

USING THE AHP METHOD TO SELECT AN ERP SYSTEM FOR AN SME MANUFACTURING COMPANY

Sławomir Kłos¹, Peter Trebuna²

¹ *University of Zielona Góra, Institute of Management and Production Engineering, Poland*

² *Technical University of Kosice, Faculty of Mechanical Engineering, Slovak Republic*

Corresponding author:

Sławomir Kłos

University of Zielona Góra

Institute of Management and Production Engineering

Prof. Szafrana 4, 65-526 Zielona Góra, Poland

phone: +48 68 328 24 64

e-mail: s.klos@iizp.uz.zgora.pl

Received: 7 July 2014

Accepted: 10 August 2014

ABSTRACT

This paper proposes the application of the Analytic Hierarchy Process method to support decision making regarding the selection of an Enterprise Resource Planning system in a manufacturing company. The main assumption of the work is that the management of the selection of an ERP system should consider that the most important selection criteria are concerned with the functionality of the ERP system. Besides this, the aspects of total cost of ownership, technical support and implementation time or vendor experience are taken into consideration to guarantee a successful ERP implementation. The proposed procedure of an ERP system selection is dedicated for small and medium manufacturing enterprises. A structure of attributes for the AHP method is proposed on the basis of an analysis and identification of critical success factors. Different kinds of production (make-to-stock, make-to-order and engineer-to-order are taken into consideration). Illustrative examples are also given.

KEYWORDS

decision analysis, Enterprise Resource Planning, Analytic Hierarchy Process (AHP), manufacturing enterprise.

Introduction

Enterprise Resource Planning (ERP) systems have become a basic tool to support the effective management of manufacturing enterprises. In 1998, Davenport defined an ERP as an integrated software solution, typically offered by a vendor as a package that supports the integration of all the information which flows through a company, such as financial, accounting, human resources, supply chain, and customer information [1]. Heizer and Render [2] define an ERP as an information system that enables the planning and identification of resources needed for acquisition, manufacturing, dispatch and the settlement of orders. Practice shows that ERP systems should not be perceived as a mere tool or software package which performs certain functions. An ERP system should rather be perceived as a component of infrastructure consisting of hardware, software, de-

financed business processes and trained personnel. Successful implementation of the system enables the reduction of operational costs, an improvement in productivity in various areas of company business and the enhancement of business processes, whereas failure, depending on the stage of the implementation of the project, may lead to a total paralysis of a company, or in the best case, end with the implementation of a very expensive prosthesis of a system which hardly satisfies anyone [3].

After 16 years, ERP systems now support processes in almost all functional areas of many manufacturing enterprises, it would be difficult to imagine such companies doing business without them. Most big companies (with more than 250 employees) have already implemented new or updated versions of old ERP systems, but a lot of small and medium manufacturing enterprises (SMEs) are still looking for an effective solution in this area. The selection

of an ERP system is crucial for every manufacturing company because it is designed to support business processes for many years. In the last few decades, ERP vendors have acquired experience in key areas of production management and ERP software has become increasingly efficient and reliable. ERP solutions dedicated to SMEs do not differ greatly from each other and generally encompass similar functionality and implementation costs.

To support the decision process of the selection of an ERP system, the Analytic Hierarchy Process (AHP) method may be used, a method which is based on multi-criteria decision making. The AHP, introduced by Thomas Saaty (1980), is an effective tool for dealing with complex decision making, and may aid the decision maker to set priorities and make the best decision. By reducing complex decisions to a series of pairwise comparisons, and then synthesizing the results, the AHP method helps to capture both subjective and objective aspects of a decision [4].

According to ERP system selection assessment criteria, a method for selecting an ERP system was established based on a nominal group technique and the AHP method [5]. The AHP method for an ERP system selection was proposed by Wei et al. [6]. They elaborated a comprehensive ERP system selection framework in which an objective hierarchy was constructed and appropriate attributes are specified to provide detailed guidance for ERP system evaluation. The procedure for selecting a suitable ERP system is based on choosing the most appropriate ERP system on the one hand, and choosing the best ERP vendor on the other. Karaarslan and Gundogar used the AHP method for ERP system selection [7]. They selected the most appropriate software between two pre-selected candidate systems. The final choice of system was designed to support a factory which was planning to use ERP software that fits its functions and needs. Wei and Wang proposed a hierarchical attribute structure to evaluate ERP projects systematically, and in addition, they used fuzzy set theory to aggregate linguistic evaluation descriptions and weights [8]. At the first stage of the attributes of ERP evaluation, they took into account: ERP implementation project factors, software system factors and vendor factors. Karsak and Özogul developed a novel decision framework for ERP software selection based on quality function deployment (QFD), fuzzy linear regression and zero-one goal programming [9].

