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ENTERPRISE SOFTWARE PACKAGE SELECTION BY USING DATA ENVELOPMENT ANALYSIS

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ABSTRACT
Advanced information technologies have become absolutely necessary part of companies in today's competitive environment. The emergence of new information technologies is very speedy. One of the advanced enterprise information technologies that emerged in the past decade is Enterprise Resources Planning (ERP) system. ERP is a total integrated, computerized business management system that covers all functional areas of the organization. Hence, it is very important to select the right and appropriate ERP software package for the organizations. In this paper, Data Envelopment Analysis (DEA) methods are used to select the acceptable ERP software package in a Turkish automotive manufacturing firm, and then the results are presented and discussed.
Keywords: Enterprise resources planning, software selection, data envelopment analysis.

1. INTRODUCTION
ERP systems are commercial software packages that enable the integration of transactions oriented data and business processes throughout an organization.

Today no one would dispute that information technology (IT) has become the most important cornerstone of an enterprise's ability to compete successfully in global markets. ERP software package, as one of the most important IT systems, is now gaining the universal attention all over the world. Market researcher International Data Corp. predicted a compound annual growth of %11 for the worldwide ERP market from 2001 to 2006, reaching US$39.6 billion.

In this paper, ERP software selection problem is handled and a decision making methods of DEA is used to select the most appropriate software in a Turkish automotive manufacturing firm between 23 alternatives.

2. ERP AND ERP SOFTWARE SELECTION
ERP systems represent the latest and most ambitious application of administrative and computer-based technologies in developing management information systems. ERP systems are such an innovation; their general aim is to enable central and integrative control over all processes throughout the organization by ensuring a data entry point and use of a common database [1,2].

There are many firms enable ERP software in he world. One of them, SAP, dominates the ERP software market. SAP R/3 has a function set and data dictionary that is approximately five times larger than the other one, Baan IV. Oracle is the number one manufacturer of database software. It is the second software enabler in the world behind Microsoft. Oracle focuses on other areas than the ERP market mostly. For SAP, PeopleSoft, and Baan, Oracle is a competitor and a partner. They can

provide an organization with the sole source for the database and application layers of their IT infrastructure. Oracle applications are broad and complete products.

PeopleSoft is the third vendor in the ERP market. They differentiate themselves by facilitating an incremental approach to technology acquisition and deployment for their customers. A middle market solution offered by PeopleSoft through direct sales channel has been a huge hit with their customers. SAP and Oracle, on the other hand, rely on reseller channels and consulting partners. For instance, PeopleSoft is known for its human resource applications and SAP for its manufacturing applications.

Baan is best known in the aerospace, automotive, defense, and electronics industries for their ERP software. Baan competes with larger ERP vendors by focusing on customizability. Baan provides a tool called Orgware that uses customized business processes to automatically configure its enterprise software to a customer's unique way of doing business. It is predicted by analysts that Orgware could cut implementation times by up to 50%. The success of Orgware is due to Baan separating business processes from the software product. All these vendors and others are working on extracting business processes from their software to make the systems more flexible [1].

From a company's perspective, several choices are available when choosing the best system. For example, it can decide,

- to have one vendor for all ERP modules,
- to combine existing legacy programs and new ERP modules,
- to create a system based on the vendors' specialized strengths, etc.

3. DATA ENVELOPMENT ANALYSIS

Data envelopment analysis (DEA) is a methodology for measuring the relative efficiencies of a set of decision making units (DMUs) that use multiple inputs to produce multiple outputs. DEA is a useful technique because of the nature of the relations between the multiple inputs and multiple outputs involved in many activities. DEA utilizes techniques such as mathematical programming, which can handle large numbers of variables and relations (constraints). Studies of benchmarking practices with DEA have identified numerous sources of inefficiency in some of the most profitable firms that had served as benchmarks by reference to their (profitability) criteria. Also, DEA does not require the user to prescribe weights to be attached to each input and output, as in the usual index number approaches.

It is critical to compare softwares to find their relative efficiencies. Data envelopment analysis (DEA), as an evaluation method, can estimate the relative efficiencies of ERP softwares systematically. This methodology is in wide spread use in a broad range of application areas. The efficiency of the ERP systems can be benchmarked by using DEA. DEA presented a model for evaluating the performance of a set of comparable DMUs. Each DMU is evaluated in terms of a set of outputs that represent its successes, and a set of inputs that represent the resources [3].

3.1. CCR and BCC Models

In the DEA literature, there are basically two kinds of DEA models. These are CCR (Charnes, Cooper and Rhodes) and BCC (Banker, Charnes, Cooper) models. The CCR model is built on the assumption of constant returns to scale of activities, but the BCC model is built on the assumption of variable returns to scale of activities. That is, if an activity (x,y) is feasible, then, for every positive scalar t, the activity (tx, ty) is also feasible. On the other hand, the BCC model has its production frontiers spanned by the convex hull of the existing DMUs. The frontiers have piecewise linear and concave characteristics, which lead to variable returns to scale characteristics. There are two versions of both the CCR and BCC models. One version of these models aims to minimize inputs while satisfying at least the given output levels. This is called the input oriented model. The other type of models, called the output oriented model, attempts to maximize outputs without requiring more of any of the observed input values [4].

