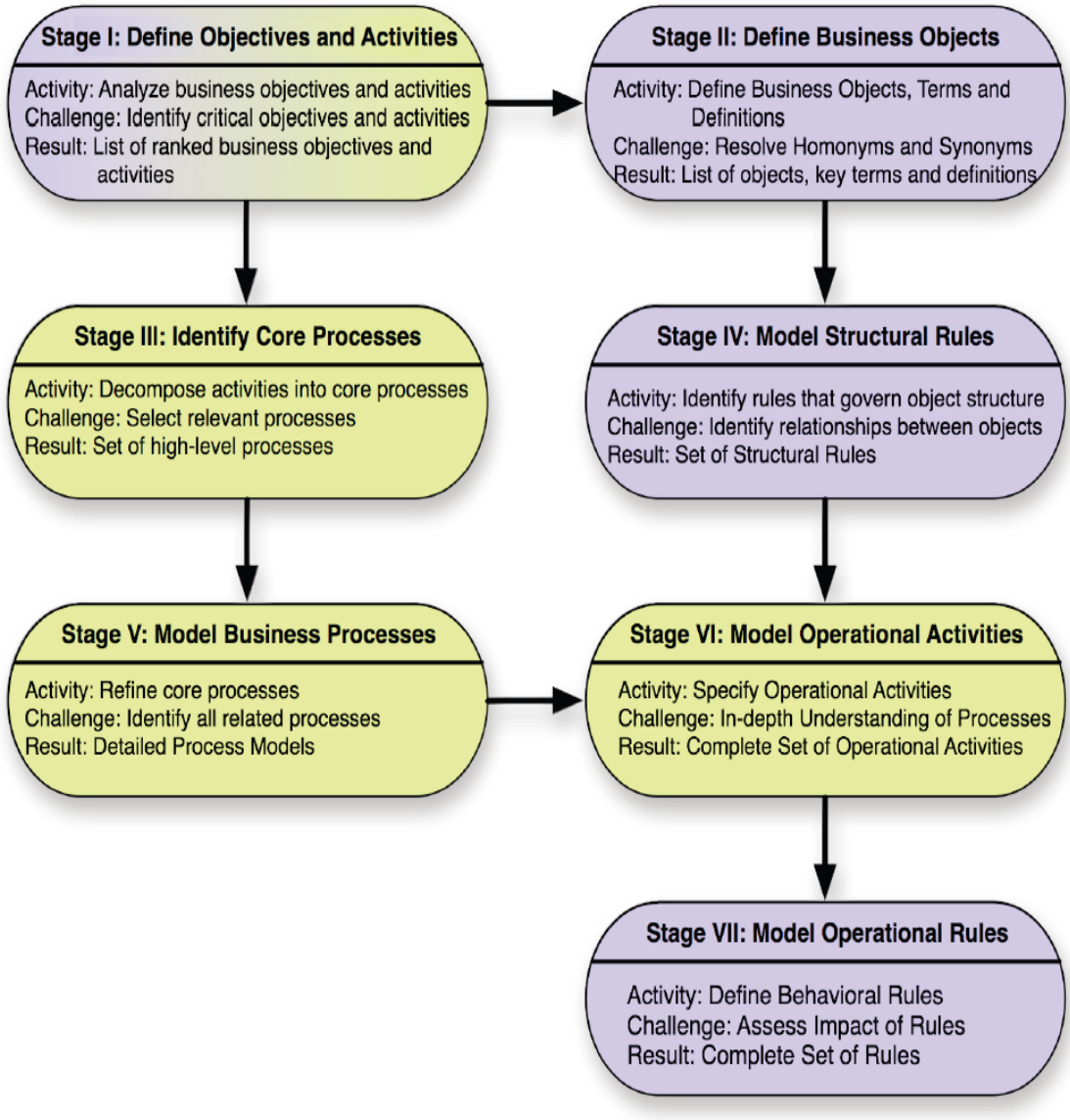
Comparative studies between business rules notations and business process models have exemplified the complementary role both techniques have in representing the business.
No empirically proven methodology exists that integrate business rules and business process modelling while theoretical studies using the BBW ontology by Bunge–Wand–Weber (Weber, 1997) evaluates the which constructs the different notations are able to represent. A combination of a business rule notation with an business process modelling notation will create the highest representation power of all constructs defined in the BBW ontology. (Zur Muehlen M. a., 2010)

2.2.4 The integrated procedure framework

In this section we provide a framework defined in the literature to effectively combine business rules and business process modelling. The framework does not specify the notation of business rules and/or specific characteristics business process models. No current example exists that illustrates the implementation of this framework in a case study at an organization. Together with the chosen notation of business rules and business process modelling discussed later in this paper, the framework for integrating business rules and business processes forms the basis for the case study.

The basis of the framework is shown in Figure 2. This framework is designed as a methodology for an approach to integrating business rules and business process modelling. (Zur Muehlen M. M., 2008)

Figure 2 Integrating business rules and business process modelling.



The first step in the framework ensures the complementary role of both business techniques. By firstly defining the objectives and the activities related to these objectives we ensure that business process models and business rules have the same critical objectivities and activities.

The framework shows that a parallel method for developing the business process model and the business rules is proposed to ensure that the end products are fully complementary.

A top-down approach is used in which high level business objectives and critical processes are defined. After the specification of business objectives and activities, high level business objects are

defined. Business objects need to be specified to ensure that all business rules use the same notations and definitions of the business objects they apply too in later stages of the development. A common high level business object is for example a customer. Business rules can further specify an instance of the business object “customer” when developing the set of business rules. Different rules may apply for specific customers, specific groups of customers or customers of different product lines.

Linehan defines noun types in the SBVR notation. He further elates that these noun types are similar to class types in UML notations. (Linehan, 2008) Business objects shows similar characteristics to the noun types mentioned by Linehan. Using and defining business objects reduces the chance of homonyms and or synonyms at an organization. The definitions defined in this stage should be used throughout all facets of the organisation including the support IT systems. It is crucial that the business objectives have the same names in the databases of the organization to ensure the possibility of separating business logic form the code of the ERP system.

During Stage 3 the activities are decomposed into core processes. The result is a high level process description of the organization. It is crucial to define which business objects are used by tasks and activities in the process map. Insight into the moment when business objects are addressed is needed to define triggers that fire business rules for a particular process activity on a particular business object or multiple business objects.

In the fourth stage an analysis of all business rules is performed to identify the set of structural rules that apply on the various business objects. Often these rules are constraints due to resource issues of policies in an organisation. Because business rules apply to business objects and not business processes rules are not bound to a single process and can be standardized and used in various processes in the organization. In this stage it is important to identify the various relationships between the objects and the logic regarding these relationships.

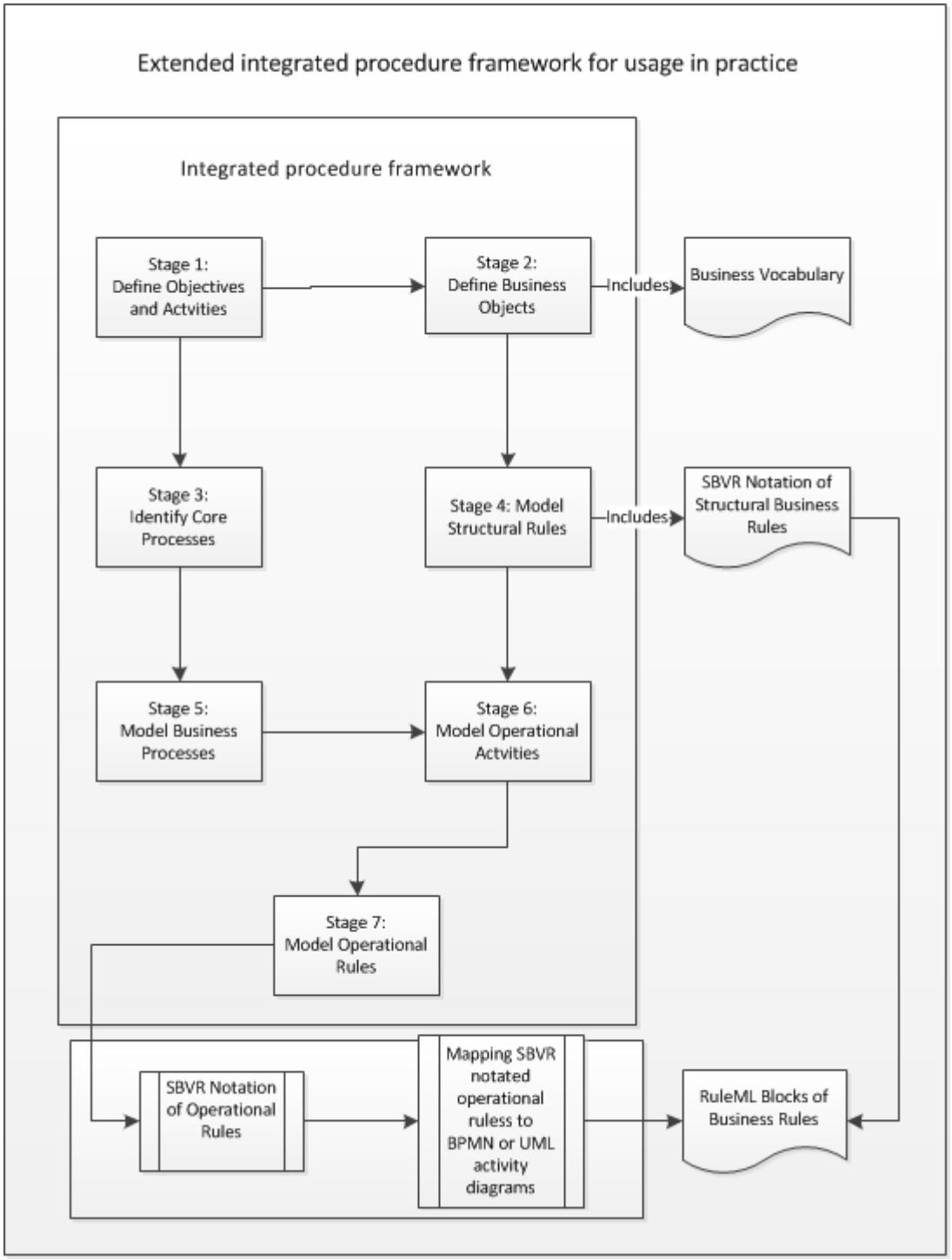
After the first four stages a high level structure of the business objects, rules and processes should be identified. A general understanding of the relations between the processes and rules is gained and used to work out the actual implementation of the structural rules and processes.
Stage 5 models the business processes by refining the core processes to process models. This stage provides a detailed description of all processes in the organization. The resulting detailed process models should provide insight in the way the organisation conducts business and all tasks/activities an organisation undertakes to reach his/her objectives.