The method of a comparative analysis of successful and non-successful ERP implementation, based on case studies, was presented in a paper [10]. Based on surveys and analyses of companies implementing ERP systems, the authors [11–13] defined critical

success factors which help to determine the success of ERP implementation. Ahmad and Cuenca also analyzed critical success factors for ERP implementation in SMEs [14].

Different methods have been proposed for selecting an ERP system. The scoring method is simple and very popular [15]. Lee and Kim [16] combined the analytic network process (ANP) and a 0–1 goal-programming model to select an information system. The data envelopment analysis (DEA) approach has also been applied to the process of selecting an ERP system. Early adopters of the DEA method for decision making used the methodology to screen, and respectively limit the number of alternatives. Further evaluation by other multiple attribute decision making (MADM) techniques used the DEA method to analyze and compare the performance of ERP packages [17].

The main problem discussed in this article is formulated as follows: *Given a small or medium manufacturing enterprise which plans to implement an ERP system. How is it possible to create an ERP evaluation attribute hierarchy, using the AHP method, for the different kinds of production performed in SMEs and one which is based on critical success factors?*

The next chapter includes a description of the AHP method and defines some assumptions for an ERP system selection dedicated to SMEs. Also in the chapter, the selection procedure of an ERP system is proposed. Conclusions and directions for further research are presented in the last chapter.

The Analytic Hierarchy Process

The AHP was elaborated by Thomas Saaty in 1980 [4]. It is an effective method for dealing with complex decision making, and may aid the decision maker to set priorities in order to support the best decision. By reducing complex decisions to a series of pairwise comparisons, and then synthesizing the results, the AHP enables us to capture subjective and objective aspects of a decision. In addition, the AHP encompasses a useful technique for checking the consistency of the decision maker's evaluations, thus reducing any bias in the decision making process [4]. The AHP considers a set of evaluation criteria, and a set of alternative options among which the best decision is to be made. The AHP can be implemented in the three following steps [4]:

1. Computing a vector of criteria weights.
2. Computing a matrix of option scores.
3. Ranking the options.

In order to compute the weights for the different criteria, in the first step, the AHP starts by creating a pairwise comparison matrix \mathbf{A} . The matrix \mathbf{A} is a $m \times m$ real matrix, where m is the number of evaluation criteria considered. Each entry a_{jk} of the matrix \mathbf{A} represents the importance of the j -th criterion relative to the k -th criterion. If $a_{jk} > 1$, then the j -th criterion is more important than the k -th criterion, while if $a_{jk} < 1$, then the j -th criterion is less important than the k -th criterion. If two criteria have the same importance, then the entry a_{jk} is equal to 1 [4]. The entries a_{jk} and a_{kj} satisfy the following constraint:

$$a_{jk} \cdot a_{kj} = 1, \quad (1)$$

wherein $a_{jj} = 1$ for all j . The relative importance between two criteria is measured according to a numerical scale from 1 to 9, where [4]:

- 1 – j and k are equally important,
- 3 – j is slightly more important than k ,
- 5 – j is more important than k ,
- 7 – j is strongly more important than k ,
- 9 – j is absolutely more important than k ,
- 2, 4, 6, 8 – are intermediate values.

On the basis of matrix \mathbf{A} , we can be create a normalized pairwise comparison matrix \mathbf{A}_{norm} by making the sum of the entries on each column equal to 1, i.e. each entry \bar{a}_{jk} of the matrix \mathbf{A}_{norm} is computed as:

$$\bar{a}_{jk} = \frac{a_{jk}}{\sum_{l=1}^m a_{lk}}. \quad (2)$$

Next, the criteria weight vector w (that is an m -dimensional column vector) is built by averaging the entries on each row of \mathbf{A}_{norm} , i.e. the elements of the vector are computed as follows [4]:

