Supporting the module sequencing decision in the ERP implementation process—An application of the ANP method

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Abstract

The paper addresses the alignment between business processes and information technology in enterprise resource planning (ERP) implementation. More specifically, we concentrate on one of the key decisions at the tactical alignment level: the decision on the implementation sequence of the ERP modules. Since the module sequencing problem involves a myriad of organizational and technical issues, connected to each other in networked manner, the analytic network process (ANP) methodology is applied. As a result of the study, we present first a general level conceptual framework to sequence ERP module implementations and expand the model to a more detailed level in a case study. The priorities for the implementation sequence of the ERP modules are determined in the case study.

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1. Introduction

Contemporary organizations operate in a global environment that is characterized by constant change and different cultural settings. To avoid the fragmentation of the operational data in different business units, companies implement enterprise wide information systems, such as ERP (enterprise resource planning) systems that can increase control, improve coordination and communication, and create the picture about the corporate functions on the aggregate level. Typically, ERP-systems support financials, human resources, operations and logistics, and sales and marketing functions (Davenport, 1998).

The objective of ERP systems is to conduct the business processes more efficiently and effectively, in an integrated manner. They are a way to control functions of the organization and to make all the units perform in a more uniform way. Dramatic operational improvements are possible, through integration and redesigning of processes. It is assumed that the standard software package more or less fits all organizations, and all units inside one organization, which creates risks for ERP investments.

In theory, business processes are modified to fit the systems, since customizing the system is considered too expensive and too risky. But in practice both business processes and ERP systems are suspects to be changed during the implementation process. The technical nature of ERP software is already quite well described and known (see, for example, Klaus et al., 2000), but because of the ERP implementation related context-sensitive social diversity is huge, the perceived results and outcomes of ERP implementation vary a lot (Ross and Vitale, 2002; Scott and Vessey, 2000). There are a lot of problems reported in the implementation of these systems, and even the objectives of the system investments may evolve during the process (Glover et al., 1999; Nandhakumar et al., 2003; Themistocleous et al., 2001). Technology and the organization are in a continuous interaction with each
other during technology adoption and use, according to Orlikowski (1992). The alignment between business and IT is a dynamic process with bi-directional interaction.

The decisions affecting the alignment of the business and IT are made on strategic, tactical and operational levels (Hendrickx, 2002). The strategic decisions concerning ERP projects include, for example, which modules are implemented and how much business process re-engineering is conducted (Parr and Shanks, 2000; Mabert et al., 2003). The decisions on issues, such as, using internal or external resources for implementation and in which order the modules are implemented can be considered tactical in nature. Finally, the operational decisions are those concrete decisions affecting daily workflows.

The implementation of ERP software packages necessitates disruptive organizational change (Soh et al., 2000) and that's why there are considerable risks involved. When the problems surface they require countermeasures that require resources and time, such as providing more personnel training when the ERP implementation introduces significant changes in workflows. The risks and misfits between the organization and technology should be identified early for planning the change management issues (Soh et al., 2000, 2003). The scope of decisions that a company can make becomes smaller when the implementation process approaches actual operational implementation. The implementation can be conducted either as "big bang" or as phased implementation by site or by module (Mabert et al., 2000).

This paper studies the alignment of business and IT in a case where it was decided to phase the implementation by the ERP modules. A survey investigating companies in the United States reported that about 17% of organizations in their sample phased the ERP implementation by modules (Mabert et al., 2000), indicating that phasing the implementation by modules is rather common. Thus, the module sequencing decision can be considered as a relevant research problem. The aim of this paper is to provide the analytical means to analyze the investment parameters, including the risks, before the actual implementation starts, and based on the analysis to decide on the implementation sequence of the ERP modules. The implementation of some modules may need to be postponed, because the identified risks require time consuming countermeasures, whereas other modules may need to be implemented as soon as possible, because, for example, the legacy system is not working properly and has to be replaced. For some monolith and rigid ERP packages this module sequencing decision may be driven by technical imperatives, but more flexible technologies and service-oriented architectures will call for social negotiation to decide optimal sequence for available ERP modules and services.