The detailed process models contain specified activities that are performed during the processes. In stage 6 these activities are further specified to gain an in-depth understanding of processes.
The specified activities are especially useful to analyse the effect of rules on the processes.
The final stage completes the methodology by providing the final set of business rules for the organisation. This rule set contains the set of structural rules and the set of behavioural rules. Behavioural rules are defined and noted in this last stage after an understanding and detailed description of operational activities is defined in stage 6. Operational activities address behaviour of processes and the effect of business rules on this behaviour. In the last stage the set of business rules is completed to model the exact behaviour of the business and its business processes.

Zur Muehlen states in his research that there is a lack of validation regarding the integrated methodology. The aim of this paper is to explore the practicality of the proposed framework using a case study to demonstrate the feects of this apporach in practice. Although the methodology can not be validated based on the case study of this paper, the case study shows how this methodology is used in practice and will provide a detailed description of eache phase in practice.

2.2.5 Extension of integrated procedure framework

Figure 3 Extended integration procedure framework



This extension on the integrated procedure framework illustrates the further stages required to successfully implement business rules in business processes and the preparation required to map the business logic for usage in IS systems.

2.3 Business logic and ERP effectiveness

In a previous section of this research we touched upon the purpose of an ERP system in an organisation, focusing on the particular role and usage of the ERP system in SME's. The primary role of an ERP system in any organization is to support business activities. In order for an ERP system to be effective an understanding of these business activities and the reasons for these specific activities needs to be in place. This understanding is modelled through the use of business process modelling and business rules. The business rules contain the behavioural logic that causes business activities to happen in the way they do in practice. While trying to support business activities, an ERP system needs to be adopted and customized to fit the specific way an SME conducts business.

Business rules contain the logical guidelines an ERP system needs to learn to become effective for the business environment it is placed in. While in large organizations standardization takes place among business processes to fit an ERP system, in SME's this is not always the best option. Specific business processes that are often part of the core strengths of SME's cannot be standardized or the SME may lose its competitive capability. By understanding and translating the business logic of these specific processes and adapting the ERP system to fit the needs of the business, the SME is able to adapt to modern ways of working while maintaining his competitive capability.

In most practical examples of customized ERP systems these business rules are hardcoded in the software. System engineers have coded various restrictions and policies on the system in the code of the ERP system to adapt the ERP system to fit the business needs. This research proposes to define business rules on a business process level first.

2.3.2 Business process understanding in ERP systems

As stated paragraph 2.2.3 regarding the relationship between business rules and business process modelling both techniques serve the same purpose. Just as understanding business logic through business rules an understanding of the overall business process through modelling enables an ERP system to be fitted to the specific needs of the organization. The business process model defines all tasks, business objects and workflow-patterns of the business.

Quiescenti et al. state seven phases of the business process management lifecycle which are strictly necessary. They indicate that a business process oriented approach to the design of an ERP system involves the need to asses and model organisational structures and business processes. They note that the phases are particularly critical in dynamic and diversified environments such as those of SME's. (Quiescenti, 2006)

Ehie et al. present an ERP implementation strategy in which an analysis of the current business processes is necessary before selecting the ERP system. Furthermore Ehie et al. illustrate the need for customizing the business processes during the ERP implementation. Throughout the research literature the notion of analysing business processes when implementing an ERP system is present. However the literature does not mention inclusion of business rules during analysing business processes. The impact of business logic is neglected in ERP implementation while a focus on process oriented design is well documented and illustrated in the literature. Customization of an ERP system should not only include business process modelling and reengineering, but also look at business rules that apply to business objects and activities of the organisation. (Ehie, 2005)

A study on business process modelling benefits shows that next to improved understanding, communication and processes in general, business process modelling addresses the issue of model-driven process automation. This benefit ranks fourth in the top 10 benefits of business process modelling according to Indulska et al. and enables organisations to facilitate or support process

automation, execution or enactment on the basis of the models. (Indulska, 2009)

This process automation role is one of the key functionalities an ERP system offers.

2.3.3 Organizational Processes

The goal of business process modelling is to understand, analyse and improve business processes in an organisation. The value of business process modelling is often hard to measure as it only provides indirect profit gains or cost savings. Indulska et al. ranked the top 10 most noted benefits from business process modelling. Figure 4 shows the results from the research on business process modelling benefits. (Indulska, 2009)

Figure 4 Business process modelling benefits

Table 2. Overall (across all 3 stakeholder groups) top 10 business process modeling benefits.

Rank	Issue	Description	Mean Rating	Std. Dev.
1	Process improvement	Greater ability to improve business processes	11.452	1.452
2	Understanding	Improved and consistent understanding of business processes	10.787	1.861
3	Communication	Improved communication of business processes across different stakeholder groups	7.539	0.909
4	Model-driven process execution	Ability to facilitate or support process automation, execution or enactment on the basis of the models	7.202	6.771
5	Process performance measurement	Issues related to the definition, identification or modeling of adequate levels of process abstraction.	6.207	5.464
6	Process analysis	Greater ability to model processes to analyze them for possible problems, and/or time/cost reductions	5.266	4.619
7	Knowledge management	Support for identification, capture and management of organizational knowledge	4.276	3.721
8	Re-use	Greater ability to re-use previously designed and validated processes	4.006	3.496
9	Process simulation	Greater ability to see how a current or re-designed process might operate, and its implications	3.093	5.357
10	Change management	Support for business change management practices, results or impacts	3.035	5.256

Most benefits are correlated as process improvement is only achievable if understanding of the business process is realized. A survey held in 2007 shows that 75% of active business process modelling initiatives are concerned with process improvement. (Palmer, 2007)

Studies indicate that business process modelling in itself does not provide an organization with tangible benefits. Business process modelling however is often noted as an important contribution to the success of many other business components?, especially ERP systems. Success factor studies of IS systems have either explicitly or implicitly suggested the importance of process modelling. (Bandara, 2005)

Business process modelling enables other disciplines like information systems or business process reengineering to increase the performance of an organization. This is measured in an overall increase in operational efficiency or cost savings in general. No empirical data exists on making these perceived benefits tangible. The case study in this research illustrates the struggle of an SME to use an ERP system effectively and demonstrates how a methodology using business process modelling and business rules is applied to realize operational efficiency.

2.3.4 BPM modeling techniques

After demonstrating the purpose and value of business process modelling we use this section to further describe the basics of business process modelling and the different characteristics and terms used. We start by defining a process using the definition used by Davenport: processes are defined as “structured, measured sets of activities designed to produce a specified output for a particular customer or market’’. (Davenport, 1992)

This correlates with our earlier stated definition of an activity as a task being executed for a specific product by a specific resource. The specification of activities mentioned by Davenport and

Reijers can be generalized to be applicable for any business object instead of only customers, products or resources.

