

VILNIUS UNIVERSITY

DONATAS RATKEVIČIUS

**THE ANALYSIS AND EVALUATION OF FUNCTIONAL ABILITIES OF
ENTERPRISE RESOURCE PLANNING SYSTEMS**

Summary of doctoral dissertation

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Scientific supervisor:

Prof. Dr. Rimvydas Skyrius (Vilnius University, social sciences, management – 03S)

Consultant:

Assoc. Prof. Dr. Česlovas Ratkevičius (Vilnius University, social sciences, management – 03S)

The dissertation will be defended at the Vilnius University Scientific Council in the field of management and administration.

Chairman:

Prof. Habil. Dr. Jonas Mackevičius (Vilnius University, social sciences, economics – 04S)

Members:

Prof. Habil. Dr. Albinas Marčinskas (Vilnius University, social sciences, management– 03S)

Prof. Dr. Danutė Diskienė (Vilnius University, social sciences, management – 03S)

Prof. Dr. Vytas Navickas (Lithuanian University of Educational Sciences, social sciences, economics – 04S)

Prof. Habil. Dr. Borisas Melnikas (Vilnius Gediminas Technical University, social sciences, management– 03S)

Opponents:

Prof. Habil. Dr. Narimantas Kazimieras Paliulis (Vilnius Gediminas Technical University, social sciences, management – 03S)

Prof. Dr. Arvydas Paškevičius (Vilnius University, social sciences, economics – 04S)

The dissertation will be defended at the public meeting of the scientific council in the field of management and administration on 20 December 2013 at 2 pm in auditorium 403 at the Faculty of Economics, Vilnius University.

Address: 9 Saulėtekio ave., bldg. II, LT-10222, Vilnius, Lithuania.

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VILNIAUS UNIVERSITETAS

DONATAS RATKEVIČIUS

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Mokslinis vadovas:

prof. dr. Rimvydas Skyrius (Vilniaus universitetas, socialiniai mokslai, vadyba – 03S)

Konsultantas:

doc. dr. Česlovas Ratkevičius (Vilniaus universitetas, socialiniai mokslai, vadyba – 03S)

Disertacija ginama Vilniaus universiteto Vadybos ir Verslo administravimo mokslo krypties taryboje:

Pirmininkas:

prof. habil. dr. Jonas Mackevičius (Vilniaus universitetas, socialiniai mokslai, ekonomika – 04 S)

Nariai:

prof. habil. dr. Albinas Marčinskas (Vilniaus universitetas, socialiniai mokslai, vadyba – 03 S)

prof. dr. Danuta Diskienė (Vilniaus universitetas, socialiniai mokslai, vadyba – 03 S)

prof. dr. Vytas Navickas (Lietuvos edukologijos universitetas, socialiniai mokslai, ekonomika – 04 S)

prof. habil. dr. Borisas Melnikas (Vilniaus Gedimino technikos universitetas, vadyba – 03 S)

Oponentai:

prof. habil. dr. Narimantas Kazimieras Paliulis (Vilniaus Gedimino technikos universitetas, socialiniai mokslai, vadyba – 03 S)

prof. dr. Arvydas Paškevičius (Vilniaus universitetas, socialiniai mokslai, ekonomika – 04 S)

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Adresas: Saulėtekio al. 9, II rūmai, LT-10222, Vilnius, Lietuva.

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SUMMARY OF DOCTORAL DISSERTATION

Relevance of the topic. Enterprise resource planning (ERP) system is an integral part of modern business management. ERP is most often defined as business software which automates the main business processes of an organization, such as manufacturing, logistics, finances, marketing, human resources, etc. For a long time being related to the biggest companies of private and public sectors, now ERP software becomes available for midsize or even small companies.

An ERP system, if properly chosen and installed, provides the following advantages: facilitates management decisions, simplifies financial management, improves customer service and retention, accelerates business operations, reduces the need for inventory and management personnel, reduces production cycle, increases revenue, provides additional opportunities for organizational growth and development (Hawking et al. 2004, Eresource Infotech, 2013).