Since the decision problem of the module sequence involves a myriad of organizational and technical issues, which are interconnected in networked manner, we propose the analytic network process (ANP) method (Saaty, 2001; Saaty and Özdemir, 2005) to be applied. The ANP methodology includes defining the decision-making criteria and their interrelationships as well as the decision alternatives. ANP methodology supports complex, networked decision-making with various intangible criteria. It improves the visibility of the decision-making process and generates the priorities between the decision alternatives. ANP has been applied to a variety of decision problems, including, for example, allocating proper service concepts to the different IT market segments (Partovi, 2001), investment evaluation (Kengpol and O'Brien, 2000), evaluating componentized Enterprise Information Technologies (Sarkis and Sundarraj, 2003), ERP systems evaluation (Shyur, 2003), and R&D project selection (Meade and Presley, 2002).

The application of the ANP methodology requires, first, developing the general level conceptual framework and, second, developing the framework at the detailed level for applying it in an actual case. In the next two sections we review the literature on ERP implementation and business and IT alignment to provide the conceptual foundations for the paper. Section 3 also describes the principles of the ANP method and defines the focus of analysis in the paper. Section 4 presents the results of the case study. Finally, section five discusses the results and conclusions of this paper.

2. ERP implementation process

ERP systems automate and integrate an organization’s business processes and allow data and information sharing across the different business functions. ERP implementation is an organizational, economic, and technical challenge. ERP implementation requires substantial business process changes at strategic, tactical as well as operational levels. ERP implementation is usually an extensive and costly process that takes time even years and many companies experience serious problems during the implementation process.

Because ERP implementation is both an organizational change process and an IT implementation process, the general models of organizational change and the general models of IT implementation process can be applied to the planning, execution, and evaluation of the ERP implementation. In the Lewin–Schein theory of change any organizational change can be viewed as a three-step process consisting of unfreezing, moving (or changing), and refreezing phases (Lewin, 1952; Schein, 1961). Unfreezing increases the receptivity of the client system to a possible change in the distribution and balance of social forces. Changing, or moving, alters the magnitude, direction, or number of driving and resisting forces, consequently shifting the equilibrium to a new level. Refreezing reinforces the new distribution of forces, thereby maintaining and stabilizing the new social equilibrium. Kwon and Zmud (1987) elaborated Lewin–Schein theory of change in their six-phase implementation model as described in Fig. 1.

As a response to the implementation problems with ERP systems, a number of factor and process models have been proposed to moderate these problems. The factor models describe an extensive set of risk factors as well as critical success factors for ERP implementation projects.
(Al-Mashari et al., 2003; Hong and Kim, 2001; Kositanurit et al., 2006; Nah and Lau, 2001; Sumner, 2000). The basic strategy behind the process models varies from a detailed phase model to a big bang approach. Rajagopal (2002) extended the process model proposed by Kwon and Zmud to the problems of the ERP implementation process and tied each phase of the general implementation model to the realm of ERP implementation. Parr and Shanks (2000) classified ERP implementations into three broad categories (comprehensive, middle road, and vanilla) and according to them ERP implementations differ with respect to the following characteristics: physical scope, BPR scope, technical scope, module implementation strategy, and resource allocation.

During the implementation process, different types of decisions have to be made. Mabert et al. (2003) recognize the following seven key strategic decision variables in the ERP implementation process:

- Single ERP package versus multiple packages.
- Big-Bang or mini Big-Bang versus a phased-in approach.
- Number of modules implemented.
- Order of implementation.
- Modifications to system.
- Major reengineering upfront versus limited reengineering.
- An accelerated implementation strategy.