A business modelling technique is able to provide means to describe the structural and dynamic characteristics of the functioning of an organization and its environment. (Hommes, 2000) Two categories of existing business process modelling techniques are defined in literature. Graphical techniques such as UML(unified modelling language), BPMN and EPC(event-driven process chain) are used to capture and understand processes for scoping and discussing process improvement initiatives. Graphical modelling techniques are high level abstract notations of business processes easily understandable by business analysts. (Recker J. C., 2009)

Other process modelling techniques as BPEL and Petri-nets are founded on rigid technical and mathematical paradigms. These techniques are considered net-based (Petri-nets) or workflow programming languages (BPEL). (Zur Muehlen M. a., 2010) These techniques focus on the areas of process analyzation, execution and simulation. (Recker J. C., 2009) Within the case study proposed in this research a graphical notation is used when an understanding of the business processes and business logic is required to improve the effectiveness of the ERP system. If major business process reengineering is required a more technical BPM technique would be beneficial.

Recker found apparent support for his construct stating that there is “no representation for state, stable state, unstable state, conceivable state space, state law, lawful state space, conceivable event space, and lawful event space, state modelling will lack definability and focus. Thus, the depiction of business rules that rely on state and transformation laws will be unclear. ” (Recker J. C., 2009)

Research on the representation power of BPM techniques using the BBW ontology by Bunge–Wand–Weber (Weber, 1997) shows that business process modelling techniques lack constructs that

express state, state laws, conceivable and legal state space which provides a logical foundation for the integration of business rules to fulfil these constructs. (Zur Muehlen M. a., 2010)

2.3.5 BPM notations

As described above two main categories of business process modelling exist in the current literature. Technical, mathematical based business process models are dominated by the BPEL language. Business process execution language focuses on analysing and executing business processes. Recker et al. uses representation theory to look at the representation completeness of various techniques of both categories. The following table shows the results of this analysis. Table 1 is distracted from results of Recker et al. (Recker J. C., 2009)

Table 1

Language:	**Petri-net**	**ANSI flowcharts**	**EPC**	**IDEF3**	**BPML**	**WS-BPEL**	**BPMN**
	1962	**1970**	**1992**	**1995**	**2002**	**2003**	**2004**
Total Degree of Deficit	58,6%	93,1%	62,1%	62,1%	65,5%	48,3%	34,5%
Total Degree of Completeness	41,4%	6,9%	37,9%	37,9%	34,5%	51,7%	65,5%

This research shows that BPMN is the most complete language among the different BPM techniques. Furthermore BPMN provides a relative ease of use and understanding by business analysts. BPEL offers more analysis tools but requires a more technical definition and is therefore much harder to use in practice. The graphical representation of BPMN allows the user to represent the business processes of an organisation in a more understandable fashion.

BPMN's lack of representation for business rules had a strong and negative effect on its perceived usefulness. (Zur Muehlen M. a., 2010) This is a general concern for all business process

modelling techniques. The research by Recker et al. comparing the techniques shows that no modelling language is able to represent the construct “states’’ and all other state related constructs. (Recker J. C., 2009) Business rules are required to fill this representational gap and provide a notation to represent states. The goal of an integrated approach to represent business is to complement the lack of states representation by BPM languages with the usage of business rules. Therefore using BPMN in combination with a business rule notation will allow the methodology on process improvement to achieve full representation of the business logic and therefore able to represent unique business processes in an ERP system.

The BPMN model provides a graphical representation for the inclusion of business rules in its 2.0 version. A so-called business rule task can be included to model the static invocation of a business rule calculation in a specific activity of the process. The business rule engine will calculate the desired outcome of the business rule task based on the stated rule and the specific instance it is used. This allows the BPMN model to incorporate both operational and structural business rules. The business rule task provides a mechanism for the process to provide input to a Business rule engine and to acquire output from the business rule calculation. (Koehler, 2011)

These business rule tasks simplify a process model by providing a mechanism that can eliminate or describe paths in the process model. The calculation of the business rule task is done by a rule engine which often requires a business object in the process model as input. Specific values of this business object are used to identify the specific instance of the business object and used to calculate the preferred outcome according to the set of business rules. (Koehler, 2011)

While structural rules are fairly easy to implement in the model since they are static and not situational, operational rules require great insight in the specific situations in which certain business rule outcomes need to be obtained. (Koehler, 2011) In our extension of the integrated procedure framework we define structural rules in the business rule notation SBVR independently from the business process model. Operational rules are derived in a later stage of the framework and

described in SBVR after the business process models are completed. Operational activities that are used in the business process models form the basis for the set of operational rules.

2.4 Business Rules

The usage of business rules is beneficial to any organization. It's main purpose is to document the perceived understandability and analysability of business logic.
Furthermore it provides a formal and structured method for organizing business rules using well defined logical operators and blocks.

The explicit documentation of business practice decisions enables organizations to get business logic out of people's heads and applications, and on the table. The externalization of business rules providers a clearer understanding of application behaviour. As a result of this better understanding we expect to increase consistency of business practices. Business rules can be duplicated and applied in multiple areas. (Rouvellou, 2000.)

The comparative analysis study by Indulska shows that combining any business rules language with the business process modelling technique BPMN allows for the most complete representation of business processes.

2.4.2 Designing Business rules

Business rules are set by leaders in an organization. The rules therefore represent the degrees of freedom that the business rule setter allows for its business objects including suppliers, customers and employees. There are several standards for the design and methodology of business rules. The purpose of all business rules methods and notations is the same, however their capability of representing business-specific rules can differ.

Classification of business rules has first been proposed in the GUIDE project. (GUIDE, 1993) This classification distinguishes three types of business rules:

- Structural Assertions
- Action Assertions
- Derivations

Ross further extended this scheme by describing several types of action assertions. Furthermore we define several characteristics business rules possess. (Ross, 1997)

Gottesdiener summarizes that business rules are:

• Declarative (i.e. non-procedural);

• Atomic (indivisible yet inclusive);

• Expressed in natural language;

• Distinct, independent constructs;

• Business, not technology, oriented;

• Business, not technology, owned; (Gottesdiener, 1997)

Kardasis distinguishes three different phases based on three views for approaching information systems analysis. Intentional analysis of the business involves defining a set of business rules that capture the prepatory activities that aim at understanding business objectives. Intentional rules are expressions of business rules seen from an business context perspective. (Kardasis, 2004)

The operational view describes operational rules seen form a business process perspective. They either prescribe action on the occurrence of a business event or describe valid states of information entities in an organization. Operational rules are derived from intentional rules by adopting a formal rule statement notation using a convenient rule language and repository schema. When operational

rules are expresses in an implementation specific manner, the rule is examined from an IS implementation approach. (Kardasis, 2004)

As proposed by multiple research studies on representation power of BPM and Business rules notations a combination of a BPM language and a business rules language is required to reach an high degree of completion. Business rules are able to represent states of processes and entities which is not covered by any existing BPM language. Multiple studies show that a combination of the BPMN language for BPM models and a language for business rules is able to reach the highest degrees of completion (Recker J. C., 2009) (Rosemann, 2009) (Zur Muehlen M. a., 2010). The choice of business rules language is therefore made based upon the capability of the language to ensure that the model does not get too technical and complicated. Just as BPMN is chosen for its graphical representation and the numbers of research articles on the language, the Semantics of Business Vocabulary and Business Rules (SBVR) seems to be the business rules language that will be the easiest to implement. Furthermore, as both languages are created by the same organisation (OMG), the possibilities for integration are already discussed and documented.

The first business rules language SRML (Structured rule mark-up language) was designed in 2001 as a generic rule language consisting of the subset of language constructs common to the popular forward-chaining rule engines. Citing from (reference): “Because it does not use constructs specific to a proprietary vendor language, rules specified using this XML DTD can easily be translated and executed on any conforming rule engine, making it useful as an interlingua for rule exchange between Java rule engines.” (Thorpe, 2001)

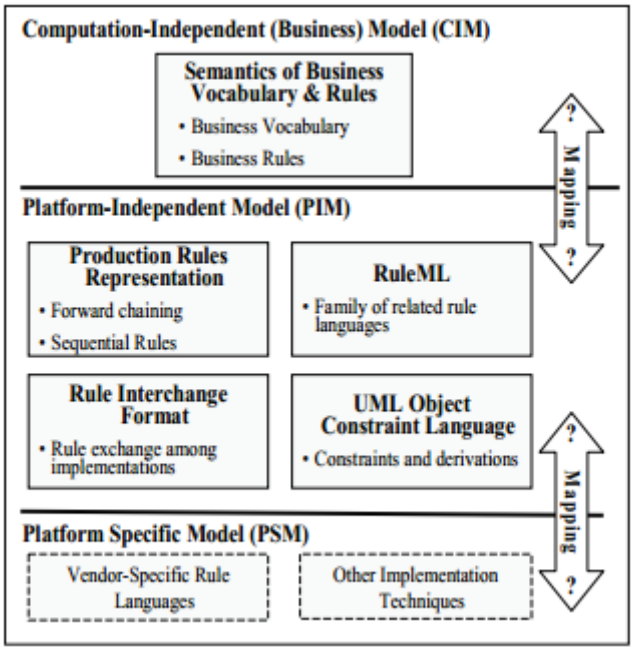
The IBM Watson research center developed an XML notation called BRML (Business Rule Mark-up Language). This is an extension of the SRML language and focuses on the specific representation of business rules in an Xml format to be used by rule engines. The proposed constructs of the BRML notation led to the development of RuleML, a combination of CLP(Courteous Logic Programs) and BRML notation. “RuleML is, at its heart, an XMLsyntax for rule knowledge representation (KR), that is inter-operable among major commercial rule systems.” (Grosof, 2001) The interoperability of this

notation between various commercial rule engines enables that the RuleML notation is very useful to adopt in this practical implementation of an integrated framework for BPM and Business Rules. The usage of the RuleML notation in the case study is well suited for usage in the existing ERP system, as commercial applications that implement business rules in information systems in general use variations of the RuleML notation. Notation of Business rules in Xml will only be necessary in the actual implementation of the business rules in a business engine plug in for the ERP system.