$$w_j = \frac{\sum_{l=1}^m \bar{a}_{jl}}{m}. \quad (3)$$

In the next step, a matrix \mathbf{S} of option scores should be created ($n \times m$ real matrix). Each entry s_{ij} of \mathbf{S} represents the score of the i -th option with respect to the j -th criterion. In order to derive such scores, a pairwise comparison matrix $\mathbf{B}^{(j)}$ is first built for each of the m criteria, $j = 1, \dots, m$. The matrix is a $n \times n$ real matrix, where n is the number of options evaluated. Matrix $\mathbf{B}^{(j)}$ is a $n \times n$ real matrix, where n is the number of options evaluated. Each entry of the matrix represents the evaluation of the i -th option compared to the h -th option with respect to the j -th criterion. If $b_{ih}^{(j)} > 1$ then the i -th option is better than the h -th option, while if $b_{ih}^{(j)} < 1$, then the

i -th option is worse than the h -th option. The entries $b_{ih}^{(j)}$ and $b_{hi}^{(j)}$ satisfy the following constraint:

$$b_{ih}^{(j)} \cdot b_{hi}^{(j)} = 1, \quad (4)$$

wherein $b_{ii} = 1$ for all i . The AHP applies to each matrix $\mathbf{B}^{(j)}$ the same two-step procedure described for \mathbf{A} , i.e. it divides each entry by the sum of the entries in the same column, and then it averages the entries on each row, thus obtaining the score vectors \mathbf{s} , $j = 1, \dots, m$. The vector contains the scores of the evaluated options with respect to the j -th criterion. The score matrix \mathbf{S} is obtained as $\mathbf{S} = [\mathbf{s}^{(1)}, \mathbf{s}^{(2)}, \dots, \mathbf{s}^{(m)}]$ i.e. the j -th column of \mathbf{S} corresponds to $\mathbf{s}^{(j)}$. The weight vector \mathbf{w} and the score matrix \mathbf{S} have been computed, the AHP method obtains a vector \mathbf{v} of global scores by multiplying \mathbf{S} and \mathbf{w} , i.e.

$$\mathbf{v} = \mathbf{S} \cdot \mathbf{w}. \quad (5)$$

The i -th entry v_i of \mathbf{v} represents the global score assigned by the AHP to the i -th option [4]. The AHP includes an effective technique for checking the consistency of the evaluations made by the decision maker when building each of the pairwise comparison matrices involved in the process, namely matrix \mathbf{A} and matrices $\mathbf{B}^{(j)}$. The Consistency Index (CI) is obtained by first computing the scalar x as the average of the elements of the vector whose j -th element is the ratio of the j -th element of vector $\mathbf{A} \cdot \mathbf{w}$ to the corresponding element of vector \mathbf{w} . The CI index is computed as follows:

$$CI = \frac{x - m}{m - 1}. \quad (6)$$

A perfectly consistent decision maker should always obtain $CI = 0$ but small values of inconsistency may be tolerated. In particular the inconsistencies are tolerable, if

$$\frac{CI}{RI} < 0.1 \quad (7)$$

and a reliable result may be expected from the AHP. In (7) the RI is the *random index* i.e. the consistency index when the entries of \mathbf{A} are completely random. The values of RI for $m \leq 10$ (small problems) are shown in Table 1.

Table 1
Values of the Random Index (RI) for small problems.

m	2	3	4	5	6	7	8	9	10
RI	0	0.58	0.90	1.12	1.24	1.32	1.41	1.45	1.51

The hierarchical structure of objectives

On the basis of the analysis of critical success factors of ERP system implementation [10–14], direct

interviews with project managers and case studies; the following three main attributes are taken into consideration to select the most applicable ERP system:

- processes and functional factors,
- business factors.

The most important objectives of ERP implementation are processes and functional fitting because the main role of the software is the improvement of business processes and the support of the decision makers in particular functional areas. The next important objective is to make the ERP fit the business. This part of the structure deals with vendor experience in ERP project management, total cost of ownership, technology fit (for example indoor ERP software installation or software as a service solution), implementation time, etc.

The main goal is to select the most suitable ERP system for small or medium manufacturing enterprises. The AHP hierarchy dedicated to fulfilling the main goal is presented in Fig. 1.

