Abstract

In this paper, an ANP (Analytic Network Process) model is developed to aid a buyer company in prioritizing suppliers for adopting electronic invoicing. The case company is a leading Finnish textile and clothing design company. Because implementing e-invoicing with all the suppliers at the same time would require too many financial and other resources, it is necessary to schedule the implementations among the suppliers. Since the problem involves a lot of interconnected decision making criteria, the ANP method is considered suitable for this type of decision problem. The ANP model is constructed based on the business value concept as the main goal. As the result of analysis, the priorities between the suppliers are computed and the results can be applied to schedule the e-invoicing implementations among the supplier companies.

1. Introduction

The invoicing process is one of the key processes between organizations that can be automated. The European Union has recognized electronic invoicing (e-invoicing) applications as one of the most important sources of productivity increases in Europe [1]. According to the European Association of Corporate Treasurers (EACT), the resulting processing cost reductions in the supply chain expenditures total 243 billion Euros across Europe [1].

In addition to the traditional EDI applications, companies are implementing the XML-based, many to many e-invoicing to administrate invoicing activities as a critical part of the supply chain. Investment in a modern e-invoicing application improves organizational IT integration capability. Generally, the relation-specific IT investments, like e-invoicing, enhance cross-border, interorganizational processes and capabilities and, as a consequence, allow more efficient governance structures.

In this paper our focus is on the decision problem of transferring the firm’s suppliers to electronic invoicing. Since it is reasonable for a firm to invest in those IT projects that give the highest total benefits in every given situation, we examine which one of the firm’s suppliers are those that should be transferred to the e-invoicing first, i.e. which of the supplier relationships are those that would benefit most of automating the invoicing process. However, this is not a straightforward problem, since moving one single supplier to the e-invoicing system may require administrative efforts, user education, system adoption, and other implementation actions. Furthermore, it is important to consider the risks related in electronic invoicing projects since Standish Group [2] estimated that only 32% of IT projects were delivered on time, on budget, with required features and functions.

The primary research question of the paper is: In which sequence should the suppliers be transferred into the e-invoicing system? Since the decision problem involves a myriad of organizational and technical issues, which are interconnected in networked manner, we propose the Analytic Network Process (ANP) method [3, 4, 5] to be applied. The ANP methodology includes defining the decision-making criteria and their interrelationships as well as the decision alternatives. The ANP methodology supports complex, networked decision-making with various tangible and intangible criteria. It improves the visibility of the decision-making process and generates the priorities between the decision alternatives and among decision criteria. ANP has been applied to a variety of decision problems, including, for example, allocating proper service concepts to the different IT market segments [6], investment evaluation [7], evaluating componentized Enterprise Information Technologies [8], ERP systems evaluation [9], and R&D project selection [10].

In the current study, we develop and apply an ANP model to support supplier prioritization for e-invoicing at Marimekko corporation. Marimekko is a leading Finnish textile industry company, focusing on clothing, interior decoration, and bags. Marimekko operates mainly from Finland, but has subsidiaries in Sweden and Germany, as well as a retail shop in UK. In addition, Marimekko products are exported to over 40 countries. The results of the ANP analysis were considered valuable by the decision makers in the company providing support for the practical usability of the method.

The paper is organized as follows. In the next section we discuss the business value considerations to establish the theoretical foundation for the scheduling decision. In section three, we develop the ANP decision model. Section four presents the case study. Finally, the results are discussed and the paper is concluded in section five.
2. Maximizing business value in scheduling supplier e-invoicing project phases

2.1. Theoretical scopes

Different theoretical approaches have been applied to study the value created by IT in supply chain management. Transaction cost theory [11] explains the particular structure of a firm, especially, the extent of the vertical integration. The theory proposes when a firm should produce goods or services on its own or to use markets by outsourcing. Because the usage of markets is not free, a firm should, in addition to the sole market prices, pay special attention to transaction costs like search, contracting, coordination, and communication costs. The make-or-buy decisions are finally based on those costs. Transactions can have high or low uncertainties (risks) depending, at least partly, on the length of time over which the transactions are going to take place. Operating on markets creates the risks of one type whereas operating inside the organizations can create the risks of another type.