According to the three layer Model-Driven-Architecture ruleML is a format that resides at the platform independent level. When specifying business rules in the framework that defines business processes and business rules on a business level, specification by the OMG group called SBVR is the logical option. RuleML notation directly corresponds with this OMG specification called SBVR. (Boley H. , 2012) (Object Management Group, 2006)

Figure 4 depicts the architecture used by Linehan to capture, analyse and transform business knowledge in structured rules that can be mapped in an xml language notation for implementation in an ERP system. (Linehan, 2008) It illustrates how SBVR fits in the Computation Independent Modelling (CIM) of the OMG's three-layer Model Driven Architecture. (Miller, 2003)

Figure 5 OMG's three-layer Model Driven Architecture



(Miller, 2003)

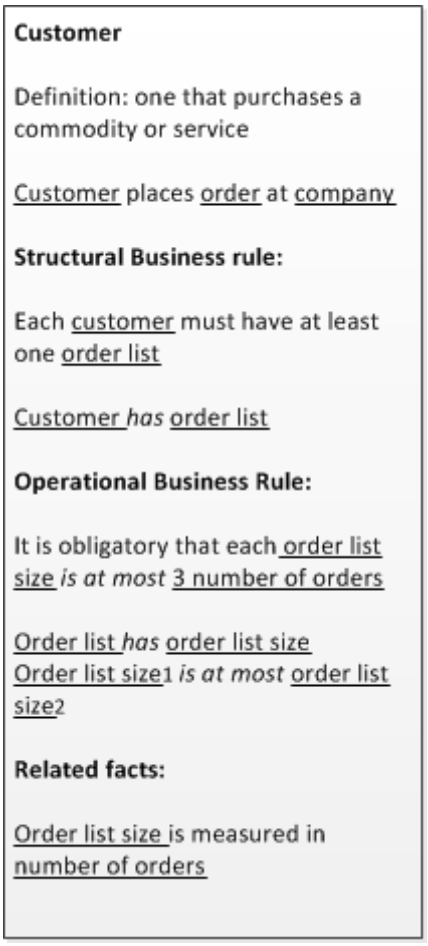
The extended integrated procedure framework combines various aspects of the three-layer Model Driven Architecture to illustrate the notation and procedures required for actual usage of the framework in practice.

The SBVR notation for business rules is categorized in two main notations. The business vocabulary defines nouns, associations between nouns and instances of nouns. In stage 2 of the integrated procedure framework model we describe a list of business objects. These business objects are described in the business vocabulary of SBVR as nouns.

Associations between nouns are used in SVBR to define business rules. The rules are based on the different relationships between business objects. Linehan uses the following noun and business object "customer" as an illustrative example. (Linehan, 2008)
The business object 'customer' has specified associations with other business objects and can have multiple instances. When business logic dictates that a customer cannot have more than three orders currently in process, this can be formulated as a business rule that defines the association between the business objects 'customer' and 'orders in process'. The business rule task in BPMN will trigger this business rule whenever a new order is requested by checking the number of orders in process for that particular customer instance.

The following example shows the notation of a customer in SBVR Business Vocabulary.

Figure 6 Business Vocabulary



This block describes the definition of the noun concept customer as well as an event a customer can trigger. Furthermore it describes two rules that apply to the particular triggered event, a structural and an operational rule in the SBVR notation. (OMG, 2008)

2.5 Validation through ERP performance metrics

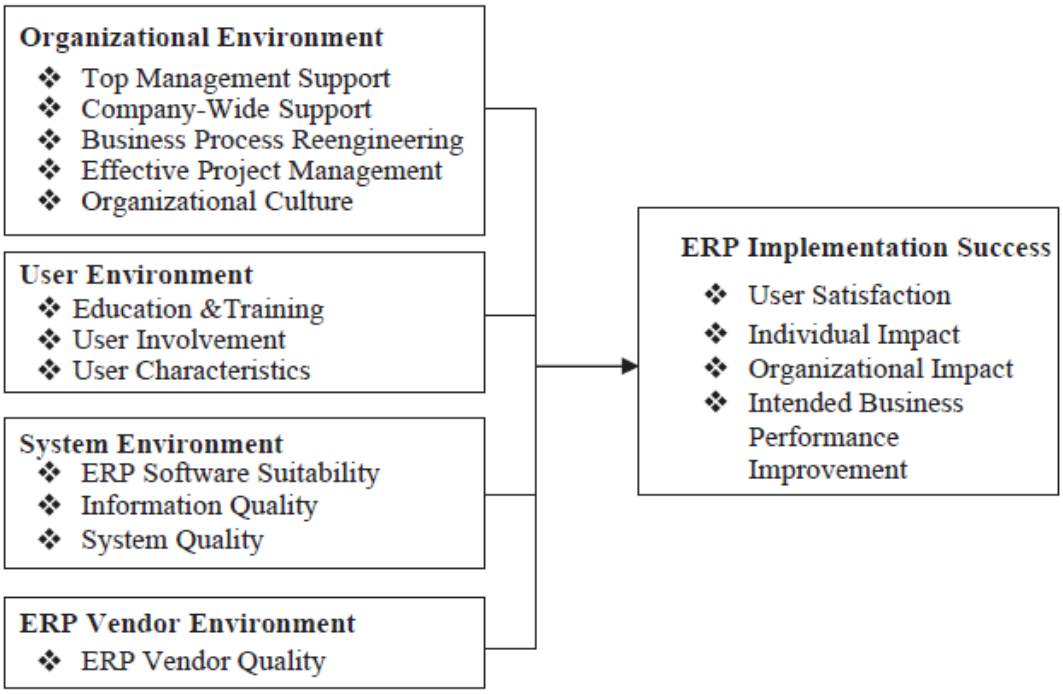
2.5.1 Process oriented measurement of ERP performance

There are numerous frameworks that describe and use various measures to gain insight in the performance of organisations related to an implementation of an IS system. The Delone en McLean information systems success model has been widely used to measure the success of an IS implementation through various dimensions. (DeLone, 1992) his model is widely accepted as an useful approach to IS success and includes a business process dimension.

A more recent study uses the model by Delone and McLean as a basis for measuring ERP implementation success specifically. This research therefore makes some basic adaptations to the model by eliminating various dimensions and adding certain dimension to make the model suitable to the ERP implementation context. (Zhang, 2005)

The model describes multiple characteristics that influence the success of an ERP implementation. In the model we can see that IT-Business alignment is a factor that influences the success of the ERP implementation, in the organizational environment as well as the system environment. The suitability of the software within the organisation and the available BPR opportunities both require a good understanding of the current processes and are aided by the usage of BPM techniques.

Figure 7 Zhang's model for measuring ERP implementation success



(Zhang, 2005)

2.5.2 Resource-based view on ERP performance

The Resource-based theory perspective and in extension research on the business value of IT notes that business processes provide a context in which an organization can examine IT value. This context allows research to base IT value through a process-oriented assessment. This perspective is based on the argument that the first noticeable effects of IT occur at the operational level. (Mooney, 1996)

Mooney recognizes three in which IT affects business processes: Automational effects, informational effects and transformational effects. Mooney also describes certain strategic or tactical level dimensions which are impacted by the business. Although the research states that specific metrics are required to measure the impact of IT on the business value of processes a set of generic metrics by Kraemer et al is included in the process oriented assessment of IT value by Mooney. (Mooney,

1996) (Karim, 2007) Figure 8 illustrates generic metrics for measuring IT value on processes. (Kraemer, 1994)

Figure 8 Dimensions of IT Business Value

Business Processes	Dimensions of IT Business Value		
	Automational	***Informational***	***Transformational***
Operational	Labor costs Reliability Throughput Inventory costs Efficiency	Utilization Wastage Operational flexibility Responsiveness Quality	Product and service innovation Cycle times Customer relationships
Management	Administrative expense Control Reporting Routinization	Effectiveness Decision quality Resource usage Empowerment Creativity	Competitive flexibility Competitive capability Organizational form

In this study we will use the generic measures defined by Kraemer as a basis for defining measures that are specifically addressing the validation for the extended integrated procedure framework. To validate the usefulness of the integrated procedure framework extended with the inclusion of business rules we look at impacts on the following operational measurement constructs; We measure the extent to which new insights in business processes and business rules allows the ERP implementation of a SME to improve process efficiency, effectiveness and flexibility. (Karim, 2007)

Process efficiency is measured as the differences in operational costs as a result of the usage of the ERP system. (Karim, 2007) This usability of the ERP system is dependent on the implementation of the insight in the business through the usage of the extended integrated procedure framework. Effects measured by process efficiency are the result of the automational effects of the ERP system .