The implementation and the effective use of ERP becomes one of the main prerequisite of company's existence in today's dynamic market. It can be proved by the huge expenditures that are directed towards ERP implementations. In 2012, companies spent on average 7.1 millions USD (Panorama Consulting Solutions, 2013) for ERP software. However, not everything is invested at the beginning. As companies change their business activities in order to adapt to current business environment, there is a constant need to modify organizational structure and business processes that are not mapped with ERP functionality during initial ERP implementation. Therefore, companies are forced periodically update and replace existing ERP solutions that causes additional expenditures.

ERP efficiency highly depends on their characteristics and user satisfaction level (Aloin et al, 2007). If selected incorrectly, system requires more additional customization, the time of implementation increases accordingly. As it becomes even more complex to use, the demand for new system could increase. Therefore, ERP selection can predetermine the success of ERP implementation as a whole. It is a complex and continuous process that involves not only the final comparison of ERP solutions but also the early preparatory works, considering the company's business vision, functional requirements for current and expected system, identification and mitigation of project risks.

Because ERP systems are complex, the ERP selection process requires different knowledge about ERP products in the market, their advantages and drawbacks, the development of IT trends, business processes etc. Current ERP market can offer several products with similar functionality almost for each company, but namely the small difference between them in the majority of the cases can significantly affect the overall operating efficiency of the company. Taking into account the huge global market of ERP systems, high software prices and the large risk of failures during ERP implementation, any instrument that facilitates ERP selection process is of particular importance nowadays.

The research problem and awareness in Lithuania and the world. ERP implementation is a highly complicated activity which includes several closely related processes (selection, analysis, customization, support) and demands both IT and business knowledge. The problematic of ERP selection as the first ERP implementation phase

could be justified by the large number of research articles analyzing this subject (Gungor Sen, et al., 2009). These articles are published in journals of information systems, business management, production technologies, computer sciences and others. Thus, it indicates that in order to solve the problems of ERP selection process, the approach of interdisciplinary sciences should be applied (Kraemmergaard and Schlichter , 2010). The scientific interest in this problem is stimulated by practical standpoints. Managerial or practical approach is predominant in the majority of publications on ERP selection process, so the amount of purely scientific publications is relatively low comparing to the number of articles in professional journals ((Sarpola, 2003, Dong, et al., 2002, Esteves and Pastor, 2001, Shehab et al., 2004, Schlichter and Kraemmergaard, 2010, Addo-Tenkorang and Helo, 2011, Nazemi et al., 2012).

Even though a large number of Lithuanian scientists such as Simanauskas (Simanauskas, 2008), Brazaitis (Brazaitis, 1998), Skyrius (Skyrius et al., 2008), Barčkutė (Barčkutė, 2008), Paliulis (Paliulis, et al., 2004, Paliulis and Astrauskienė, 2003), Domeika (Domeika, 2008) have been researching the area of ERP systems, the topic of ERP selection is still under-researched. Except for publications of Strončikas (2008) and Kovalevskij (2009), a few more practical articles were issued only by the consultant of this dissertation thesis Česlovas Ratkevicius (1997, 1998, 2003).

Comprehensive analysis of foreign scientific journals, conference papers and technical reports on ERP selection were conducted by Sen, C. G., Baracli, H. and Sen, S (Sen, et al., 2009). The analysis covered general publications on ERP selection (Brownstein and Lerner , 1982; Edmonds and Urban , 1984; Frankel , 1986; Anderson, 1989; Eskenasi , 1989; Williams, 1992; Lai , et al. , 1999; Lai et al. , 2002) and articles about standard computer software (Subramanian and Gershon, 1991; Adeli and Wilcoski , 1993; Romanazzi and Jeanrenaud , 1994; PKO BP , et al. , 1995; Morris and Tsoukas , 1997; Tran and Liu , 1997; Feblowitz and Greenspan , 1998; Maiden and Ncube , 1999; Jung and Choi , 1999; Kunda and Brooks , 1999; Ochs et al. , 2000; Alves and Castro , 2001; Sedigh - Ali , et al. , 2001; Morera , 2002; Miller and Yeoh , 2006, Shyur , 2006) as well as other problems relevant for more specialized business software (Sarkis and Talluri , 2004; Huang et al. , 2007; Talley , 1983; Dominick and Kuan , 1986; Meier , 1989; Sahay and Gupta , 2003; Colombo and Francalancia , 2004; THOMAIDES , et al. , 2006; Lin , et al. , 2007; Salhie , 2007). The proposed in these articles software selection techniques are mostly based on decision making methods that use multiple criteria. Almost all these authors emphasize that ERP selection criteria should be evaluated and measured, but the majority of the proposed techniques tend to use subjective data, without scientific or systematic approach. Thus, the use of inappropriate criteria for the selection process has a direct negative effect on the final decision.