Implementing new IT technology is generally seen as a means to create such kinds of organizational structures that the different components of the transaction costs are reduced. In supply chain research, transaction cost theory has been applied extensively to study the direct or indirect effects of IT [12, 13, 14].

Another perspective to the strategic decision making and management and the economic theory of an organization, especially that of the firm, is the resource-based view of the firm [15, 16, 17]. This approach suggests that firms should position themselves strategically based on their rare, valuable, nonsubstitutable, and imperfectly imitable resources and capabilities instead of the products and services. It is assumed that the collection of these resources (tangible and intangible assets) are the primary predictors also of the market-based and financial-based performance. According to this approach, the competitive advantage of a firm is finally based on resource heterogeneity and resource immobility. In the markets, there are not similar organizations with similar resource-bases and competitors find it impossible or difficult to imitate or substitute these resources.

For information systems research, the resource based view provides a coherent framework to evaluate the business value of IT-related resources [18, 19, 20, 21]. Wade and Hulland [20] categorize IS resources into eight classes including resources for managing external relationships and resources to provide cost effective IS operations. The first one ‘represents the firm’s ability to manage linkages between the IS function and stakeholders outside the firm’. Secondly, IS resources can aim to reduce costs and to increase business value. It is clear that IS resources related to e-invoicing can improve managing linkages to suppliers and to reduce involved costs.

From both a theoretical and a managerial point of view, organizations can realize relational advantages [22, 23] and network externalities by cooperation and networking. A growing source of competitive advantage is gained by building inter-organizational routines and processes. Instead of a single firm, the relational view emphasizes the pair or a network of firms. It is assumed that the relation specific investments and knowledge sharing routines between firms are the major sources of competitive advantage and other types of business value. The realization of the relational advantages is dependent upon the effectiveness of the governance applied. The primary aim of entering into e-invoicing is to increase the effectiveness of interorganizational financial governance in order to achieve business value otherwise not available.

Generally, network externalities are “positive or negative effects that one economic agent’s actions have on another’s welfare that are not regulated by the system of prices” [24]. One type of network effects is local network effects [25]. The network effects depend on the interaction patterns of local collaborators rather than the total number of members in the global network. In e-invoicing context the utility for two collaborators is created through automatic data sharing.

2.2. Supply chain management and business value

Mentzler et al [26] define supply chain management (SCM) “as the systemic, strategic coordination of the traditional business functions and the tactics across these business functions within a particular company and across businesses within the supply chain, for the purposes of improving the long-term performance of the individual companies and the supply chain as a whole”. In their conceptualization SCM incorporate such activities as integrated behavior towards customers and suppliers, sharing information, risks and rewards mutually, cooperation, keeping the same goals and focusing on serving customers. The performance or the efficiency of the supply chain (SC) can be evaluated by a number of measures such as lower costs, improved customer value and satisfaction, and competitive advantage [26].

Generally, individual behavior as well as organizational processes are at the bottom based on values. Values are those grounding preferences that guide our selections in different decision situations. In Rokeach’s definition, values are seen as forms of beliefs: A value is “an enduring belief that a specific mode of conduct or end-state of existence is personally or socially preferable to an opposite or converse mode of conduct or end-state of existence” [27]. Instead of a single value, a person’s behavior is guided by a cluster of values or by a value system where hierarchical relations typically exist, as Fritzscbe states: “A series of clusters of values together form a person’s value system consisting of a value hierarchy or priority structure based upon the relative importance of the individual values” [28].

In organizational context, “organizational value systems
opportunities may or may not be materialized and a are called positive risks or opportunities. Risks and Sometimes risks have favorable impact on outcomes and alternative indicate risks to the involved organization. Mental effort needed and the quality of decisions [30, 31].

Researchers in behavioral decision making have proposed a cost-benefit theory suggesting that benefit analysis. In general, all decision situations have favorable and unfavorable concerns. Favorable concerns are indicative of successful outcomes whereas unfavorable concerns are manifesting opposite, negative outcomes. Whatever the SC decision involves there always are favorable and unfavorable concerns to be evaluated. Similarly, some outcomes are relatively definite and fixed whereas others have more unpredictable aspects. This certain-uncertain dichotomy holds equally to favorable and unfavorable concerns.