The following metrics are included to define the efficiency of operational processes.

- Order throughput time
- Operational costs

In this study the metric proposed to measure process effectiveness is the ability to make decisions quickly and the number of errors in the organisation. Quick decision making is stimulated by process effectiveness through better access to data, better integration of data and better understanding in processes of all functional departments. The same informational effects also can be directly linked to the number of problems within the internal processes of the organisation. Effects measured by process effectiveness s are the result of the informational effects of the ERP system .

The following metrics are included to define the effectiveness of operational processes.

- Utilization of resources
- Responsiveness
- Problem Prevention
- Problem Fixing

Process flexibility is measured by the extent to which the ERP implementation can provide firms with more flexibility in response to changing business environments by providing new ways to customize their processes and become more agile. Process flexibility can be quantified by measuring the ability of the organisation to adapt to changing business environment. The ERP systems role in this adaptability is to be able to provide the technical capabilities and information to drive change.

The following metrics are included to define the flexibility of operational processes.

- Cycle Times
- Customer Satisfaction

2.5.3 Role of Business Process Modelling in performance of ERP system

In our section regarding ERP systems and their implementation we state a number of purposes for which an ERP systems is used in an organization. The role of an ERP system as defined and discussed here is to support business activities. This support should result in an improvement of performance by providing an entire business with a suite of software modules covering all activities of the business. (Hitt, 2002)

A business process modelling technique is able to provide means to describe the structural and dynamic characteristics of the functioning of an organization and its environment. (Indulska, 2009) It provides a graphical representation that includes processes, tasks, activities and their relations. While BPM allows an organization to understand, analyse and improve business processes, underlying tasks and activities in an organisation, an ERP system aims at supporting business activities. An ERP system does not require business process modelling to be implemented and used. However, to be effective and efficient in the task of support business activities and improve the business, BPM is a commonly used tool in the design and/or implementation of an ERP system. (Bandara, 2005)

In general an ERP implementation is far from being an IT project, and is more of an integrated organizational development approach that changes the way organizations do business, and the way work is done. (Al-Mudimigh, 2007)This perspective demands attention to the overall ways an organisation conducts business, as the ERP system will demand changes in business processes. This research however proposes a holistic approach in which business process modelling and business rules techniques form the core link between the interactions of the ERP systems and the business.

BPM is used to indicate which business processes need to be adapted to allow the ERP system to work successfully, but also as a tool which indicates and defines specific core processes in such a way an ERP system is able to align the ERP implementation to these specific core processes. It is

important to use BPM and business rules tools for this role to prevent that the ERP systems loses its core working functionality.

A study on the relation between an organization's business processes and ERP implementation shows that business processes have a noticeable effect on ERP performance in the following defined categories: ' System Quality' , 'Information Quality', 'User Satisfaction' and 'Organizational Impact'. The study provides support for the hypothesis that companies with a gap between business processes and system processes have significant differences in ERP performance. (Wen-Hsien T, 2010)

2.5.4 Role of business rules in the performance of ERP system

There seems to be a dialectic influence pattern between ERP systems and their business environment. While most organizations choose to adapt the business to the rules an ERP system imposes, rules are also used customize ERP systems to fit the business environment they are operating in. In general studies the first direction of influence, i.e., an ERP system imposing rules on a business, has been addressed and widely recognized as an important factor for a successful implementation. (Haddara, 2011) (Vincent A. Mabert, 2003)This method, however, is only effective in large-scale organizations that do not have specific business rules as their core competitive advantage. Large organizations often gain profit based on economies of scale, while small organizations offer distinct capabilities or business rules that provide a unique service in a particular market.

While small organizations often have similar reasons for adopting ERP systems as large organizations, they do not have the same competitive advantages and therefore an ERP system performs a different role in a small organization. An ERP implementation cannot provide the same amount of standardisation benefits in a small organization, but it is easier customized to fit the business environment and to perform a more flexible supporting role to the business. Large organizations will generally gain benefits from the implementation of structural business rules in the

ERP implementation that contain policies and authorisation standards. In small organizations the small scale of the organisation allows for a more flexible and more effective implementation of business rules in an ERP system that includes operational rules specific to certain business scenario's or events.

So although adoption reasons for ERP systems are generally the same for small and large organizations, the role of business rules in the ERP implementation reflects the supporting role the ERP system performs in the operation. In larger organizations ERP systems with implemented business rules provide general standardization and policy enforcements on an organizational or departmental level. In small organizations the role of ERP system with implemented business rules offers an implementation tool for tacit knowledge and dynamic rules at an operational level.

3 Case Study

3.1 Introduction

The data collected belongs to a small 3PL in the Netherlands. The logistics business relies heavily on business process optimalization, especially in the operational processes. The quality of logistics services is defined by time of delivery. A 3PL needs to be able to deliver goods fast and correctly to satisfy their customers.

Therefore it is crucial to define and optimize the operational processes to make sure that the operations are effective, efficient and flexible. This flexibility is a huge core value within the organization as due to the high competition and high bargaining power of customers the organisation has a culture of adapting to any needs of customers.

3.2 ERP implementation choice

The relationship between the 3PL and the ERP provider is old and based on trust. While the ERP provider had no experience in building ERP systems, it had developed a Transport Management System which was used at the 3PL prior to the ERP system. The new ERP module was based on Microsoft Dynamics and developed to suit the logistics industry. Both parties agreed that the development of the software by the software provider would be better as the company already had great knowledge of the logistics business.

The implementation was lead by an ERP consultant and the application IT manager, which had worked at the software developer before joining the 3PL. The 3PL provider was the first organisation in which the new ERP system was implemented and therefore closely followed and extended even after the implementation.

3.3 ERP performance analysis

The next step was to analyze the ways in which the ERP system affected the operational activities of the organisation. The operational activities were divided among operational divisions which all performed actions that were critical in the continuation of the order fulfilment. Operational activities are therefore always time-bound within the logistics industry. Of each operational division at the 3PL an activity diagram is drawn to identify the main activities of each division within the operations. Then, it is possible to identify which role the ERP system plays when performing the defined operational activity.

UML activity diagrams were used to illustrate the activities each operational division performs to fulfil a logistics order. These divisions all perform a key function within the logistics order fulfilment process. Because of the nature of the logistics branch, time to correctly deliver the order is directly tied to the quality of the service.

Within these activity diagrams of different divisions the different roles of the ERP system become apparent. The activities show the different ways the ERP system supports the operational processes required to fulfil an order. An example can be found in the appendix of this thesis regarding the order entry process at the small 3PL drawn in an UML activity Diagram in which the following four major activities are seen:

Activity 1: Customer order entry and registration online.

Activity 2: Customer order entry and manual printing and registration of order.

Activity 3: Decisions made regarding the order entry process based on order type and time.

Activity 4: Order control process, checking if order has all required data.

For each activity the primary role of the ERP system can be identified. In activity 1, where customers fill in orders online that get booked in to the ERP system immediately, the ERP system supports the activity by automating the process. In all other activities the ERP system is used to store and distribute information regarding orders and their fulfilment. In these activities the ERP system fulfils the information role as the system is an integral part of the informational capabilities of the organization regarding the order entry division. So within the order-entry division the ERP system mainly fulfils an informational role as well as providing some automation. The ERP has no transformational effects on the order-entry activities.

4. Research Design and Methodology

The general consensus at the 3PL is that the implementation of the ERP system has not been easy and as a result the ERP system is not reaching its desired and expected potential. The case study conclusion specifies the various problems and issues that hinder an efficient and especially effective ERP system to support the business.

A general lack of knowledge concerning business processes and task responsibilities underlines the argument that most of the processes and methods used in the business are not described and analysed from a business process perspective. This lack of process and task description has led the organisation to become very flexible and adaptive as well as inefficient and uncoordinated.

The lack of business rules knowledge and business process knowledge across the organization is one of the main reasons for the misalignment of the business and the ERP system that supports the business.