ERP packages are wide-scale products that cover all significant functions of organizations. ERPs are not, however, monolithic, undivided giants, but are rather constructed by a number of modules that are independent in the sense that their implementation order can be determined relatively freely taking into account the organizational requirements. Proper implementation of the modules requires two decisions: (1) selection of the modules and (2) sequencing the implementation order of the modules. Both of these implementation decisions are grounded on business goals and requirements, costs, and risks. Additionally, for example, some technical solution constraints, resource limitations and organizational priorities can affect the decisions. Next, we discuss the alignment of business and IT in the ERP implementation process.

### 3. Alignment of business and IT in the ERP planning and implementation process

#### 3.1. Alignment along the phases of the ERP planning and implementation process

The alignment process can be seen as a change management process interacting with three domains: information systems, organizational processes, and organizational strategy (Earl et al., 1995). Alignment can be seen as an agreement of common goals between business and IT at strategic, tactical and operational levels and is realized when the common goals are achieved. Alignment is not a single “yes–no” decision, but a lasting attitude towards the cooperation between two or more parties. Also, alignment is not a separate process but it is inherent in every step of organizational decision making, change, and implementation processes.

Alignment must be considered along the phases of a multilevel decision process as business and IT are integrated at strategic, tactical and operational levels. An essential characteristic of strategic decision-making is its lack of structure, which might be due to the shortage of relevant information, high risk and uncertainty, novelty, and deficiencies in the decision-making process (Smith, 1988). The process can, however, be described through the following phases, according to Hofer and Schendel (1978):

2. Environmental analysis: to identify the major opportunities and threats.
3. Resource analysis: principal skills and resources available to close the strategic gaps.
4. Gap analysis: a comparison of an organization’s objectives, strategy, and resources against the opportunities and threats in its environment.
6. Strategic choice: the selection of one or more of the strategic options for implementation.

The strategic decisions are concretized at the tactical decision level. If, for example, an ERP strategy with given modules has been chosen, the right implementation order of those modules is a tactical level decision. Further, at the operative level, even more concrete measures are taken to...
implement the chosen system. At this stage, alignment of business and IT is achieved through very concrete changes in workflows and everyday processes.

Fig. 2 describes the ERP implementation process and positions the tactical module sequencing decision on the process. It should be noted that the scope of business, processes, organization units and IT decisions and the range of decision alternatives is diminishing along the implementation process. In practice this process is iterative and contains discontinuities when real world constraints disturb the ideal construction process.

3.2. Applying the analytic network process for the module sequencing decision

Campbell et al. (2005) have shown that the alignment between business and IT is a complicated process with a number of inter-relationships and feedback structures, which requires that the decision making method must be able to handle complicated feedback relationships between the key factors of the problem. The main advantage of the analytic network process is the ability to deal with various interactions and dependencies prevailing in real-life decision structures (Saaty, 2001; Saaty and Özdemir, 2005). ANP is a methodology that extends the analytic hierarchy process (AHP) (Saaty, 1980) to problems with dependence and feedback between the clusters of the decision situation. In ANP the hierarchical relations between criteria and alternatives are generalized to networks. “Many decision problems cannot be structured hierarchically, because they involve the interaction and dependence of higher-level elements on lower-level elements. Not only does the importance of the criteria determine the importance of the alternatives as in a hierarchy, but also the importance of the alternatives themselves determines the importance of the criteria” (Saaty, 2001). The selection of the ANP method for the current study is seen justified, because the decision problem at hand is of networked nature involving a myriad of tangible and intangible factors. The main strength of the ANP method is that it is goal oriented, like AHP, and it also allows the feedback loops in the model. Additionally, the ANP method also allows modeling the inter-related factors in the decision problem, which was considered important in this case.

Thus, in ANP the decision alternatives can depend on criteria and each other and criteria can depend on alternatives and other criteria. It is assumed that feedback can better capture the complex direct and indirect effects of the interplay in organizational settings and hence allows more systematic analysis of the decision situation. It allows the inclusion of both tangible and intangible criteria and the ratio scale measurements with pairwise comparisons are used to capture the judgments of the
decision makers. As a default structure, ANP offers four kinds of control criteria: benefits, costs, opportunities, and risks. These clusters of criteria can be used to make comparisons of outer or inner influences between the elements of the decision situation.