When the economic aspects of a decision are of importance, relatively certain, favorable outcomes are known as ‘benefits’ and unfavorable outcomes as ‘costs’. In traditional cost-benefit analysis (or benefit-cost analysis) benefits and costs are expressed in terms of money. The cost-benefit ratio is a key measure of an investment analysis and it attempts to identify the relationship between the costs and benefits of decision alternatives. The challenge with cost-benefit analysis is to transform qualitative, intangible outcomes into monetary measures unambiguously. A lot of research efforts have been made to include both quantitative and qualitative factors in cost-benefit analysis. Researchers in behavioral decision making have proposed a cost-benefit theory suggesting that decision makers change decision strategy depending on the mental effort needed and the quality of decisions [30, 31].

Unfavorable and uncertain outcomes of a decision alternative indicate risks to the involved organization. Sometimes risks have favorable impact on outcomes and are called positive risks or opportunities. Risks and opportunities may or may not be materialized and a significant part of SCM is to mitigate risks and maximize opportunities.

In Table 1, the business value concept is classified by the four dichotomies discussed above into four sets and named benefits, costs, opportunities and risks. This classification in commonly used in studies applying the principles of the Analytic Network Process as discussed in section three. In the table, the uncertain outcomes are affected by factors inside the organization (unique, organization specific factors) and factors that are beyond the control of the organization (market factors). In SCM, there can be tangible as well as intangible benefits and in IT –mediated SCM there are, of course, business related and IT related costs.

<table>
<thead>
<tr>
<th></th>
<th>Certain outcomes</th>
<th>Uncertain outcomes</th>
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<tbody>
<tr>
<td><strong>Favourable</strong></td>
<td>Benefits</td>
<td>Opportunities</td>
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<tr>
<td>outcomes</td>
<td>• Tangible</td>
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<td>• Intangible</td>
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<td><strong>Unfavourable</strong></td>
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<td>outcomes</td>
<td>• Business cost</td>
<td>• Market</td>
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<td></td>
<td>• IT costs</td>
<td>• Unique</td>
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</table>

Table 1. Constitution of business value

2.3. Strategies for electronic invoicing

By definition, electronic invoicing means transferring the invoice data in electronic format between the two business entities. As a concept, electronic invoicing is not something totally new as invoices have been transmitted in electronic format for decades. Already in the 1970s, EDIFACT was used by large companies as a means to exchange invoice data. These systems were point-to-point systems, and required somewhat heavy investments in establishing the connection between the two companies or organizations. In this paper, however, we leave these legacy systems out of our scope and define electronic invoices as invoices transmitted through many-to-many networks and XML-based open standards (e.g., Finvoice standard developed by the Federation of Finnish banks or the TEAPSSXML standard developed by Tieto in the Finnish context).

Our focus is on the automation of invoicing processes and this in turn requires that the invoice data is sent in a structured format. Therefore, invoices that are transmitted as attachments (PDFs etc) in e-mails are not considered as electronic invoices. This is because e-mail attachments do not allow for the invoice data to be automatically processed in the payment system. For the most recent developments on e-invoicing systems in Europe, we refer to Innopay [32] and Billentis [33].

In Finland, there are two types of operators in the field of electronic invoicing. First, there are the banks that target the SMEs in providing a cost-efficient way of transmitting
invoice data in structured format between the buyer and the seller. Second, there are the IT operators that provide invoice transmission service but with more complete systems that are integrated to the company’s financial systems.

To initiate electronic invoicing, a company chooses one operator (bank or an IT operator) for its incoming invoices and another for outgoing invoices. A company can choose the same operator for both incoming and outgoing invoices, but very often companies select different operators. This is due to the fact that some operators focus their R&D and systems development on either incoming or outgoing invoices. As an example, some of the operators offer scanning services, which means that the incoming paper invoices are scanned into electronic format by the operator. Figure 1 depicts the alternative ways of transmitting electronic invoice data in Finland.

![Figure 1. Alternative e-invoicing strategies (Tieke [34])]()

The ultimate objective in electronic invoicing is that the invoice data flows directly to the payment and accounting systems of the buying organization, allowing the automation of payment processes as well as, eventually, accounting practices. Receiving the invoice data in electronic format makes the invoice handling process at the buying organization more efficient and generates cost savings. The seller, on the other hand, saves in mailing costs, and it is also reported that implementing electronic invoicing reduces the number of errors in invoicing between the two business parties. The lower number of errors generates cost savings mainly to the seller organization.