The following hypotheses are defined to support the claim that a lack of explicitly documented business knowledge regarding business processes, activities and rules affects the effectiveness of the ERP system. In the literature we defined three specific effects on business processes caused by an ERP system and we will test and measure the effectiveness of the ERP system with regard to the effect on the business processes. ERP performance is measured in terms of the business value of automational business processes, the business value of informational business processes and the value of transformational business processes. The three categories of business value are directly affected by the ERP system on an operational level of the organization.

H1: The implementation of the extended integrated procedure improves automational capabilities of business processes.

Automational effects directly influence the following quantifiable variables identified as efficiency metrics in section 2.5.2:

- Order throughput time.
- Labour Costs

H2: The implementation of the extended integrated procedure framework improves informational capabilities of business processes.

Informational effects directly influence the following quantifiable variables:

- Utilization
- Responsiveness
- Wastage

H3: The implementation of the extended integrated procedure framework improves transformational capabilities of business processes.

Transformational effects directly influence the following quantifiable variables:

- Customer relationships
- Cycle times

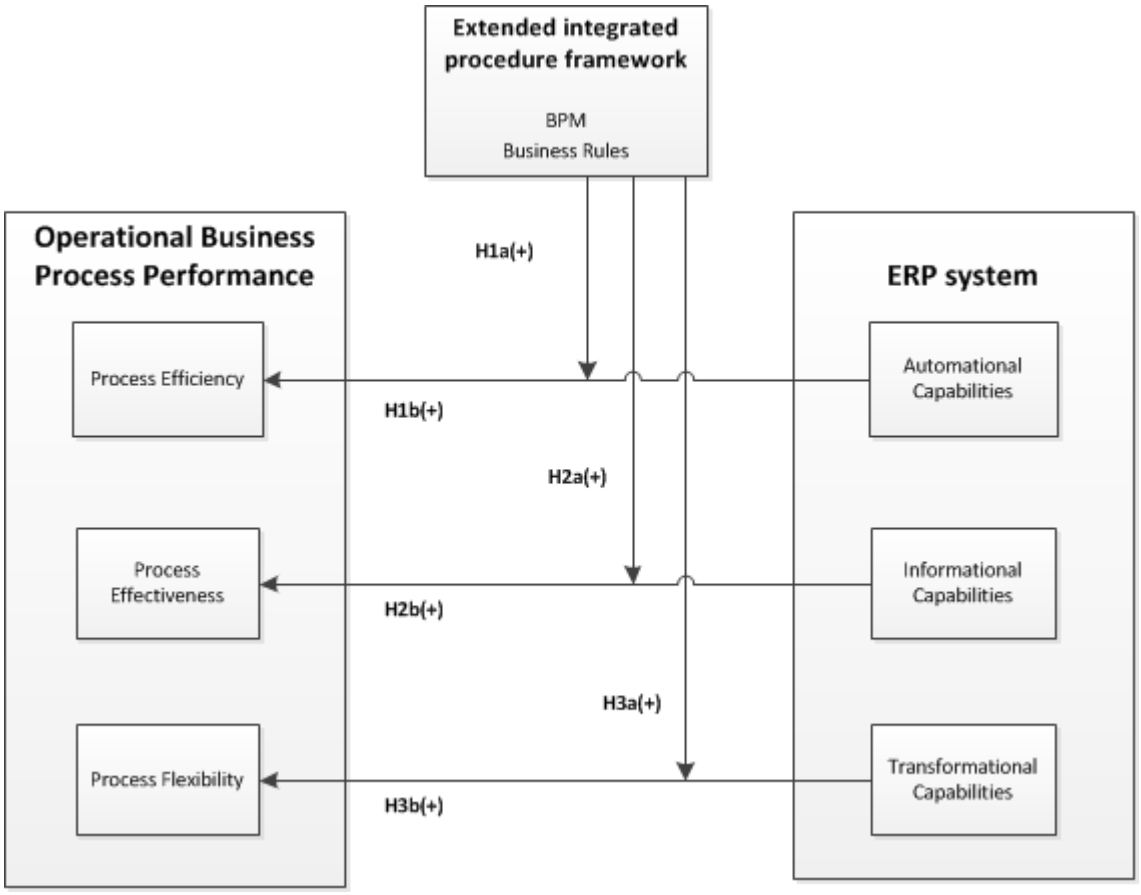
The design of this study starts with measurement of the current status of the operational effectiveness of the ERP implementation. These statistics will be used as a benchmark for comparison when evaluating the effects of the extended integrated procedure framework on the organisation.

When measuring operational performance a variation of quantitative and qualitative variables are addressed to gain evidence to support the claims of notable improvement effects on automational, informational and transformational business processes.

The hypotheses drawn above illustrate direct relations between the ERP system's ability to automate, transform and inform business processes. These business processes are evaluated on their effectiveness, efficiency and flexibility, thus providing direct relations between the ERP system and process efficiency, effectivity and flexibility.

While relations can be found between each capability of the ERP systems and each operational performance category, this study focuses on the largest and most direct relationships. In the following research model we illustrate how the extended integrated procedure framework is used to support the automational, informational and transformational effects of ERP systems on internal business processes that affect operational performance.

Figure 9 Research Framework



5. Data Collection:

The objective of the first step in the data collection phase is to gain a good impression of the current state of the ERP implementation and the level of integration between the business and the ERP system. In order to look at possible improvements in the alignment of the business processes and the supporting ERP system we first analyse the current fit of the system. This alignment can be analysed through a variation of quantitative and qualitative variables that define operational efficiency in the organization. A number of interviews are held to gain quick insight in the current workings and problems of the functioning of the ERP system at the SME.

The research design illustrates the various variables defined to take an in-depth look at the current alignment between internal operational processes and the ERP system.
These variables are measured using two distinctive research methods, the interview and quantifiable measures stored within the organization's ERP system. The following table summarizes the defined variables that are impacted by automational, transformational and informational effects on operational processes.

Table 2 Business Process Variables

Business process effects	**Operational Performance**		**Quantitative or Qualitative**	**Variable**	
Automational	Process Efficiency	Order throughput time	Quantitative	Order throughput time	ERP system, order status logs
		Operational Costs	Quantitative	Direct Operational Costs	Income statement
Informational	Process Effectiveness	Utilization of Resources	Quantitative	Drivers used vs drivers available Trucks used vs trucks available	ERP system
		Responsiveness	Qualitative	Set of questions regarding changes during processing an order	**Answers from users**

		Problem Prevention	Quantitative and Qualitative	Set of questions regarding	**Answers from users** and financial statements
		Problem Fixing	Quantitative and Qualitative	Set of questions regarding	**Answers from users**
Transformational	Process Flexibility	Customer relationships	Qualitative	Set of questions regarding customer satisfaction	**Answers from users**
		Cycle times	Quantitative	Number of issues fixed per release	Issue log of releases ERP system

Table 2 illustrates the methods used to collect the required data for assessing the effects of the ERP system on the performance of the operations at the 3PL. Whenever possible, this study opts to use quantitative data collection methods using the database the ERP system provides. If the variables are not available through databases, interviews are held to gain clear insight in the level in the influence of the ERP effect on the performance metrics.

5.1 Implement Extended Integrated Procedure Framework

Both the roles of the business and the supporting ERP-system are to be studied to gain full insight in the current alignment of the business and the supporting ERP system. The extended integrated procedure framework presented in this study as a practical adaptation of the integration framework is used to gain insight into the various processes and rules that affect the current business. These processes and rules are identified, analysed and formatted to a structural notation which allows the ERP system to better align its core structures and activities to the needs of the business.

Following the steps of the extended integrated procedure framework a number of products are delivered that show the results of the business process modelling techniques. In order to identify the alignment of the ERP system and to identify and implement changes that affect this alignment

the following products should be completed. The study creates an overview of the ERP system and the implementation path up to now. Next to this overview of the current ERP implementation an overall model of the business processes is completed. This overview is complemented with the various specific business rules that are operational within the business.

The general notion is that a better understanding of the current fit between the ERP system and the business will provide opportunities to improve the alignment. The insights tell the organization why the current system is as effective as it is. Furthermore the framework provides a comprehensive approach to define alignment in terms of processes and rules in the business and in the ERP system. The products completed based on the framework will provide the basis for improving the effectiveness of the ERP implementation.

Implement changes derived from analysis of Business- ERP system alignment:

A full understanding of the current business process models, activities and business rules provides insight in the current fit of the ERP system and the business processes it is supporting.
This new found understanding should lead to new methods, ideas and other suggestions to improve on the current alignment between the ERP system and the business processes.

6. Data Analysis

The data collected at the small logistics provider is analyzed and summarized to illustrate how the ERP system at the small 3PL is utilized. We use business process models in UML to show the role of the ERP system within the operations of the organisations. Then we indicate how this affects performance measures linked to the three ERP operational roles as shown in Table 1.