3.2. Mathematical Structure of DEA

The DEA model discussed in this paper is the CCR model of the following form:

Objective function :

$$\max \frac{\sum_{k=1}^{s} v_k y_{kp}}{\sum_{j=1}^{m} u_j x_{jp}} \quad \dots (1)$$

Constraints :

$$\frac{\sum_{k=1}^{s} v_k y_{ki}}{\sum_{j=1}^{m} u_j x_{ji}} \le 1 \quad ; \quad v_k, u_j \ge 0 \quad \dots (2)$$

If we want to find the relative efficiency, the following formulation can be used:

$$EF = \frac{\sum_{(j=1)}^{J} (T_j \times Output_j)}{\sum_{(h=1)}^{H} (W_h \times Input_h)} \quad \dots (3)$$

where J is the number of outputs, H is the number of inputs, EF is the efficiency ratio of the implementation, T_j is the weight assigned to output variable j, $Output_j$ is the actual value of output variable j, W_h is the weight assigned to input variable h, and $Input_h$ is the actual value of input variable h [4].

4. AN ERP SOFTWARE SELECTION APPLICATION

In this study, the aim is the selectin of the most efficient ERP software (inputs) in a Turkish automotive manufacturing firm, so an input oriented CCR model is used to evaluate the efficiency scores. To solve input oriented CCR models, Lingo 9.0 is used.

23 ERP software alternatives are compared here. There are several inputs and outputs to run DEA. In this paper there are 13 inputs and 4 outputs to select the most appropriate ERP system to the firm. The inputs and outputs used in this application are shown in Table 1.

After executing Lingo 9.0 for each ERP software, the efficiency scores appeared. Efficiency scores for each ERP software are shown in the Table 2.

Table 1. The inputs and outputs for DEA.

Inputs	**1**	Average cost per user
	2	Average no. Of users
	3	licence implementation cost / licence cost
	4	average annual fee/user
	5	no of customers - worldwide
	6	manufacturing integration
	7	transportation and warehousing integration
	8	information integration
	9	finance and insurance integration
	10	management of companies and enterprises
	11	compability with microsoft
	12	XML support
	13	max. Size of inventory code
Outputs	**14**	revenue 2006
	15	revenue 2005
	16	average revenue/ customer
	17	average no of employees / customer

Table 2. The inputs and outputs for DEA.

ERP Software	Efficiency	ERP Software	Efficiency	ERP Software	Efficiency
mySAP All-in-One solution	0.458608	iRenaissance	1	Visual Enterprise / Visual Manufacturing	0.717261
Epicor Enterprise	1	Made2Manage® Enterprise Business System	0.60082	Acomba	0.23188
Microsoft Dynamics™ GP Professional Edition	1	Microsoft Dynamics™ GP Standard Edition	1	Blue Link Elite	1
Microsoft Dynamics™ NAV Professional Edition	1	Microsoft Dynamics™ NAV Standard Edition	1	Foundation 3000	1
SunSystems eXFM	1	ResQ Enterprise	0.458608	Integrated Office Accounting	1
EliteSeries	0.946288	SYSPRO	1	Microsoft Small Business Financials	1
Exact Globe Enterprise	0.703377	Vantage	1	Quantus Software	1
Exact Macola ES	0.640947	VIRTUO	1		

In conclusion, we can see the relative efficiencies of 23 ERP softwares in the efficiency scores. Efficiency score of 15 of 23 softwares are 1, and efficiency score of 8 of 23 softwares are between 0 and 1.

5. CONCLUSION AND DISCUSSION

In this paper, ERP software selection problem is handled and a decision making methods of DEA is used to select the most appropriate software in a Turkish automotive manufacturing firm between 23 alternatives. The ERP application reported here has given a result that 15 software of 23 alternatives can be appropriate for the firm. This result illustrates an important lesson for investigators conducting surveys: Researchers should not rely on a single data analysis technique. The researcher is normally restricted to the kind of responses that subjects are willing to answer, particularly for sensitive data. Therefore, using multiple modeling techniques can augment the findings from survey data and provide greater insight.

6. REFERENCES

[1] Wei C.-C., Chien C.-F., Wang M.-J.J.: An AHP-based approach to ERP system selection, International Journal of Production Economics, 96(1): 47-62, 2005.,

[2] Mabert V.A., Soni A., Venkataramanan M.A.: Model based interpretation of survey data : A case study of enterprise resource planning implementations, Mathematical and Computer Modelling, 44(2): 16-29, 2006.,

[3] Kao C.: Interval efficiency measures in data envelopment analysis with imprecise data, European Journal of Operational Research, 174(2): 1087-1099, 2006.,

[4] Cook W.D. and Zhu J.: Classifying Inputs and Outputs in Data Envelopment Analysis, European Journal of Operational Research, 180(2), 692-699, 2007.