2.4. Supplier prioritization for e-invoicing

Cox [35] categorized buyers’ relationships with suppliers as reactive or proactive. Buyers with the reactive focus have only short-term contracting relationships with suppliers and the relationship is not truly collaborative. Proactive focus means developing the supplier relationships actively. The buyer and the supplier make dedicated investments in the relationship and create technical bonds and relationship specific adaptations [35]. The aim is to create a collaborative long-term relationship. Considering the context of the present study, companies can consider establishing electronic invoicing to reduce the costs of the relationship and to help building a long-term relationship with the suppliers. However, the buyer needs to consider which ones of the suppliers would be the most potential for developing the enhanced relationship, in terms of, for example, expected cost savings and other benefits.

There is an abundance of research on supplier selection and efficient procurement that utilizes various types of optimization methods with single or multiple criteria [36]. The concept of value is always at least in implicitly in the supplier evaluation process and as discussed above there are basically three of thought concerning values: the transaction cost based perspective, the resource based perspective [37] and the relational view. Based on the transaction cost theory, the co-operative arrangements increase integration among economic activities in order to exploit transactional efficiencies or latent production economies [38]. In addition to the consideration of the benefits, the transaction cost perspective also includes the consideration of the risks related to the co-operation. The resource based perspective takes a more holistic approach to value creation, emphasizing that, in addition to the primary goals, such as cost reduction, there may occur an array of other benefits over time as the relationship develops [37]. Relational view highlights the value created by relation-specific investments in the network of firms.

Arguably, supplier selection is a multi-criteria problem, since, for example, in the case of electronic invoicing it involves criteria related to business and IT. The supplier selection process should start with problem definition, i.e. defining what exactly we want to achieve by selecting a supplier [36]. In the e-invoicing context examined in this paper, we propose that suppliers for e-invoicing are selected based on the potential business value that could be generated. The next step in the process is criteria formulation and pre-selection of suppliers (reducing the set of suppliers to a small number of candidates) [36].
3. ANP model with BOCR

3.1 Analytical Network Process (ANP)

Since the supplier prioritization decision involves an array of organizational and technical issues, connected to each other in a networked manner, the Analytic Network Process (ANP) methodology [3, 4, 5] is applied in this study. 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. 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.

ANP has been applied to a variety of decision problems, including, for example, allocating proper service concepts to the different IT market segments [6], investment evaluation [7], evaluating componentized Enterprise Information Technologies [8], ERP systems evaluation [9], R&D project selection [10], and SWOT analysis [39].

The main advantage of the ANP is the ability to deal with various interactions and dependencies prevailing in real-life decision structures [3, 4, 5]. ANP is a methodology that extends the Analytic Hierarchy Process (AHP) [40] to problems with dependence and feedback between the logical grouping of the elements (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" [3]. 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.

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.

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 (suppliers) have the highest limit priorities indicating that they must be implemented first. ANP process typically consists of the seven steps which can be grouped into a common framework of decision making – intelligence, design, and choice – as proposed by Simon [41].

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. After 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.

Saaty [40] 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.

As a default structure, ANP offers four kinds of subnets: benefits, costs, opportunities, and risks. These subnets can be used to organize the model into controllable branches and to make comparisons of outer or inner influences between the elements of the decision situation.
3.2. Modeling business value by ANP: Benefits, opportunities, costs, and risks

As discussed in section 2, business value is defined in this study by four key concepts: Benefits, Opportunities, Costs, and Risks (BOCR). Saaty [3] calls these overriding criteria (value drivers) as merits that allow establishing a default structure in ANP modeling. Technically they are subnets that outline the whole model structure. The relative value of the merits with respect to the final goal can be evaluated by strategic criteria or by value functions (formulas).

The ANP modeling with the BOCR approach has recently been applied in a number of occasions. Tan et al. [42] build an ANP model for supplier selection problem and implement it in a diesel manufacturing context. Lee et al. [43] compare the performance of different energy management projects in China. Azizi and Modarres [44] construct a model for selecting an appropriate location for plywood and veneer plants in Iran. Later they develop a strategic plan for selecting the best options for the supply of raw material to feed paper producing plants [45]. Chang et al. [46] integrate ANP with BOCR to goal programming and fuzzy Delphi methodologies in order to find the best revitalization strategies for a forest railway in Taiwan. Feglar et al. [47] extend a traditional SWOT decision analysis approach by an ANP based BOCR analysis. Dağdeviren and Eraslan [48] propose an ANP model for prioritizing strategic energy policies of Turkey.