ERP selection criteria are very different in nature. Often the evaluation is based on qualitative elements that can hardly be modelled using classical mathematical techniques. In addition, as there is always a limited amount of information for decision-making process, the evaluation process tends to be closely related to assessors' current expertise that often faces the problem of subjectivity. Therefore, in order to minimize the risks associated with inappropriate ERP selection that could originate from inaccuracies and uncertainties, it is very important for all practitioners involved in this process to provide objective data about characteristics of contemporary ERP systems.

Object of the research – the functionality of contemporary ERP systems.

Purpose of the research – to perform the analysis and quantitative evaluation of functionality of ERP systems available on the market, thus facilitating ERP selection process for the companies of different industries in order to choose the best fit solution. To meet this purpose the following tasks were formed:

1. To determine the most important ERP selection criteria, to define the relationships between them and to evaluate the importance of each criteria.
2. To select the most important functions of ERP software based on the industry where company is working.
3. To perform the statistical analysis of contemporary ERP software for allocating the systems into different clusters by their versatility and appropriateness for the distributing, manufacturing and financial accounting companies of different size.
4. To compare functional power of Lithuanian accounting software with foreign ERP systems.
5. To create the evaluation model of the usage of ERP functionality.
6. To anticipate the possibilities of practical applications of dissertation thesis.

Research methods. In order to accomplish the main goal and tasks of the research, methods of collection, classification, summarizing and comparison of theoretical and practical literature (articles, researches, recommendations, reviews) on ERP selection and implementation subject were used.

In order to define relationships between ERP selection criteria that were identified through analysis of scientific literature, the empirical research have been conducted using *Delphi* survey method. The technique of Fuzzy Cognitive Maps was applied to create the model of these relationships. The visualization of the model was performed with *Pajak* program. The effect of ERP functionality changes to the other ERP selection criteria was simulated by using *FCMapper* (v. 1.0) software. All collected and analyzed data about ERP functions were transformed from qualitative to quantitative nature using the mathematical model proposed by thesis author. Databases of ERP characteristics created in this way have been processed with *IBM SPSS* (v.2) and *Stargraphics Centurion XVI* software using statistical clustering analysis methods. Mathematical formulas defined by thesis author or through the analysis of scientific literature are also presented in this dissertation.

Research resources. During the preparation of the dissertation, an analysis of scientific and practical literature, as well as ERP selection and implementation methodologies of foreign consulting companies was carried out. A survey was conducted with the help of 12 ERP implementation experts. The databases of ERP characteristics were formed using the following sources of information:

- The lists of standard ERP functional requirements from the foreign consulting companies such as *Technology Evaluation Centers* , *Axia Consulting*, *Custer Consultants*, *Infotivity Technologies*, *CTS*, *On- Line Consultant Software Solutions*.
- The lists of summarized functional characteristics from commercial decision support systems such as *The Accounting Library*, *TEC Advisor*, *TechMATCHPRO*, *Systems Analysis Tool*, *Technology Evaluation Centers*
- Documentations and user manuals of analyzed ERP systems.

