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Enrichment of a Utility Ranking Method Using Data Envelopment Analysis- A Case Study of an ERP Selection Problem

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ABSTRACT

In this article we are analyse an ERP selection problem faced by an Austrian company. We describe the chosen approach including: i) the decision model, ii) the data acquisition and iii) the final decision. Thereafter, a structural analysis of the gained data is suggested using data envelopment analysis (DEA) tools. This results in a reduced significant set of attributes and reveals key qualities of the vendors.

INTRODUCTION

ERP systems promise the development of competitive advantage in the global marketplace through enhanced decision support, reduced asset bases and costs, more accurate and timely information, higher flexibility or increased customer satisfaction [1-4]. As an enabling key technology as well as an effective managerial tool, ERP systems allow companies to integrate at all levels and utilise important ERP applications such as supply-chain management, financials and accounting applications, human resource management and customer relationship management [5]. The acquisition and implementation of ERP systems are very effort-intensive processes.

In recent years, most ERP system suppliers have increased their focus on medium sized organizations. The availability of relatively inexpensive hardware has helped to decrease ERP adoption costs only to a small degree since the predominant proportion of the adoption costs originate from consulting services needed at various stages after the adoption decision, especially during implementation. Therefore ERP vendors have created selection and implementation strategies particularly for SMEs in order to decrease the high costs involved, e.g. Accelerated SAP [6], Peoplesoft's Compass Method [7], or Implex from Intentia [8]. Some studies investigated certain factors in the ERP context special to smaller organisations mainly for the area of implementation [9]. Contributing to the acquisition stage, work was published concerning a methodological approach to the acquisition of ERP solutions by SMEs [10] and certain specificities in the acquisition process of Austrian SMEs [11]. Other authors analysed the decision process for selecting an ERP software with the case of an holding company (ESC), which completed the acquisition of an well-known solution in March 1997 [12].

The paper is structured as follows. First we give the company background information including the drivers for adopting a new ERP solution. We then describe the ERP selection process for the underlying case study consisting of the applied decision model, the data acquisition approach, product evaluation and system selection. The main focus of the analysis lies upon the usage of data envelopment analysis (DEA) as a means to reveal more structural details in the vast amount of selection criteria.

COMPANY BACKGROUND INFORMATION

Primagaz Austria is wholly owned subsidiary of SHV Gas based in Paris, which is according to its own statement the world leader in the distribution of Liquefied Petroleum Gas (LPG). The headquarters in France allow their subsidiaries to develop their own IT, respectively ERP strategies, therefore enabling Primagaz to arrive at its own IT/IS decisions. Today, Primagaz Austria has 90 employees, generates annual revenues of • 55 million, and supplies 12.000 Austrian end-customers with their petroleum gas products and services, while pointing out, that they are an ISO-9002 certified tank gas provider.

Until 2003, all primary functions, such as finance, marketing and operations, run on a 20 year old COBOL based system called Portasoft (produced and serviced in Munich/Germany) in a Novell 3.2 NetWare environment (newer Novell NetWare operating software was not supported by Portasoft). The drawbacks of this software environment were the driving force behind the ERP adoption decision. The system did not allow embracing the Austrian divisions, which caused data redundant storage. The back-office operations could not be linked or integrated with front-office operations, meaning that every working place needed two PCs (Windows/Netware). External operations were neglected, e.g. there was no internet connection possible to support external data inquires. Reporting functionality was limited, e.g. no longer time scales (reports over the last 7 years) were supported. In addition, monthly reports could only be produced within a delay of 5 days after the end of the each month. The system required new programming by the vendor for every change in the data export interface. These were needed for more sophisticated reporting or controlling purposes. Also the accounting capabilities did not meet the requirements. Because no further releases of the legacy system could be expected to revise these shortcomings, the management decided to replace the legacy system. Consequently, the company did not only seek to replace the software, the new software was also supposed to foster and strengthen the company's strategic and financial position. The introduction of a state of the art enterprise resource planning and customer relationship management software should provide new tangible and intangible benefits as well as cost reductions.