Technically, in ANP, the system structure is presented graphically and by matrix notations. The graphic presentation describes the network of influences among the elements and clusters by nodes and arcs. The results of pairwise comparisons (weights in priority vectors) are stored to matrices and further to a super matrix consisting of the lower-level priority vectors. After the super matrix is “normalized” to be column stochastic, arbitrary large number of powers of the matrix is taken. This is the genuine idea and challenge in ANP. By taking powers of the matrix, the indirect effects of the feedback relations are cumulated towards the equilibrium. In equilibrium, when all direct and indirect influences in the network are evaluated, the most important and most preferred alternatives have the highest limit priorities indicating that they must be implemented first. ANP process typically consists of the following six steps:

- Problem structuring:
  - Determine the logical grouping of the elements (clusters) in the problem to be modeled.
- Model definition at upper level:
  - Create the clusters.
- Model definition at lower level:
  - Build the nodes (elements) within each cluster.
- Model construction:
  - Create the links between nodes in the same cluster or in the other clusters.
- Data collection:
  - Make judgments in the form of pairwise comparisons with respect to a controlling element. System calculates priorities for decision elements.
- Solution:
  - Synthesize to prioritize the alternatives with respect to the structure of the whole system.

The problem-structuring phase cannot be done effectively without a deep understanding about the domain in question. Theoretical and practical knowledge helps to find the most essential issues and their relative significance. Typically the process starts from upper level and continues towards details.

The modeling process with an appropriate support system continues with the definition of the key clusters. Some clusters are devoted to criteria and some of them include the decision alternatives. When the clusters are defined, the elements inside each cluster are identified. After that, the relationships between the elements are defined in a dichotomized fashion; there is a link between two elements or there is not.

In data collection, it is important to present the questions in the right form. Alternatives are evaluated by the importance with respect to a criterion but a criterion is evaluated by the dominance of an alternative. Similarly, when making judgments about costs and risks, the questions are formulated asking which element is more costly or more risky. Fortunately, the construction of the super matrix and the process to synthesize are performed automatically by the support systems.

Saaty (1980) has shown mathematically that the eigenvector of the reciprocal comparison matrix corresponding to the highest eigenvalue is the only correct method to derive priority vector for the matrix. This holds true in ANP also. In ANP the singular priorities are collected to the super matrix according to the upper level control criterion. The highest control criterion is crucial when the resulting, system level, limiting priorities are interpreted. For example, if the highest criterion is “best ERP module implementation sequence”, then the priorities of the alternatives indicate the order of the implementation.

To summarize the discussion above, Table 1 describes the phases of the implementation process from the strategic decision to the tactical decisions as well as the application of the ANP method to the module sequencing problem, with an emphasis on the business/IT alignment perspective.

Phases 1–7 describe the strategy process where an organization defines its business strategies and investigates the resources and the strategic options to fulfill the plans. In the tactical phases of the process (phases 8–12) the ERP software and the vendor are selected, appropriate modules are chosen and their proper order of implementation is determined.

In this paper our focus is on the module sequencing phase and the decision process in that phase is operationalized following the principles of the ANP process, as described in Fig. 3. The components of the process are discussed in detail in the next section. It is assumed that the strategic decisions have been made as well as those concerning ERP software selection, vendor selection, and module selection.

Next, we will present a descriptive case to illustrate and evaluate the application of the ANP method for the module sequencing decision.

4. Application of the ANP method to the ERP module sequencing problem

4.1. Case context

The case organization is a global industrial manufacturing company, which has been growing through acquisitions. IT investments have been at quite a moderate level and the legacy systems are rather heterogeneous. Even the newest and most common legacy ERP software (referred to as legacy ERP) was not capable to respond to the sales & operations planning (S&OP) requirements, which caused the business to consider a major investment into a new enterprise information system.