- Studying commercial proposals for the companies that were looking for ERP software or cooperation proposals for the companies that implement ERP solutions.
- Using practical data about functional ERP power of accounting software *Konto Professional* and *Rivilė Solo Plus* as well as *Microsoft Dynamics NAV 2009* and *iScala* systems implemented at the Faculty of Economics of Vilnius university
- Information gathered from ERP vendors through direct requests.

Scientific novelty and theoretical significance of the research. Scientific novelty of the dissertation can be highlighted by theoretical and empirical findings:

1. The analysis of ERP selection criteria and their classification separating software-related and implementation-related criteria is an original approach combining practical and scientific views.
2. Using the data from conducted expert survey, a model of Fuzzy Cognitive Map of ERP selection criteria has been developed. The parameters of this model were specified using the technique of simulation modelling.
3. There is no systematic analysis in Lithuania or abroad about the functionality of contemporary ERP systems. In the majority research papers only general recommendations are provided by taking into consideration business environment of the companies. The indicator of ERP functional power proposed by the author provides the opportunity to quantify the characteristics of different ERP systems.
4. Quantitative evaluation of the functionality of the most widely used ERP systems has been introduced for the first time using thousands of characteristics. The functionality of Lithuanian and foreign ERP software was compared.
5. The method of clustered analyses was used to identify homogenous ERP features that were “hidden” among large number of heterogeneous characteristics. The systems finally were divided into groups by their suitability for enterprises of different sizes and industries.
6. A mathematical model for evaluating the efficiency of usage ERP functionality has been developed.

Practical significance of the research. Results of this work have not only theoretical but also practical significance. They were used in the research and development project No. VP2-1.3-ŪM-02-K-02-119 that was partially financed by EU structural funds.

The definition of the most important ERP selection criteria and empirical data of their relationships can be utilized for modelling automated ERP selection decision support system. The database of ERP functional characteristics collected and analyzed in this research could be the basis of the system. By constantly updating the content of this database, it would be possible to maintain accuracy of information.

This research also could be useful for consultants and business managers who perform ERP software selection projects. The requirements definition for their ERP systems could be simplified using data from collected and statistically processed contemporary ERP systems functional characteristics database.

Quantitative evaluation of the functionality of ERP systems could be useful for ERP vendors comparing their software with solutions developed by competitors in order to identify strengths and weaknesses of own systems.

By using proposed methodology it is possible to evaluate the degree of acquired ERP functionality that is constantly in use. The decrease in this ratio indicates the beginning of ERP erosion process that would require a new end users training cycle or other instruments for more efficient utilisation of current ERP functionality.

Finally, the information from this paper could be used in the curriculums of management information system subject at high schools.

Structure and scope of the study. The doctoral thesis consists of the introduction, four chapters, conclusions and recommendations, a list of references, and annexes. The doctoral dissertation contains 268 pages, 20 tables, 39 figures and 55 annexes; 287 references were used for the purposes of the thesis.

The logical structure of the dissertation is presented in Fig. 1. It shows the consecutive realization of the study objectives.

Theoretical aspects of ERP selection criteria. In the literature, there is no unique classification of ERP selection criteria. Kumar, Kumar and Maheshwari (2002), referring to a practical survey of 20 enterprises in Canada, distinguished four groups of ERP selection criteria. The first group consists of ERP software-related criteria (functionality of the system, system reliability, fit with parent/allied organization systems, cross-modular integration, best business practices available in the system). All these criteria were mentioned in more than 50% of cases. The second group includes criteria related to the implementation project manager (project management skills, functional experience, experience in IT management). The third group consists of criteria related to the implementation partner, and the last one is associated with implementation consultants' criteria (reputation, experience, etc.).

According to Ayağ and Özdemir (2007), ERP selection criteria may be classified in three dimensions. First, three determinants are defined with regard to their influence on the company's performance indicators: competitive advantage, productivity, profitability. After that, 7 dimensions and 22 criteria were described. All criteria of every dimension are connected and influence each other either positively or negatively. Competitive advantage is related directly to system costs (licence fee, consultant expenses, maintenance cost, infrastructure cost). Productivity directly correlates with the system support efficiency. Profitability influences more than half (13 out of 22) of the criteria (upgrade possibility, ease of integration, ease of in-house development, functionality, module completion, function fitness, security level, reliability, stability, possibility of recovery, ease of use, ease of operations, ease of learning, technology advance, standardization, integration of legacy systems, easy to maintain).