DECISION MODEL AND DATA ACQUISITION

An empirical study of the ERP decision making process in Austrian enterprises [13] revealed that only 30% of the organizations (when excluding conventional financial evaluation methods) used some sort of formal evaluation techniques and almost every company out of this 30% proportion used the kind of utilization ranking and scoring techniques [14]. Primagaz is one of these companies, they also decided to use a weighted utilization scoring method. The requirements of ERP software (stated prior) were classified into the main business functions: business management, sales, services & engineering, purchasing, logistics, accounting and controlling & reporting. An additional area was added covering the needs of local divisions (see Table 1 for a summary). Several attributes were defined in each group for evaluation summing up to 82 criteria. Additionally a discrete weight was pre-defined for each attribute. Possible weight-values were 1 (not important), 2 (important) and 3 (very important). Possible scores for attributes ranged from 1 to 5 (discrete, as well), were 1 stands for not sufficient and 5 means excellent. The overall benefit *B* of each ERP alternative was measured by the weighted sum of all scores s_i:

$$B = \sum_{i=1}^{82} w_i s_i$$

, where w_i are the weights for each criterion *i*.

Data acquisition was done with interviews in workshops with pre-selected vendors. 3 vendors remained (from 10 pre-selected ones) after first contact or presentation. These three were Mesonic (MES), Ramsauer und Stürmer (R&S) and Navision (NAV).

EVALUATION AND DECISION

Table 1 shows the consolidated evaluation of the three competitors. The first column for each vendor denotes the plain scores and the second one reveals the weighted figures. As you can see, R&S exceeds its competitors in unweighted and weighted sum. Whereas MES and NAV can be considered to be equally good (according to this decision aid).

Table 2 shows the estimated investment expenses consisting of license, estimated consulting and hardware costs for each of the three alternatives. Here NAV costs almost twice as much than the others.

When including this information in the selection decision, it is obvious the NAV was not selection. Instead Primagaz decided to contract MES, which is interesting, because it is (besides a small investment benefit) ranked only on second place. The reason for the decision was that Primagaz felt to be better supported during the acquisition phase by MES. They offered more flexibility and therefore gained the contract.

BEYOND FIXED-WEIGHT RANKING

The ERP system selection is a very critical task which involves many different views of many different people of many different critical evaluation elements. All this demands for a tool which supports: multi-factor input to output evaluation and objective and consistent group decision capabilities.

In the ERP context, a promising alternative to ranking and scoring technique is the data envelopment analysis (DEA) approach [15]. Bernroider and Stix stated that DEA provides a number of opportunities,

Table 1: Aggregated categories of the applied ranking and scoring method.

	MES		R&S		NAV	
Business Area	s_i	w_i*s_i	s_i	w_i*s_i	s_i	w_i*s_i
Business Management	13	34	16	43	14	37
Sales	24	61	25	63	27	65
Services & Engineering	15	31	18	38	18	38
Local Divisions	12	22	13	26	9	16
Purchasing (Petroleum Gas)	8	20	7	19	5	13
Logistics	9	21	6	14	6	16
Accounting	14	32	21	48	16	33
Controlling & Reporting	13	32	15	37	14	34
Total	**108**	**253**	**121**	**288**	**109**	**252**

Table 2: Investment costs.

	MES	R&S	NAV
Investment	• 105,903.-	• 108,250.-	• 196,739.-

which seem to justify its use. This includes the usage of minimal a priori assumptions, objectifying characteristics, group decision capabilities and additional enormous amount of freedom through the simple LP structure. Another aspect to mention is that DEA does neither require to specify the relation between inputs and outputs nor does these hidden functional dependencies has to be equal among all alternatives. As we will see shortly DEA can also help decision maker to find structural patterns in a large amount of data in order to additionally support their decision.

DEA is a method of comparative efficiency measurement and has been successfully used over many years to measure the performance of any form of decision making units [16-21]. The field of application is vast, we want just mention a few recent articles in different management areas. The DEA method was extensively applied to purchasing decisions [22, 23]. In [24] the DEA model was used for production input/output estimation when some of the original input/output entities are revised in order to be more competitive. DEA was used in decision models for technology selection problems, e.g. in the area of manufacturing technologies [25, 26]. Other interesting fields of application were to analyze the economic value of IT [27, 28] or the productivity of software engineering projects ([29, 30]. For a complete introduction into DEA see [17] and for step by step guide to apply the method to ERP decision making see [15].

STRUCTURAL ANALYSIS USING DEA

We examined the described decision problem further by using DEA techniques. The analysis showed that it can reveal further structural characteristics of the problem. In the following a contribution of an attribute measured in a percentage means: how large the share of that specific attribute is, compared to the weighted sum (i.e. the weight of the attribute times its value over the weighted sum). Weights itself on the other hand are given as float point numbers. It should be noted that all weights are chosen by the mathematical model and thus deduced by the data itself. This objectiveness is one of the DEA's key qualities.