In some cases all four value drivers (B, O, C, R) can have equal weighting but usually they do not. In ANP, strategic criteria with subcriteria and subnetworks can be located above those drivers and then the importance of each driver can be evaluated in pairwise fashion. Another way is to establish a functional relationship between the value drivers and then rate the alternatives without strategic, top-level criteria and pairwise comparisons. In principle, there is a limitless number of ways to calculate the overall priorities of the alternatives from the priorities of each alternative under the benefits, opportunities, costs, and risks. We can form any kind of functional relationship between the value drivers but the Super Decisions software offers five default formulas. In this study only the most conventional formulas, additive and multiplicative value functions, are used.

In additive case, the overall priorities of alternatives are simple weighted sums of priorities under value drivers (merits):

\[ P_i = b_1 B_i + o_1 O_i - c_1 C_i - r_1 R_i, \]

where

- \( P_i \) = Overall priority of alternative \( i \),
- \( B_i, O_i, C_i \) and \( R_i \) = the synthesized results of alternative \( i \) under drivers B, O, C and R, respectively,
- \( b, o, c \) and \( r \) = normalized weights of drivers B, O, C and R, respectively.

Depending on the synthesized priorities of the value drivers (B, O, C, and R) and their coefficients (b, o, c and r), the overall priorities of all alternatives can reach negative values, too.

In multiplicative case, positive outcomes (B, O) are multiplied and the product is divided by the product of costs and risks (C, R):

\[ P_i = \frac{B_i O_i}{C_i R_i}, \]

where \( P_i \) = Overall priority of alternative \( i \), \( B_i, O_i, C_i \) and \( R_i \) = the synthesized results of alternative \( i \) under drivers B, O, C and R, respectively.

The four dimensions of the BOCR analysis resemble the dimensions of the SWOT analysis used in strategic planning to evaluate the strengths, weaknesses, opportunities, and threats involved in organizational decisions. On the other hand, the four perspectives of the Balanced Scorecard (BSC) as initiated by Kaplan and Norton [49] also try to catch the most crucial, multidimensional value drivers of an organization. It is common to BOCR and BSC approaches that they both try to find what aspects are behind the financial outputs and that measurement metrics are aligned to the final goals and strategy of the organization.

In the next section an actual application of the proposed approach in selecting suppliers for e-invoicing is described.

4. Case Study: A Finnish textile corporation

4.1. Case Marimekko

Marimekko Corporation is a leading Finnish textile and clothing design company that was established in 1951. The company designs, manufactures, and markets high-quality clothing, interior decoration textiles, bags, and other accessories under the Marimekko brand, both in Finland and abroad (for further details see www.marimekko.fi). Using IT in financial administration is nothing totally new to Marimekko – they adopted electronic banking systems and even electronic ordering already a few years ago. However, they have only quite recently adopted electronic invoice handling systems for incoming invoices. Approximately 16,000 – 17,000 invoices flow though their invoice management system every year.

Marimekko is currently inviting their suppliers to join in the electronic invoicing initiative. Currently, around 20% of the incoming invoices arrive to Marimekko in electronic format. The remaining 80% of invoices come in paper format and have to be scanned manually into the electronic invoice management system. The scanning procedures are conducted by Marimekko’s partner and generate costs to Marimekko.

In this section we describe the application of the ANP method on selecting suppliers for e-invoicing. Before starting the present study we conducted a pilot study [50] to get an understanding of the implementation of electronic
invoicing and to create a first draft of the assessment criteria. The application of the ANP method is described along the phases of intelligence, design and choice. In the intelligence phase, we conducted interviews in the case company to define the relevant criteria for the decision problem. In addition to that, we complemented the model with criteria found in the literature. The data collection for the analysis was conducted with representatives of the case company, whose everyday responsibilities are closely related to the invoicing process. During the data collection, the consistency of the comparisons was regularly checked using the Super Decisions software. Furthermore, we recorded the discussions during the data collection so that we were able to better understand the evaluations made by the company representatives when making the analyses.