Bueno and Salmeron (2008) have modelled a practical ERP selection tool and defined the largest set – twenty seven – of ERP selection criteria. 17 of them are related to ERP software and the other 10 to the organization where implementation is performed. The further identification of relations among the criteria separated them into another six subgroups. Four of them involve criteria related to ERP software, whereas the last two are related to the organization. According to their significance the ERP

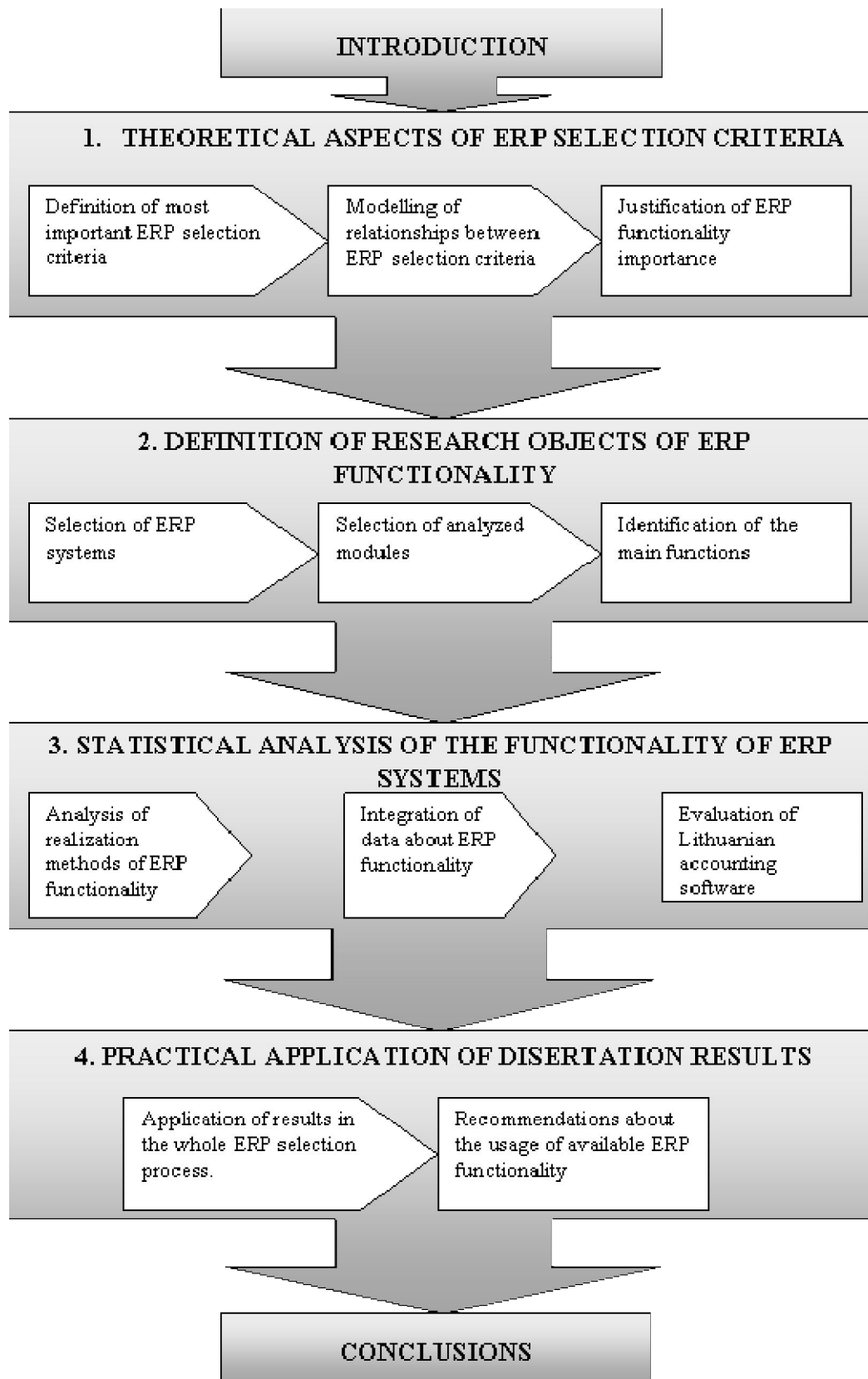


Fig. 1. Logical structure of the dissertation

Source: compiled by the author

related criteria according to their importance were sorted in this diminishing order: ERP system reliability and the spectrum of offered services; implementation efficiency; project costs; ERP vendor prestige. In the organizational factors group, the subgroup of organization flexibility strongly outweighs another one – ERP similarity to current IS/IT.

Verville and Halington (2003), also Wei, Chien and Wang (2005) have highlighted the importance of choosing a suitable ERP vendor. Wei draws a clear boundary between ERP selection factors related to the ERP system itself and factors related to the ERP vendor. In the ERP software selection process, he suggests to take into account six groups of criteria related to minimization of ERP implementation time and costs, ensuring required functionality level, related with user-friendly interface, system flexibility and reliability.

From the arguments presented above, it is evident that the diversity of ERP selection factors complicates their classification into standard groups. Most often, system selection criteria are defined regarding the researchers' area of interests and are divided into two, three or four groups. Taking into consideration the nature of criteria in this research, we have split the ERP selection criteria into two groups: software-related and implementation related.