UML activity diagrams were used to illustrate the activities each operational division perform to fulfil a logistics order. These activities are in one or multiple ways supported by the ERP system. The activity diagram shows the various roles the ERP system has to support the activities of all the operational divisions. This provides a great indication on the significance of the ERP system within the logistics process in terms of automating, informing and transforming the activities within the operational logistics process. The process described within the Case Study to analyze the significance of the three ERP roles within the activities of each operational division can be used on all operational divisions. The following table gives an overview of all the activities within the operation and the main role the ERP system fulfils within each of these activities.

Table 3 Process Activities per division

Division	Activity	ERP Role
Order Entry	Online Order Entry	Automational
	Manual Order Entry	Informational
	Order Processing	-
	Order Control	Informational
Planning	Order distribution	-
	Driver instructions	Informational
	Loading ride on boardcomputer	Automational
	Guidance during drive	Informational
Distribution	Prepare order documents driver	-
	Control cargo	Informational
	Load truck	-
	Deliver cargo	-
	Return documents	-
Dossier control	Control dossier	Informational
Facturation	Create declaration	Automational
	Send declaration	-

Within the UML activity diagrams one can clearly conclude that the ERP system fulfils an informational role most often. The ERP system is used as a database in which information is stored and distributed throughout the operations. The ERP system is used as a supporting tool within the different activities. Some automation is perceived within the operational processes. Within the operational activities the ERP system is almost never used in a transformational role as the processes have not changed much since the introduction of the system. The ERP system is a support system that provides information and automates simple tasks but it does not change entire divisions or business processes.

The UML-activity diagrams illustrate where and how the ERP system is used within the operational business processes. It does however not indicate if the ERP system is affecting the efficiency, effectivity and flexibility. For these variables it is necessary to use the Research Model 1 in section which we illustrate the relations between the ERP roles and the performance measures of the business processes.

The scope of the research model is to look at the effects of automational capabilities on process efficiency, i.e. Hypothesis 1, the effects of informational capabilities on process efficiency, i.e., Hypothesis 2 and the effects of transformational capabilities on process flexibility, i.e., Hypothesis 3. The choice is made to focus on these three relations out of the possible nine relations as they are by far the three most important relations as illustrated in the research literature. For example, the informational capability of an ERP system can increase efficiency of certain business processes, but this relation is not within the scope of this research as we focus on automational capabilities to increases efficiency.

For each business process type we have constructed a number of variables which can be extracted from the interviews as well as the ERP data. Research Table 1 shows the variables that illustrate the relations between the capabilities of the ERP system and the subsequent business process effects.

To illustrate the effects of the automational capabilities of the ERP system on the business process effects as stated in Hypothesis 1b , we look at the variables defined in Research Table 1. In Research Table 1 we have identified the quantitative variable 'total throughput time' as an indicator to measure the efficiency of the operational business processes. Within the 3PL provider we have gathered the status logs of all orders within the past 6 months. A total of 61326 orders were recorded within the ERP system from 1-1-2013 till 31-6-2013. These orders are analyzed based on the states "start" and "afgehandeld" on which a date and time has been recorded. Based on the date and time we can conclude the number of days an order is in the ERP system and we can gather an estimate of efficiency of the operational business processes.

Although various other variables may be more suitable to measure operational efficiency, in the case of the 3PL provider the data provided by the status log tables within the ERP system proved to be optimal for measuring efficiency. In the logistics industry the operational process is time-bound and linear which allows throughput time to be a valid and analyzable measure.

Table 4 and Table 5 show the operational efficiency of the organization in number of days needed to complete an order. The efficiency is heavily influenced by the automational capabilities of the ERP system. The results tell a lot about the operations and the efficiency of the system as the physical shipment of the orders happens within 24 hours of the placement of the order.

Figure 10 Frequency Table of Order Processing Time

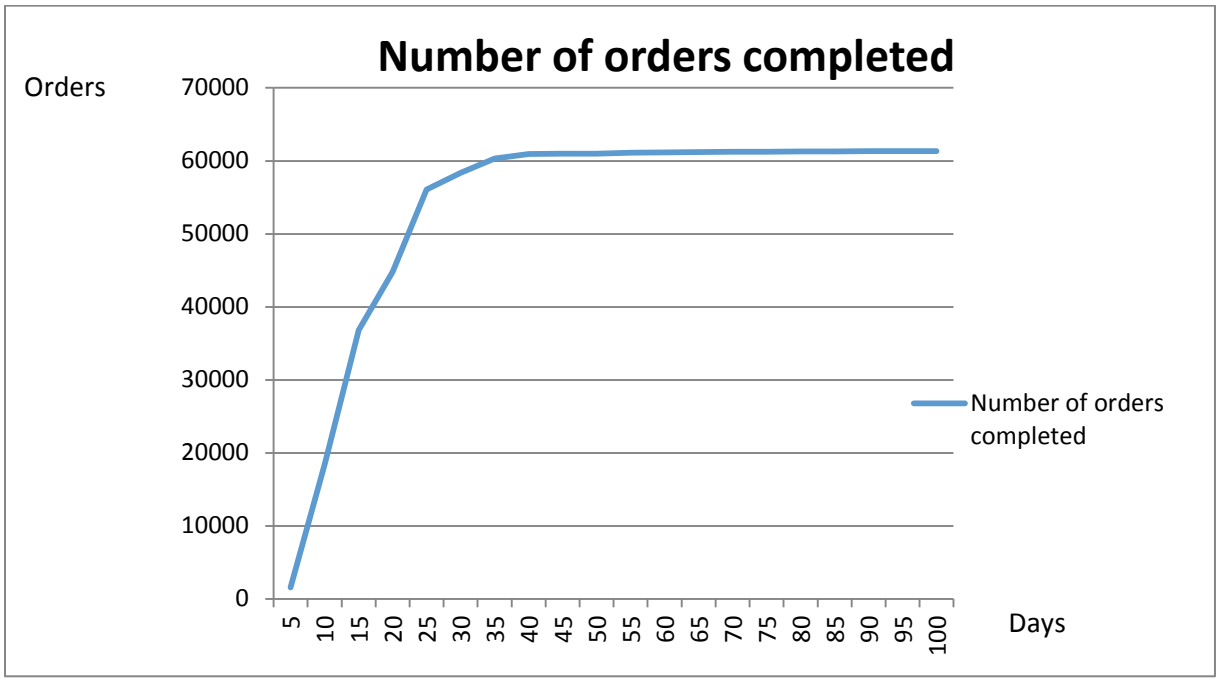


Table 4

Statistic:	Number of Days:
Number of orders completed	61326
Average of number of days	15,44
Standard Deviation	8
Minimum	2
First 25%	9
First 50%	14
First 75%	22
Maximum	100

While the physical shipment of the orders happens within 24 hours of the placement of an order as is required to be competitive within the logistics industry, the total process of completing an order takes on average 15.44 days. This shows that the ERP system is not functioning efficiently within the organisation as the numerous administrative processes alongside the physical shipment hurt the operational efficiency. Automational capabilities of the system should be able to greatly diminish this time if implemented correctly. The data also shows that the ERP system is not automating the

operational processes, but only used as a database in which information about orders is stored while in process.

The bad process efficiency shown by the high throughput time of orders in the past 6 months confirms the lack of automational effect that the ERP system has on the order process time. The amount of automational effect of the ERP system differs from division and process, but overall the ERP system lacks automational effects on the entire process.

As shown in Table 3 the following performance variables have been identified to measure operational effectivity: Utilization of resources, responsiveness and wastage. Within the 3PL resources are identified as components necessary to bring goods from a to b. Three categories exist:

1. Drivers
2. Trucks
3. Trailers

The utilization of these resources show how effective the current organisation is. Using the data stored in the ERP system regarding assignment of resources on drives we can calculate how many resources are utilized each day resulting in the average resource usage at the 3PL.

The table below shows the average usage of the resources during the first 6 months of 2013. For each resource group the number of resources used per day was divided by the total resources available.

The effectiveness of the usage of the various resources tells us how effective the business processes are.

Table 5 Resource Effectiveness

	Driver	Truck	Trailer	Driver%	Truck%	Trailer%
January	133	124	104	54%	78%	74%
February ...	133	125	106	56%	79%	77%
March	131	122	104	55%	78%	77%
April	128	119	101	54%	80%	72%
May	129	119	101	54%	76%	73%
June	125	115	97	50%	72%	74%

An average resource usage of 56% for drivers in January states that in this month 56 out of 100 drivers drove a transport each day. It shows how well the resources are utilized and how much resources are wasted. Next to this quantitative data we can use information gained from the interview to look at other variables affecting the effectiveness of the business processes.

The interview questions were analyzed using a multi-criteria analysis. (Dodgson, 2009) Each question is assigned to the different variables that are used to measure informational and transformational effects of the ERP system on business processes. Each question can be addressing multiple variables.