4.2. Intelligence: Structuring the problem

The problem in this case is to find the best possible schedule to transform raw material and other suppliers to the electronic invoicing system in order to maximize the business value. In the case company, moving one single supplier to the electronic invoicing system is not a straightforward task but the project requires a lot of administrative efforts, user education, system adoption, and other implementation actions. The ANP model follows the BOCR approach and thus the business value drivers, defined as subnets, are benefits, opportunities, costs and risks. The components of the model structure at the upper level are shown in at the top in Figure 2.

When considering the main components under each value driver it became clear that there are a lot of tangible as well as intangible benefits that can be achieved if a particular supplier is joined to the e-invoicing system. There were good arguments to divide the costs-side into business costs and IT related costs. By applying the basic principles of the risk management, we divide risks at the general level to market (systematic) risks and unique (unsystematic, company-specific) risks. Market risk stems from outside of the company and unique risks are company-specific. Similarly it can be assumed that part of the opportunities opens outside and the other part inside the corporation.

The case corporation has over one thousand suppliers, some of which are small sized companies supplying raw materials and other products or services only on irregular basis whereas others are significant business partners operating on close relationship with the company. For this report only the following three suppliers are selected:

• S1 is operating in the construction industry and the case company uses its services for building work. Currently the case company receives paper invoices from S1.
• S2 is a company in the textile industry. The case company buys services from this company and the invoices are received on paper. The paper invoice also includes the delivery note as attachment.
The benefits of e-invoicing are divided into tangible and intangible benefits in our model. On the tangible benefits side, it is expected that e-invoicing would decrease processing errors and non-value added manual work. Furthermore, the total invoicing cycle-time as well as invoice approval and handling time would decrease. Moreover, the invoice processing costs as well as the interest paid on overdue payments are expected to decrease. On the intangible benefits side, it is expected that adopting e-invoicing would have a favorable effect on company image and employee satisfaction.

The opportunities created by the adoption of e-invoicing are divided to market and unique opportunities. Market opportunities mean the developments outside of the company that are beyond the company’s control. There may be some favorable effects other than the immediate benefits on the long run, such as opportunity for business expansion, expanded supplier pool using automated processes, and expanded material market, which are the result of developing improved relationships with suppliers. The unique opportunities are located inside the company and include enhanced IT infrastructure, which can be the basis, for example, for future projects such as e-procurement adoption.

Costs are divided into business costs (adaptation and administrative costs) and IT costs (continuous and one-off costs) in our model. Implementing e-invoicing may cause adaptation costs related to establishing co-operation between the buyer and the supplier. In addition, there are naturally administrative costs related to the e-invoicing adoption. IT costs include the one-off costs of the initial investment and the continuous costs caused by, for example, the maintenance of the e-invoicing system.

Risks are also divided into market and unique risks. Market risks are those beyond the control of the buyer company, including operator experience and supplier experience. Unique risks are located inside the buyer company and include the technical complexity of the e-invoicing adoption project.

In the final model (see Figure 2), there are naturally the alternative suppliers, in addition to the criteria. The four subnets (Benefits, Costs, Opportunities, Risks) have clusters and each cluster has final measures defined as nodes. Between clusters there are feedback relations and within tangible benefits some of the nodes are dependent on each other. The final model is a relatively complicated network between the value drivers and the alternative suppliers.

Using the above defined ANP model for the supplier prioritization, the pairwise comparisons were entered into our Super Decision model using questionnaire comparisons. A special session was organized in the case company to collect the required data. Although they had all the relevant knowledge and experience for collecting the data they sometimes left the room to get more specific details. In addition to the persons responsible for the e-invoicing project the authors of this paper were present to give some guidance to utilize the methodology fully. The consistency of input data is checked and the priorities of alternatives with respect to each criterion (eigenvectors) were calculated by the software. All eigenvectors of the comparison matrixes were inserted to a ‘super matrix’, the matrix was normalized and a limit matrix was computed by taking powers of the normalized matrix [5, 6, 7]. All these steps are performed immediately by the software.