As a pre-processing we removed all attributes for which all competing ERP solutions were given the same measurement. The remaining 48 attributes were put into a CCR output oriented model (CCR-O). It was not surprising that all three alternatives turned out to be 100% efficient when considering the large number of attributes. More interesting were the resulting weights which were chosen by the model in order to become 100% efficient. The chosen weight vector of the R&S alternative showed (for almost every component), that each attribute contributed the same share (namely 2.27%) to the total weighted score. There were only 4 exceptions where the weights were set to 0, thus being ignored by the model. The MES and NAV systems, however, chose different weight patterns. They both ignored 10, respectively 7 attributes by setting their weights to 0. Both alternatives weighted one single attribute very dominant. It was a logistic attribute, contributing 26.73% (weight=0.13) for the MES system and an attribute of the controlling/reporting section, contributing 30.31% (weight=0.15) for NAV. All remaining attributes contributed below 2% for both alternatives. This showed a good balance of all attribute values for R&S. The remaining two systems gained 100% efficiency by emphasizing one of their key-attribute. Indeed each of the two attributes bet the two opponents.

After this first result, we restricted all weights to be below 0.1 to force the model to find other important attributes (those where weights were larger than 0) for each alternative, which we extracted after the calculation. MES, R&S and NAV used 9, 8, and 6 attributes, respectively. These attributes can be seen to define the key qualities of each product. Due to overlapping of some attributes we came up with a set of 20 important attributes. With these attributes we started a new unconstrained CCR-O model. Again all solutions were 100% efficient but all weights along all alternatives were chosen to be strictly positive. This means, that each alternative needs all of the attributes to gain maximum efficiency, thus the set of attributes we reduced is a significant one.

As a result, we reduced the 48 original attributes to smaller set of 20 significant ones. The reduction was done by the "data" itself and not by human interference. By looking at the weights assigned by Primagaz' ranking method, 5 attributes were weighted with 1 and 2 respectively and 10 attributes were weighted with 3 (inside this significant set). By

Table 3: Contribution of the business areas to 100% efficiency.

Business area	MESONIC	R&S	NAVISION
Company	8.77%	11.11%	3.47%
Business Management	8.77%	11.11%	3.47%
Sales	8.77%	11.11%	72.25%
Services & Engineering	8.77%	11.11%	3.47%
Local Divisions	8.77%	11.11%	3.47%
Purchasing (Petroleum Gas)	8.77%	11.11%	3.47%
Logistics	29.87%	11.11%	3.47%
Accounting	8.77%	11.11%	3.47%
Controlling & Reporting	8.77%	11.11%	3.47%
Efficiency	**100%**	**100%**	**100%**

chance, the distribution of the weights inside the significant set was the same than that one in the original large set (chi-square test, significance over 99%). Applying the weights assigned by Primagaz to the significant set the resulting weighted score is: MES: 58, R&S: 67 and NAV: 60 (cp. with Table 1). It can be seen, that MES and NAV changed their position.

Up to this point only an output oriented CCR model was considered. Therefore we added the Investment for each alternative as one input to the model (cp. table 2). Since NAV is almost twice as expensive as the others it is not surprising that this mixed model evaluated NAV as only 59% efficient.

Another structural analysis we considered was the consolidation of all the attributes along the given business areas (see table 1). Table 3 summarizes the relevance of each category calculated by a CCR-O model (we neglected the investment cost in order to compare the features of the different solutions only). Again in this given structure, R&S is balanced over all areas, whereas the other solutions try to score in their key quality, which is Logistics for MES and Sales for NAV. MES, however, shows a more balanced score compared to NAV.

Our structural analysis has shown that there are too many attributes for all of the vendors. Most of them offer no significance with respect to a weighting method. The resulting significant set can help a decision maker to find key qualities within the product and maybe rethink personal weights. The investigation has shown as well, that in all cases R&S seems to offer a real good balanced product. These structural aspects are independent of the total weighted score.

CONCLUSIONS

As already mentioned, the utilization ranking method is employed by nearly every organization that uses an evaluation technique other than financial methods in the ERP software selection process. We showed that the usage of additional decision support tools can gain more insight in a complex decision problem. Here DEA has shown to be such a powerful tool for structural analysis, although all alternatives were 100% efficient in terms of ranking. This benefit is not provided by utilization ranking methods. It helps the decision maker, to extract information hidden inside the unmanageable amount of data. It is necessary to collapse the data into a smaller significant set of attributes.

The explicit setting of weights, which was done in this study and which is required by the ranking method, constrains the flexibility of the analysis. It should be emphasized to agree upon regions, in which the importance (i.e. weights) of attributes is covered as suggested in e.g. [8].

The case revealed that the decision made was different than the proposal of the model. This is well established and sound, because, as the name implies, decision support tools are mend to assist decision makers and not to make decisions.

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