The attributes associated with process and function factors encompass support by ERP operational areas of manufacturing enterprises. The importance of the attributes will depend on the kind of production or manufacturing branch in question. For example, it would be more important for companies which perform make-to-stock food production to support areas such as sales, logistics or maintenance. On the other hand, it would be more important for companies that carry out engineer-to-order production of CNC machines to support R&D processes. Busi-

ness factors should take into account the commercial aspects of ERP system implementation and exploration. For SMEs, a very important factor that can decide the choice of an ERP system is the total cost of ownership (TCO); this includes the price of licenses, costs of consultants, hardware, etc. The vendor's project management competences and branch knowledge are also very important success factors of ERP system implementation. If the consultant's knowledge about the industry branch is extensive, the implementation project of an ERP system needs less time and business support is more efficient. The technology of an ERP system typically consists of an installation platform (for example software as a service or indoor system), mobile solutions, capability of data exchange and scalability, etc. For an SME, it could be more attractive to rent software and perform work based on a Cloud Computing model rather than creating its own IT infrastructure. The factors of customization and system development are often dependent on the flexibility of ERP vendors. A description of the AHP process and its function attributes is presented in the Table 2.

The attributes concerned with processes and functions supported by an ERP system will be different for different kinds of production. The weight of the attributes should be determined for different production branches on the basis of the opinions of experts from the company that is making the decision about the ERP system selection. For different kinds of production, different sets of questions should be taken into account.

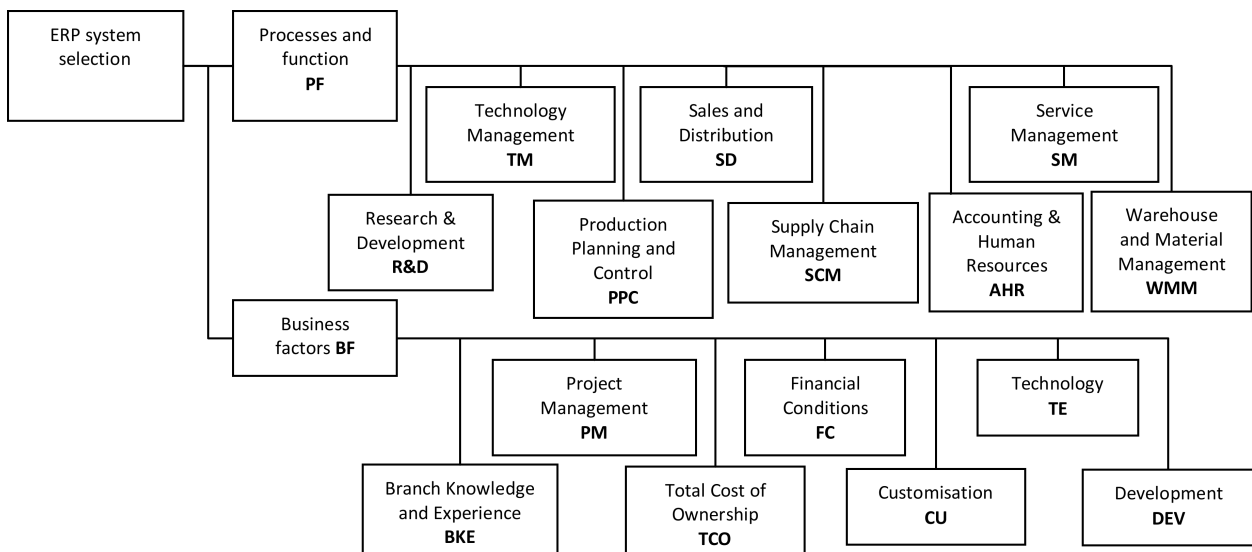


Fig. 1. AHP hierarchy of ERP system selection.

Table 2
 AHP attribute details – process and functions.

Attributes	Examples of evaluation items
Research & development (R&D)	<ul style="list-style-type: none"> ● Planning and monitoring of product innovations, ● Research project management, ● Product Data Management, ● Product Lifecycle Management, ● Bill of Materials, ● Integration with CAD, ● Product cost calculation.
Technology Management (TM)	<ul style="list-style-type: none"> ● Technology variant management, ● Planning and monitoring of process innovation, ● Reduction of waste material, ● Integration with CAM.
Production Planning and Control (PPC)	<ul style="list-style-type: none"> ● Production planning and scheduling, ● Monitoring of manufacturing processes, ● Balancing production capacity, ● Monitoring of manufacturing costs, ● Quality control management.
Sale and Distribution (SD)	<ul style="list-style-type: none"> ● Sales forecasts and budgeting, ● Customer relationship management, ● Price management, ● Sales commission management, ● Sales contract execution monitoring.
Supply Chain Management (SCM)	<ul style="list-style-type: none"> ● Material demand forecasting, ● Supplier management, ● Cooperation management, ● Material flow management.
Service Management (SM)	<ul style="list-style-type: none"> ● Customer installation planning and monitoring, ● Breakdown prevention, ● Tool and spare part management, ● Modernization management.
Warehouse and Material Management (WMM)	<ul style="list-style-type: none"> ● Minimum and maximum stock levels, ● Stocktaking management, ● Tool and spare part management, ● Material quality control.
Accounting & HR Management (AHR)	<ul style="list-style-type: none"> ● Settlements of orders, ● Stock records, ● Rewarding employees, ● Analyses of contract profitability.