European level program for reengineering of business operations was initiated, including a new business operations model, which required large changes into the enterprise information systems. Legacy ERP could be extended with supply chain management (SCM)
applications, but some of the major European business units were not interested in investing into the somewhat old-fashioned legacy ERP, which should be further extended with SCM and CRM applications. Also American and Asia-Pacific business operations were interested in investing in the new ERP system for several business reasons, but it was decided to start renewing ERP systems from Europe.

<table>
<thead>
<tr>
<th>Decision level</th>
<th>Phase</th>
<th>Aligning activities</th>
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<tbody>
<tr>
<td>Strategic decisions</td>
<td>1. Strategy identification</td>
<td>Assessment of current business and IT strategies and their main components.</td>
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<td></td>
<td>2. Environmental analysis</td>
<td>Identification of the major business and IT opportunities and threats.</td>
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<td></td>
<td>3. Resource analysis</td>
<td>Evaluation of the principal skills and resources available.</td>
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<td>4. Goal setting</td>
<td>Identification of the most important business and IT goals and objectives and their relationships.</td>
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<td></td>
<td>5. Gap analysis</td>
<td>Comparison of an organization’s business and IT goals, objectives, strategy, and resources against the opportunities and threats in its environment.</td>
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<td></td>
<td>6. Resource allocation</td>
<td>Identification, formulation and alignment of the strategic options for business and IT.</td>
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<td></td>
<td>7. ERP decision</td>
<td>Decision to redesign business processes and apply an ERP-strategy.</td>
</tr>
<tr>
<td></td>
<td>8. ERP software selection</td>
<td>Comparing and selecting the best possible ERP-software with respect to the business requirements.</td>
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<td></td>
<td>9. Vendor selection</td>
<td>Selecting the vendor for the software.</td>
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<td></td>
<td>10. Module selection</td>
<td>Deciding which modules are going to be implemented.</td>
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<td></td>
<td>11. Module sequencing (ANP)</td>
<td>Determine the logical grouping of the elements (business and technical clusters) in the sequencing problem.</td>
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<td></td>
<td>11.1 Problem structuring</td>
<td>Create the clusters.</td>
</tr>
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<td></td>
<td>11.2 Model definition at upper level</td>
<td>Build the nodes (elements) within each cluster.</td>
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<td></td>
<td>11.3 Model definition at lower level</td>
<td>Create the links between nodes in the same cluster or in the other clusters.</td>
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<td></td>
<td>11.4 Model construction</td>
<td>Make judgments in the form of pairwise comparisons with respect to a controlling element. System calculates priorities for decision elements.</td>
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<td>11.5 Data collection</td>
<td>Synthesize to prioritize the alternatives with respect to the structure of the whole network.</td>
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<td>11.6 Solution</td>
<td>Evaluate how sensitive the priorities of the alternatives are to changes in input data.</td>
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<td>11.7 Sensitivity analysis</td>
<td>Make the final sequencing choices.</td>
</tr>
<tr>
<td>Tactical decisions</td>
<td>12. Choice</td>
<td>Implement the ERP modules in organizational environment.</td>
</tr>
<tr>
<td>Operative decisions</td>
<td>13. Implementation</td>
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</tbody>
</table>
When business units decided to start investigations aiming to new ERP implementation, they thought that their financials and relatively new data warehouse-based OLAP-reporting solution should remain untouched. Therefore they did not collect key business requirements for these business domains. Software comparison started with careful focus to sales & operations planning process, which was the driving force for the future business operating model. After careful investigations and ERP software comparisons, Oracle eBusiness Suite was selected to be the preferred ERP software to fulfill the various business requirements better than competitors’...
products or the legacy ERP. Next, we will present the results of the ANP analysis on the ERP module sequencing for the case company.

4.2. ANP model for ERP module sequencing

The conceptual foundation of our analytic model is shown in Fig. 4: from the investment control perspective there are costs and risks, and the key business require-

ments and solution constraints represent the alignment perspective between business needs and technical limitations. The final grouping of the elements for ERP module sequencing decision is shown in Fig. 5. Social constraints and change resistance related elements are included in risks and solution constraints, and organizational scoping and sequencing preferences are embedded into solution requirements. Naturally, one cluster includes the alternative modules. The model is designed with the Super Decisions ANP tool (www.superdecisions.com).