Every answer is an answer based on a 5-option scale ranging from very decreased to very increased. So for each variable we evaluate whether the ERP systems influence on that particular

variable has greatly decreased, decreased a little, stayed the same, increased a little or increased greatly. These categories are quantified ranging from -1 to 1, using half a point between each scale

Each answer is linked to one or multiple measures to which they relate as well as the effect the measure has on either the effectivity or flexibility of the business process. This allows us to gain insight in the effects the ERP system has on the business processes of each department. Furthermore it tells us how this impact affects the performance of the organisation. The following table shows the scores for each department regarding each measure.

Table 6 Interview scores

	Responsiveness	Problem prevention	Problem Fixing	Customer relationships	Cycle times
Planning	-3	-2,83	-1,67	-1,17	-1,17
Order Entry	-1,5	-1,5	-1,5	0	-1,5
Balie	-0,5	-1	-1	-0,5	-0,5
Dossiercontrole	-0,83	-1	0	-1,17	0,33
Roosterplanning	-1,75	-1	-1	0	-0,25
Financien	1,67	0,83	0	0,33	0,33
IT	1,5	0,5	-0,76	-0,47	-0,24
Overall	-0,8	-0,94	-0,76	-0,47	-0,24

In general the various departments indicate that the current ERP system is not supporting their performance effectivity or flexibility. The effects the different ERP variables have on the performance is rated negatively by most of the users of the system across the various operational departments within the 3PL.

7. Discussion and limitations

The research model presented within this research is used to study the effects of the ERP-system on the performance of the operational business processes. Furthermore, we look at the implementation of business process models to aid the alignment of the ERP system within the organisation. In this study we looked at only three of the nine possible relationships between ERP effects and business process performance. These three relationships were chosen on a logical basis where the strength of the relationships are far greater than the other six relationships.

The research model is set up to use on a longitudinal set of data in which multiple instances of IT-business process alignments and the related business process performances can be compared along a period of time. This study shows how business process performance can be related to the usage of the ERP system and offers a way to evaluate the current ERP implementation.

The evaluation of the current IT-alignment based on performance is very situational. This means that a certain ERP system or IT infrastructure can be in alignment with a the business processes for one organisation, while the same setup will not work for another organisation. This research does not contain a definitive statement on the relationships between the business processes and the ERP capabilities. The set of data drawn form the case study is not suitable for this purpose.

This study however shows a business process perspective on the often complex relationship between operational performance and the ways an ERP system affects this performance.

8. Conclusion

There are multiple views in which an organization can look at the current IT-alignment. In this thesis a process-based perspective is used to gain insight and evaluate the effects an ERP system has on the operational performance.

The model introduced in this research is used to evaluate the current IT-alignment and the effects of the current ERP implementation on business process performance. The model provides a set of capabilities an ERP system has and how this is used to improve the business processes within the organization. On the operational level, three distinct capabilities of the ERP system have been identified. The ERP system functions to increase the automational, informational and transformational effects of the IT alignment on business process efficiency, effectivity and flexibility.

The research model shows how the current ERP system can be measured on a business process level, by linking the capabilities of the ERP system to various business performance variables. In the case of the 3PL logistics company the fit does not seem to be there. While the focus of the ERP system has been towards the overall performance, the capability of the system seems to be only informational of nature due to the way the ERP system is implemented. The automational and transformational capabilities of the ERP system are underused and as a result the ERP system is not optimizing the business processes. Although the current usage is effective, it does not give the operational processes the required efficiency and/or flexibility to be of great value.

When looking at the capabilities of an ERP system and its effects on business processes the focus often is on providing automation and information. Transformational capabilities of an ERP system are hard to fit within the processes of the organisation and as a result are often neglected.

9. References

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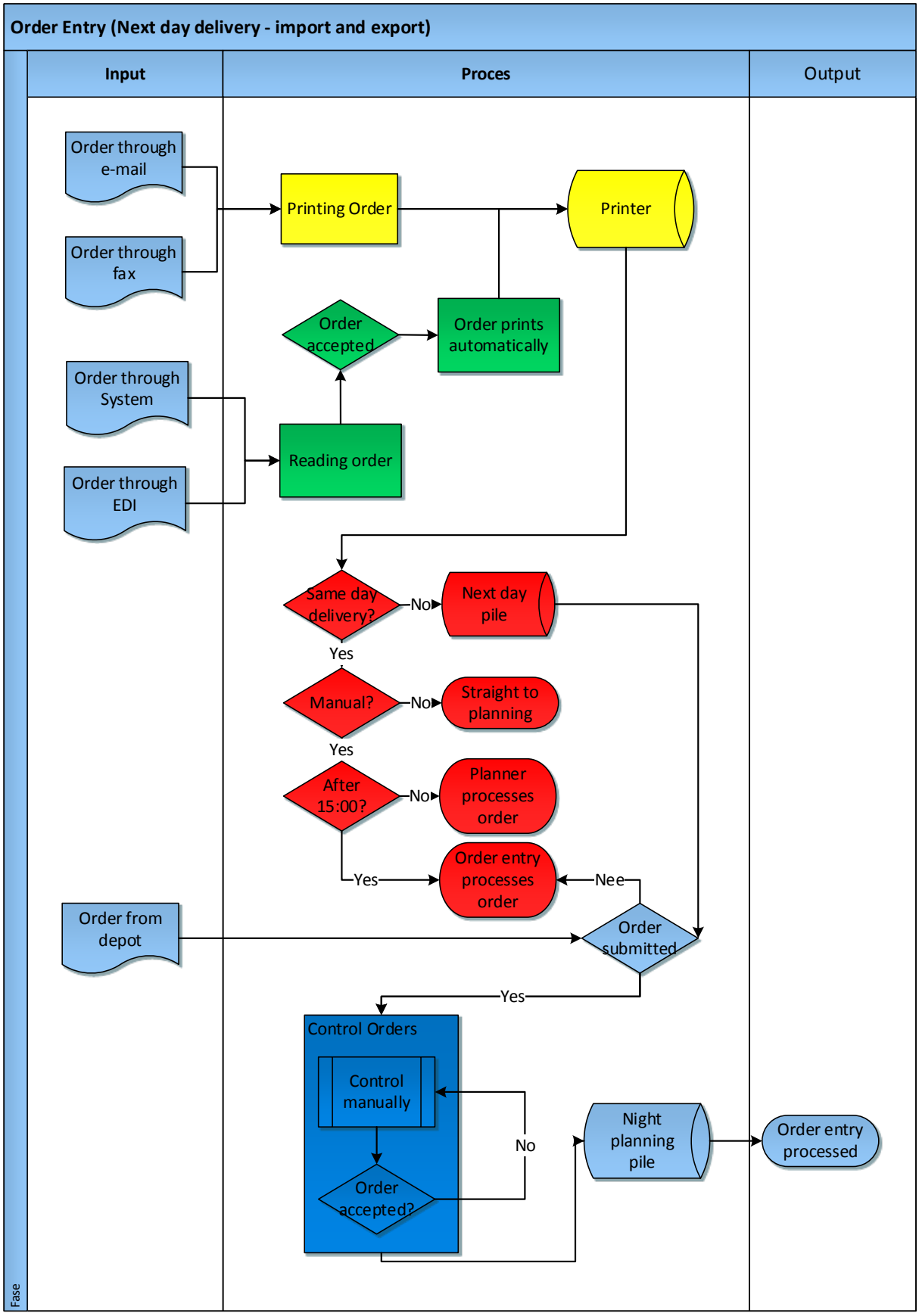
10. Appendix


Order Entry (Next day delivery - import and export)
Input
Proces
Output
Order through e-mail
Order through fax
Order through System
Order through EDI
Printing Order
Printer
Order accepted
Order prints automatically
Reading order
Same day delivery?
No
Next day pile
Yes
Manual?
No
Straight to planning
Yes
After 15:00?
No
Planner processes order
Yes
Order entry processes order
Nee
Order from depot
Order submitted
Yes
Control Orders
Control manually
Order accepted?
No
Night planning pile
Order entry processed
Fase

11. Glossary

3PL:	Third-party logistics provider.
BPEL:	Business process execution language is a technical notation for modeling business processes.
BPM:	The act of drawing and describing business processes, business process modeling.
BPMN:	Notation that can be used to perform business process modeling.
BPR:	Business process reengineering, the act of changing business processes.
ECA:	Event-condition-action is a term to describe trigger functionality, where a condition is met to trigger an action concerning a particular event.
ERP:	Software package that aims to assist all organizations functions.
PETRI-NET:	A Petri net (also known as a place/transition net or P/T net) is one of several mathematical modelling languages for the description of distributed systems.
SME:	Small and/or medium enterprise.
UML:	Unified modeling language is a modeling notation.
XML:	Extensible Markup Language (XML) is a markup language that defines a set of rules for encoding documents in a format that is both human-readable and machine-readable.