The examples of evaluation items presented in Table 1 are defined generally because they should support the choice of an ERP system for different kinds of SME. The attributes weights will depend on the individual requirements of a manufacturing company. For example, consider the case of a company that carries out engineer-to-order production and manufactures CNC machines and technical equipment for industrial engineering branches. Because it is a small engineering company, the most important functions supported by an ERP system should belong to the areas of R&D, technology and logistics. In the following chapters, the procedure of an ERP system selection and an illustrative example of AHP method implementation for a small manufacturing enterprise is presented.

The procedure for selecting an ERP system

To support the decision of the selection of an ERP system for a small engineering company, a systematic selection procedure is elaborated. A stepwise procedure follows.

Step 1. Form a project team and select a project manager.

Step 2. Define the most important function of the ERP system for the company.

Step 3. Prepare the ERP system specifications by taking into account economic and functional factors.

Step 4. On the basis of interviews and discussions; determine the weights of individual attributes.

Step 5. Verify the proposed AHP hierarchy of the ERP system selection.

Step 6. Evaluate the potential ERP systems using the AHP method.

Step 7. Discuss the results and prepare a list of requirements for the best ERP vendor.

Step 8. Make the final decision.

Figure 2 shows a flowchart for the ERP selection process. The details of each step are presented below.

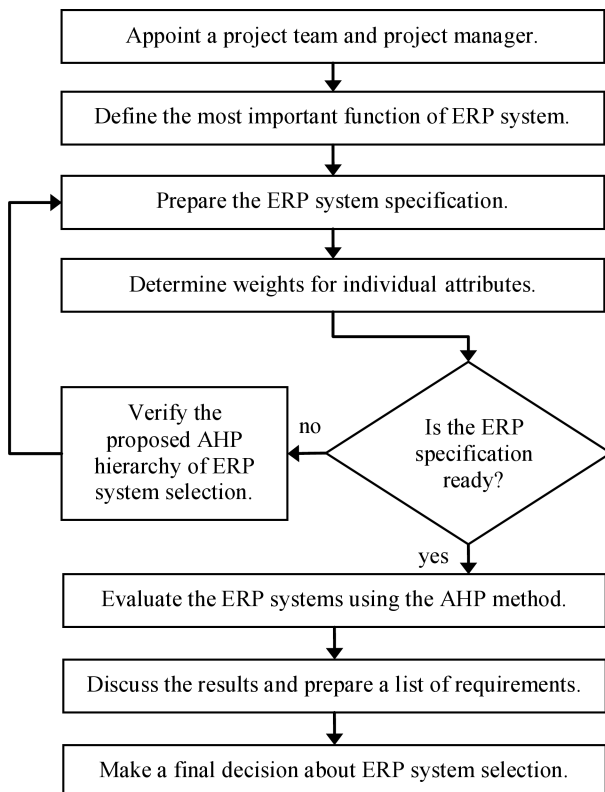


Fig. 2. AHP based ERP system selection procedure.

In the first step of the selection of the ERP system, a project team and project manager should be chosen. In small and medium enterprises the decision making process for an ERP system should be relatively short. Therefore the project manager could be a member of the management board of the company or the main decision maker (technical director, main designer, etc.). In the next step, the most important functions should be selected to support business processes and the activity of the company. To do it, the efficiency of business processes should be evaluated and the most important problems should be specified. For example, a very important problem in small and medium engineering enterprises which carry out prototype production, is that of preparing sales offers (prices, technical specifications of machines, delivery conditions, guarantee conditions, ser-

vice conditions, etc.) because the requirements of individual customers may greatly vary from contract to contract. Of course if the contract is not realized, nobody will be paid for the work. If employees spend, for example, 30% of their time preparing sales offers, the following question can be taken into account: How can the ERP system decrease labor intensity in this area? If the process is crucial for the business activity of the enterprise, the functionality of the ERP system should help to solve the problem.