### 4.4. Choice: Prioritization and sensitivity analysis

Alternative suppliers can be prioritized by any single criteria in the model, by value drivers (B,O,C,R), or by the whole model. In Table 2, column 2, whole model with additive value function (negative values allowed) is used to prioritize the suppliers. Because the costs and the risks caused by supplier S2 are so high, the final business value for transforming S2 into e-invoicing system is even negative. Whereas the multiplicative value function is used, the negative value disappears. In column 4, the supplier priorities according to benefits are given. If only benefits were considered, then supplier S1 would be taken into the e-invoicing system first, then S3 and finally S2. According to column 6, supplier S1 would cause also the highest costs but risks are obviously highest for supplier S2. No matter which value function is used, it is of value to take supplier S1 first into the new e-invoicing system. This guarantees the highest business value for the case corporation.

<table>
<thead>
<tr>
<th></th>
<th>Additive</th>
<th>Multiplic.</th>
<th>Benefits</th>
<th>Opport.</th>
<th>Costs</th>
<th>Risks</th>
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</table>

Table 2. Supplier priorities after multiplicative value function

### 5. Discussion and Conclusions

We developed an ANP model to aid the buyer company in prioritizing suppliers for managing its electronic invoicing project. In general, the ANP model can be organized by practical or theoretical perspectives. In this study, the business value concept was applied to determine which suppliers are the most potential ones for automating the invoicing process. The business value drivers in the model include Benefits, Opportunities, Costs and Risks.
opportunities can be interpreted as probabilities [51]. Moreover, the ANP method supports modeling uncertainties since the priorities with respect to risks and (BOCR). In principle, the approach adopted in this study is generalizable at conceptual as well as operative level. The key concept of the study, business value, was grounded on the transaction cost theory, resource-based view of the firm, and the network externalities. The theory base is rich enough to ensure the content validity by covering the most significant measures of the supplier selection problem in different organizational contexts. Furthermore, we took care of the construct validity in two ways. First, we conducted a pilot study to define the efficiency effects that adopting e-invoicing would have in an organization [50]. Second, when the respondents conducted the analyses in the case company we followed the inconsistency index provided by the Super Decisions software to make sure that the comparisons are logically correct.

The results of the analysis proved valuable for the decision makers and provided them with new perspectives to the decision problem. Two months after having conducted the study at Marimekko, we contacted the company again and asked them whether the results of the ANP study had had an impact on Marimekko’s supplier prioritization problems. This follow-up interview lasted two hours and we applied the framework by Sprague and Carlson [52] in evaluating the usability of the ANP method in the case company. The framework includes the measures of productivity, process, perception, and product for assessing a support system [52].

Concerning the productivity measures (time, cost, and results), the representatives of the case company pointed out that the current study considered three typical supplier types. In total, Marimekko has around 5,700 suppliers and it would not be feasible to conduct pairwise comparison across all the suppliers. In the current study, the respondents did not, therefore, feel that the method was too time consuming nor costly.

The process measures address issues related to the number of alternatives, analysis, and participants as well as the time horizon of the decision. As mentioned before the number of alternatives was only three. During the analysis, some of the pairwise comparisons and criteria had to be discussed and clarified between the company representatives and the authors. The study was conducted at the company premises and lasted only couple of hours.

In terms of perception measures, we focused on control, ease of use, and usefulness. The respondents felt that they were in control of the pairwise comparisons, although some of the criteria needed clarification. The respondents specifically perceived that the results provided by the method were useful. They informed us that it was easy to communicate the results forward in the organization.

Concerning the product measures, the software was administered by the authors so that issues related to response times, development costs, and maintenance costs were not really a concern for them. The respondents appreciated the fact that the software provided consistency indices and also that the results of the study were shown in real-time. They also pointed out that applying the ANP method provided them new insights as they realized that they, currently, do not even want to have e-invoices from certain supplier types because of the considerable efforts required. The study has, therefore, had a very concrete impact on the company.

A limitation of the ANP model is that it easily generates a lot of pairwise comparisons, which may limit its practical usability. This problem can be avoided, or at least minimized, by grouping the suppliers first into a more controllable number of classes and performing the pairwise comparisons only between the groups. However, in the present study it was not considered as a problem.

The topics for future research include investigating supplier prioritization for e-invoicing in other fields of industry, where we might be able to find interesting variations in the importance of the different decision making criteria. Furthermore, the ANP method could be extended by including strategic criteria above the value drivers.

6. References