The optimal implementation sequence is analyzed against the criteria of key business requirements, solution constraints, costs and risks, identified as clusters in the model. Clusters include sub-elements called nodes. In this model, the key business requirements, costs and risks are the criteria directly connected to the goal of sequencing alternative ERP modules. The solution constraints have more complex relationships between the alternative modules and other criteria, because what is possible from the software perspective may be limited by the sometimes conflicting business requirements, all bringing in some implementation costs and risks. In solution constraints, some of the individual tasks were considered inner-dependent, but in other clusters we assume that there aren’t any remarkable inner-dependencies. There are some two-directional relationships in the model, for example, we can compare the importance of “adaptation requirements” and “vendor experience” (in the risks cluster) with respect to the “marketing and sales” in the alternative modules cluster. Also, the importance of “business intelligence” and “marketing and sales” (in the alternative modules cluster) can be compared with respect to the “vendor experience” in the risks cluster. While making our ANP model definitions at the lower level and building the nodes (elements) within each cluster, we tied the model tightly to our case context. The key business requirements cluster has 24 nodes, which are derived directly from the most important process steps for demand forecasting as documented in the software

Fig. 4. Conceptual foundation of the ANP model.

Fig. 5. High-level ANP model for ERP module sequencing.

Fig. 6. Detailed ANP model for ERP module sequencing.
selection phase in the case company. The risks and costs of
the ERP project in the model, such as application
complexity and vendor experience, reflect rather well
other corporate wide software investments, such as the
case of Web Content Management investments reported
by Hallikainen et al. (2006). The nodes in the alternative
eBusiness Suite modules cluster include altogether nine
modules or module domains as possible candidates for
ERP module implementation. The detailed ANP model is
depicted in Fig. 6.

Next, we will discuss in more details the key business
requirements, the solution constraints as well as the risks
and costs of the ERP investment, which play a vital role
while prioritizing ERP modules for ERP implementation.
The alternative modules are determined by the ERP
software that has been chosen to be implemented.

4.2.1. Key business requirements

The key business requirements represent the features
expected from the ERP system. The case company consists
of four divisions using different manufacturing technolo-
gies and serving different customer needs, which means
that each division has somewhat different key business
requirements and priorities. This was thought to result to
four different ERP systems, but because the parent
company was willing to invest in corporate wide sales &
operations planning process support, the corporate ex-
cutives were able to drive the joint investment towards
one ERP system.

The initial list of the key business requirements was
impressive with 244 key business requirements (224 main
requirements and 20 sub-requirements) for the main
process areas covering new product development, forecast
to finished goods, procure to pay, and order to cash
processes. These requirements were generated while
preparing the ERP adoption decision, and at that point in
time the financial operations, internal accounting and
reporting processes were considered to be out-of-scope
for this investment. As the investment process proceeded,
the key business requirements became more focused and
the scope of decisions narrowed as the process continued
towards specific vendor and software selection, as
described in Fig. 2. At the time of the module sequencing
decision the vendor and software decisions had already
been made.

For ANP purposes the 244 key business requirements
are far too much for pairwise comparisons. Therefore we
focused our ANP model on the first process step of sales
and operations planning called as “demand manage-
ment”. This process step contains 24 key business
requirements ranging from new product development to
key account management, from graphical user interface to
analytical reporting requirements, from budgeting inte-
gration to master data management and customer
collaboration. Because demand management is one of
the most important strategic activities for the new
business operations model, and because this selection of
24 key business requirements well represents the whole
variety of strategic, tactical, operational and technical key
business requirements for the case, we have selected these
24 key business requirements as nodes in our ANP model.