On the basis of a list of the most important functions, the first version of an ERP specification could be prepared. In the next step, the weights for individual attributes should be determined and ordered in relation to the proposed AHP hierarchy of the ERP system selection. The specification of the ERP system could be evaluated in several iterations by different managers in the company and a final specification and the weights of attributes should be accepted by the management board of the company. The final specification of ERP functionality should be sent to different ERP vendors and on the basis of sales offers, an evaluation process using the AHP method should be carried out. The results of the ERP selection and the requirements will provide a basis for a contract with a selected ERP vendor. On the basis of scope, schedule and budget, an ERP implementation project could be prepared. The evaluation of the implementation level of the most important functions is crucial in this process.

An illustrative example

Let us consider *Alpha*, a small engineering company which performs engineer-to-order production and manufactures CNC machines and manufacturing lines. The most important processes of the enterprise are executed in the areas of product design and final assembly of the ready products. Most of the components and semi-ready products are produced by subcontractors, so logistics and coordination of deliveries is important for timely order completion. Tables 3, 4 and 5 show pairwise comparison matrices relative to an ERP system selection, it includes process and function factors and business factors.

From the results of Table 3 for the Alpha company, it is apparent that the most important are factors related to processes than business factors.

The most important functional areas which should be supported by the ERP system include: R&D and service and technology management. This tends to be typical for small and medium-size innovative, engineering enterprises.

Table 3
 AHP attribute details – ERP system selection.

	Processes and function factors	Business factors
Processes and function factors	1	5
Business factors	0.2	1

 Table 4
 AHP attribute details – process and functions factors.

	R&D	TM	PPC	SD	SCM	AHR	SM	WMM
R&D	1	2	4	3	3	5	2	3
TM	0.5	1	2	2	3	3	0.5	2
PPC	0.25	0.5	1	0.5	0.5	0.5	0.25	2
SD	0.333	0.5	2	1	0.333	2	0.333	1
SCM	0.333	0.333	2	3	1	2	0.5	2
AHR	0.2	0.333	2	0.5	0.5	1	0.2	0.5
SM	0.5	2	4	3	2	5	1	3
WMM	0.333	0.5	0.5	1	0.5	2	0.333	1

 Table 5
 The AHP attribute details – business factors.

	BKE	PM	TCO	FC	CU	TE	DEV
BKE	1	2	3	2	3	4	5
PM	0.5	1	0.33	0.25	2	3	2
TCO	0.33	3	1	2	3	4	5
FC	0.5	4	0.5	1	3	2	3
CU	0.33	0.5	0.33	0.33	1	2	3
TE	0.25	0.33	0.25	0.5	0.5	1	0.5
DEV	0.2	0.5	0.2	0.33	0.33	2	1

For *Alpha*, branch knowledge and the total cost of ownership are of critical importance in the selection of an ERP vendor. Experience in implementing ERP systems in the area of mechanical engineering prototype production can be verified on the basis of the references of the vendor. From the results of Table 4, it is evident that the financial condition of the vendor company is very important for the decision makers.

On the basis of the presented matrices, the weights for individual factors are put in order. In Table 6, the vectors of the weights are presented.

 Table 6
 Criteria weight vectors.

ERP selection	PF	BF						
Weights	0.833	0.167						
Process factors	R&D	TM	PPC	SD	SCM	AHR	SM	WMM
Weights	0.266	0.150	0.062	0.077	0.112	0.053	0.212	0.068
Business factors	BKE	PM	TCO	FC	CU	TE	DEV	
Weights	0.294	0.110	0.225	0.180	0.086	0.050	0.055	

For the matrices presented in Tables 4 and 5, the consistency indexes are calculated and presented in Table 7.

 Table 7
 Analysis of inconsistency.

	Process factors	Business factors
Consistency Index CI	0.069	0.094
Random Index RI	1.410	1.320
CI/RI < 0.1	0.049 < 0.1	0.071 < 0.1

In the final stage of the ERP system selection, the three vendors are taken into account (company VX, VY and VZ). For every attribute of the AHP hierarchy, a pairwise comparison of the ERP vendors is performed. The pairwise comparisons between the vendors in the area of processes and functions of the ERP systems are presented in Table 8. From the re-

 Table 8
 AHP pairwise comparisons – process and functions.