4.2.2. Solution constraints

The solution constraints represent mostly intangible
environmental factors that may limit the ERP implemen-
tation and the realization of the benefits enabled by the
new ERP software. The solution constraints cluster has a
loop to itself, thus the cluster is called inner dependent
(Saaty, 2005). Typically these kinds of constraints can be
related to internal and/or external resources, services,
capabilities, data models and relationships, which may
require additional efforts, time and money to be converted
into the ERP compatible model. In our case, we listed 12
solution constraints. Solution constraints are often in-
cluded as topics for change management activities, which
try to manage these constraints, risks and costs in a
proactive manner. Our ANP model includes the following
solution constraints: knowledge, process culture, localiza-
tions, integration, services, module dependencies, data,
networks, software tools/components, hardware configurations, usability, centralization/decentralization. Solution constraints may eliminate, delay or decrease the benefit realization despite of the technically optimal ERP system and implementation efforts. It is important to notice that these solution constraints and business requirements are likely to be different for different organization units.

4.2.3. Risks and costs of ERP implementation

In our model, there are both systematic and unsystematic risks. Systematic risk stems from outside of the company and unsystematic from inside of the company (Shapiro, 1991). Systematic risks can include unexpected technological changes creating adaptation requirements as well as issues related to the vendor’s experience about the applied technology and about the field of industry where the company operates. The software development uncertainty factors proposed by Barki et al. (1993) form the basis for assessing unsystematic risks in our study. The respective criteria are application complexity, application size, organizational environment, expertise, and technological novelty.

The cost are divided into business costs and IT costs, since not all cost can be directly allocated as IT costs.

4.3. Preferred ERP module sequence

Using the ANP model for the ERP module sequencing, the pairwise comparisons were entered into our Super Decision model using questionnaire comparisons. The person, who collected the data, is a senior consultant participating in the project and he discussed regularly with management representatives and other stakeholders. Thus, we see that he had all the relevant knowledge and experience for collecting the data. Moreover, the data collection was approved by the case company. A data entry example as questionnaire mode is presented in Fig. 7.

Data entry with this big ANP model is a rather tedious process, which may cause data errors. Super Decisions contains functionality to check consistency for data entries, and these features were used to eliminate the errors in data collection. Because the model structure is derived from the sequencing problem, the limit priorities of the alternative modules indicate directly the order of the implementation. The general goal (G01: Best ERP module implementation sequence), the clusters and the nodes inside them, and the influences are all developed from the sequencing problem at hand.

After the data entries we were able to report the following overall synthesized priorities for alternative ERP modules as depicted in Fig. 8.

These results mean that the prioritized ERP module implementation sequence for our case is:

1. M05.4 DP: Demand planning from M05 supply chain planning suite.
2. M02 marketing and sales: EBS/CRM marketing and sales suite.
3. M03 order management: EBS/ERP order fulfillment suite.
4. M05.5 CP: Collaborative planning from M05 supply chain planning suite.
5. M04 logistics: EBS/ERP inventory and transportation modules.
6. M01 intelligence: EBS intelligence and analytical reporting.

This list gives one possible sequence for the ERP module implementation. However, the results presented here must be addressed with caution and they may not be considered an absolute recommendation. For example, the decision-makers could evaluate various combinations and ERP module configurations before running into ERP implementation: there are other options than implementing only the top prioritized ERP modules or
implementing all the relevant ERP modules from 1 to 9 at the same time. In this case, one possible option for solution phasing might be the implementation in three different ERP module groups: demand forecasting and fulfillment history related modules ranked between 1 and 5, master data and reporting modules ranked between 6 and 8, and financials as a separate module ranked as the least important. Again, these ERP module groups might be implemented in various sequences: if quick benefits are preferred, the implementation might start from demand related modules; if risk avoidance is preferred, implementation might start from financials; if all benefits are preferred and additional investments are done to change management, then implementation project might try to implement all the possible modules at the same time.

5. Discussion and conclusions

We believe that the process presented in the paper represents a relevant model for improving business and IT alignment for ERP implementation. The ANP methodology itself seems to be applicable for this kind of decision-making, although its application is somewhat laborious and also requires theoretical knowledge on the method. However, the ANP approach enforces the analytical comparison between the alternatives as well as improves the decision visibility, for example, for external auditors and boards investing huge amounts of money in the ERP software.

The analysis conducted in the present paper brings insights to the ERP module sequencing problem. We developed an ANP model for deciding on the implementation sequence of ERP modules, using the alignment of business and IT and the IT investment perspective as the theoretical foundation for the model. We described the decision-making process for ERP module sequencing and the application of the ANP method in detail to enhance the practical usability of the method. The method can be considered rather easy to use and very informative in terms of providing clear results. Our model is technology oriented focusing on software module sequencing, meanwhile social construction elements are embedded into business requirements, risks and solution constraints. However, the method has its limitations as well, such as the model becoming easily rather complicated, which may limit its use in some situations.

The benefits from utilizing this ANP model for ERP module sequencing do not only come from the explicit priorities between the alternative modules. Major value can be derived from the knowledge transfer during the ANP data collection process, because answering to pairwise comparisons requires an enhanced dialog between the ERP vendor, the IS department and the business units. ERP implementation process is more knowledge, resource, requirements and change management challenge than technical IT system deployment. Thus, issues regarding IT and business alignment, as well as IT governance might surface during the data collection process. Key business requirements may be biased, current understanding about solution constraints may be limited, and priorities may be unintentionally sub-optimized because of bounded rationality and past experiences from non-integrated operations and systems with limited data models.

The reason for choosing the ANP method was that it is suitable for networked decision problems. Similar analysis could be conducted, for example, by applying a system dynamics model in combination with the AHP model. An example of this approach can be found in Kivijärvi and Tuominen (1991). The main strength of the ANP method is that it is goal oriented and it also allows the feedback loops in the model (which is not possible in AHP, for example).

The most obvious limitation of the applicability of the ANP method is the very high number or pairwise comparisons that need to be conducted. However, there are several different ways in which the data input can be conducted, such as graphic, verbal, matrix and questionnaire formats that can be used to input the data, which can make the data collection easier. As AHP, ANP also has the rank reversal problem, meaning that adding an indifferent alternative or criterion to the model may actually reverse the whole solution (Dyer, 1990; Pérez et al., 2006). Furthermore, the results of the sensitivity analyses in ANP are rather difficult to interpret and may thus have very limited value. Moreover, a certain amount of theoretical knowledge is needed to choose the method for calculating the limit matrix. There are many different ways to calculate the results, which may be confusing to a non-expert user. This may limit the practical use of the method. In the present paper we used the “calculus type” for calculating the limit matrix, which is recommended by, for example, Adams (2001). Finally, there are also limitations related to the software used in the analysis, for example, the Superdecisions software does not allow multiple users to work on the model simultaneously, which is allowed, for example, when using AHP and the Expert Choice software. Furthermore, the overall consistency of the model is more difficult to calculate in ANP than in AHP.

ERP module sequencing is not a simple task: it requires patience and careful analysis of the key business requirements, the solution constraints, the risks and the costs as well as the alternative ERP modules. Since the decision involves a myriad of issues, the results of the analysis must be addressed with caution and they may not be considered an absolute recommendation. For example, there are other options than implementing only the top prioritized ERP modules or implementing all the relevant ERP modules from 1 to 9 at the same time. As described in the previous section, one possible option might be the implementation in module groups.

For practical usability, the abstraction level of the ANP model should be carefully considered and the analysis should focus on a rather limited decision-making domain to control the complexity of the analysis. The ANP process itself, however, is valuable for enhanced knowledge transfer and improved communications regarding the ERP module sequencing decisions, and simultaneously improving business and IT alignment. The future research could include combining the ANP method with other decision support methods to provide a more comprehen-
sive methodology for the ERP investment process. The ANP model developed could also be used in ERP software selection phase: comparing alternative modules and solution constraints from various ERP packages could improve understanding of the differences between different technologies.

References