	VX	VY	VZ
R&D			
VX	1.000	0.333	2.000
VY	3.000	1.000	5.000
VZ	0.500	0.200	1.000
TM			
VX	1.000	2.000	4.000
VY	0.500	1.000	0.500
VZ	0.250	2.000	1.000
PPC			
VX	1.000	3.000	0.250
VY	0.333	1.000	3.000
VZ	4.000	0.333	1.000
SD			
VX	1.000	5.000	3.000
VY	0.200	1.000	2.000
VZ	0.333	0.500	1.000
SCM			
VX	1.000	0.250	0.333
VY	4.000	1.000	0.500
VZ	3.000	2.000	1.000
AHR			
VX	1.000	5.000	2.000
VY	0.200	1.000	3.000
VZ	0.500	0.333	1.000
SM			
VX	1.000	0.250	2.000
VY	4.000	1.000	6.000
VZ	0.500	0.167	1.000
WMM			
VX	1.000	2.000	4.000
VY	0.500	1.000	5.000
VZ	0.250	0.200	1.000

sults of the table it appears that the critical functions of R&D and Service Management are best supported by the ERP system offered by vendor VY. The factors for Table 7 should be prepared by the project team responsible for the implementation of an ERP system in the *Alpha* company.

In Table 9 the pairwise comparisons between the vendors in the area of business conditions are presented. From the results of Table 9, it is clear that the VX vendor has the best knowledge of both the branch and the process of customization and development of the ERP system to suit its needs. The best financial condition and the smallest total cost of ownership is offered the VZ vendor.

Table 9
AHP pairwise comparisons – business conditions.

	VX	VY	VZ
BKE			
VX	1.000	2.000	5.000
VY	0.500	1.000	0.500
VZ	0.200	2.000	1.000
PM			
VX	1.000	0.500	0.250
VY	2.000	1.000	0.500
VZ	4.000	2.000	1.000
TCO			
VX	1.000	0.333	0.250
VY	3.000	1.000	0.500
VZ	4.000	2.000	1.000
FC			
VX	1.000	0.250	0.200
VY	4.000	1.000	0.200
VZ	5.000	5.000	1.000
CU			
VX	1.000	2.000	5.000
VY	0.500	1.000	3.000
VZ	0.200	0.333	1.000
TE			
VX	1.000	0.250	3.000
VY	4.000	1.000	2.000
VZ	0.333	0.500	1.000
DEV			
VX	1.000	5.000	2.000
VY	0.200	1.000	0.250
VZ	0.500	4.000	1.000

On the basis of the matrices presented in Tables 8 and 9, the weights for every ERP vendor related to individual factors can be put in order and then an evaluation can be made.

In Table 10, the results of the AHP method are presented. The data in the table presents how the ERP systems support the functional areas of the *Al-*

pha company and provides information on the business conditions offered by the vendors VX, VY and VZ. On the basis of the decision analysis performed using the AHP method, the *Alpha* company should select vendor VY which receives the highest rating. For proper decision making, it is very important to prepare a specification of the requirements for the ERP systems and the inquiry should be the same for each potential ERP vendor. If the evaluation of the vendors is made on the basis of the presentations of ERP system, the same industrial data set, prepared in the *Alpha* company, should be used during the individual presentations.

Table 10
Results of the AHP analysis.

Process and functions factors (0.833)				
	Weights	Vendor X	Vendor Y	Vendor Z
R&D	0.266	0.051	0.144	0.027
TM	0.150	0.071	0.024	0.030
PPC	0.062	0.016	0.017	0.018
SD	0.077	0.041	0.013	0.010
SCM	0.112	0.012	0.034	0.048
AHR	0.053	0.025	0.011	0.008
SM	0.212	0.034	0.124	0.019
WMM	0.068	0.030	0.021	0.006
Business factors (0.167)				
BKE	0.294	0.029	0.009	0.011
PM	0.110	0.003	0.005	0.011
TCO	0.225	0.005	0.012	0.021
FC	0.180	0.003	0.007	0.020
CU	0.086	0.008	0.004	0.002
TE	0.050	0.005	0.001	0.003
DEV	0.055	0.005	0.001	0.003
	Final results	0.337	0.427	0.235

Conclusions

The decision about the selection of an ERP system is crucial for every manufacturing company. However, the selection on an appropriate system may prove difficult, especially for small and medium manufacturing enterprises which may not have sufficient resources (money and personnel) to properly implement the system. Due to the fact that the decision will have profound implications on the development of the company for many years, the use of all appropriate methods and tools by the decision makers is fully justified. In this paper a procedure of ERP system selection dedicated to small and medium enterprises based on the AHP methodology is proposed. In the case of big companies that usually consist of a lot of functional areas, using of the methodology may

be more difficult because the structures are bigger, encompass more functional areas and the number of functions or processes is much greater. For small and medium enterprises which consist of fewer crucial areas that need to be supported by an ERP system, the use of the proposed procedure can be simple and effective. In the decision process it is very important to define a list of the critical functions of the ERP and any key business conditions. The illustrative example can be used as a reference, and for different manufacturing companies it can be expanded or reduced depending on requirements. Preparation of pairwise comparison matrices should be made by the project team because the task requires many compromises. The analysis of business conditions should be carried out by the management board. The proposed procedure enables a systematic and effective approach to an ERP system selection. Using the AHP method allows us to analyze ERP vendors in many different ways.

Further research will concentrate on the automation of data acquisition for the proposed procedure. Such data can be acquired from various sources (vendors, rankings, ERP customers, etc.).

References

- [1] Davenport T., *Putting the Enterprise into the Enterprise System*, Harvard Business Review, 76 (4), 121–133, 1998.
- [2] Heizer J., Render B., *Operations management – International edition (7th ed.)*, Upper Saddle River, NJ: Pearson Education Inc., 2003.
- [3] Xue Y., Liang H., Boulton W.R., Snyder CH.A., *ERP implementation failures in China: Case studies with implications for ERP vendors*, International Journal of Production Economics, 97, 279–295, 2005.
- [4] Saaty T.L., *The Analytic Hierarchy Process*, McGraw-Hill, New York, 1980.
- [5] Teltumbde A., *A framework of evaluating ERP projects*, International Journal of Production Research, 28, 17, 4507–4520, 2000.
- [6] Wei Ch.-Ch., Chien Ch.-Fu, Wang M.-J.J., *An AHP-based approach to ERP system selection*, Int. J. Production Economics, 96, 47–62, 2005.
- [7] Karaarslan N., Gundogar E., *An application for modular capability-based ERP software selection using AHP method*, International Journal of Advanced Manufacturing Technology, 42, 1025–1033, 2009.
- [8] Wei Ch.Ch., Wang M.-J.J., *A comprehensive framework for selecting an ERP system*, International Journal of Project Management, 22, 161–169, 2004.
- [9] Karsak E.E., Özogul C.O., *An integrated decision making approach for ERP system selection*, Expert Systems with Applications, 36, 660–667, 2009.
- [10] Motwani J., Mirchandani D., Madan M., Gunasekaran A., *Successful implementation of ERP projects: evidence from two case studies*, International Journal of Production Economics, 75, 83–96, 2002.
- [11] Hong K.K., Kim Y.G., *The critical success factors for ERP Implementation: an organizational fit perspective*, Information & Management, 40, 25–40, 2002.
- [12] Ehie I., Madsen M., *Identifying critical issues in enterprise resource planning (ERP) implementation*, Computers in Industry, 56, 545–557, 2005.
- [13] Motwani J., Subramanian R., Gopalakrishna P., *Critical factors for successful ERP implementation: Exploratory findings from four case studies*, Computers in Industry, 56, 529–544, 2005.
- [14] Ahmad M.M., Cuenca R.P., *Critical success factors for ERP implementation in SMEs*, Robotics and Computer Integrated Manufacturing, 29, 104–111, 2013.
- [15] Ptak C.A., *ERP tools, techniques, and applications for integrating the supply chain*, St. Lucie Press, 2000.
- [16] Fisher D.M., Kiang M.Y., Fisher S.A., Chi R.T., *Evaluating mid-level ERP software*, Journal of Computer Information Systems, 38–45, 2004.
- [17] Lee J.W., Kim S.H., *An integrated approach for interdependent information system project selection*, International Journal of Project Management, 19, 111–8, 2001.
- [18] Morton N.A., Hu Q., *Implications of the fit between organizational structure and ERP: A structural contingency theory perspective*, International Journal of Information Management, 28, 391–402, 2008.