The most important software-related ERP selection criteria are listed bellow (see Table 1).

Table 1. Software-related ERP selection criteria in scientific literature

Criterion	Authors
ERP functionality	Keil and Tiwana (2006), Kumar, Kumar and Maheshwari (2002, 2003), Liao, Li and Lu (2007), Wei, Chien and Wang (2005), Siriginidi (2000), Chen (2001), Everdingen et al. (2000), Anderson and Chen (1997), Han (2004),
Total costs of ERP implementation project	Ayağ and Özdemir (2007), Bueno and Salmeron (2008), Fisher, Fisher and Kiang (2004), Keil and Tiwana (2006), Lall and Teyarachakul (2006), Rao (2000), Umble, Haft and Umble (2003), Wei, Chien and Wang (2005), Yang, Wu and Tsai (2007), Mabert, Soni and Venkatraman (2000), Bernroider and Koch (2001)
Vendor reputation	Kumar, Kumar and Maheshwari (2002, 2003), Lall and Teyarachakul (2006), Liao, Li and Lu (2007), Siriginidi (2000), Chen (2001), Bernroider and Koch (2001), Everdingen (2000), Verville and Halington (2002), Wei, Chien and Wang (2005), Keil and Tiwana (2006)
ERP reliability	Ayağ and Özdemir (2007), Bueno and Salmeron (2008), Kumar, V., Kumar, U. and Maheshwari (2002, 2003), Wei (2005), Siriginidi (2000), Everdingen (2000)
Ease of integration with other systems,	Bueno and Salmeron (2008), Fisher and Kiang (2004), Kumar, Maheshwari and Kumar (2002, 2003), Verville and Halington (2003), Sprott (2000), Everdingen (2000), Themistocleous, Irani, O'Keefe and Paul (2001), Bingi, Sharma and Godla (1999)
Technology advance	Ayağ and Özdemir (2007), Kumar, Maheshwari and Kumar (2002, 2003), Rao (2000)
Scalability	Fisher, Fisher and Kiang (2004), Han (2004), Verville and Halington (2003), Everdingen (2000)
Upgrade ability	Kumar, Maheshwari and Kumar (2002, 2003), Rao (2000), Sprott (2000), Bueno and Salmeron (2008)
Customization/parameterization possibilities	Keil and Tiwana, 2006), Berchet and Habchi (2005), Kumar, V., Kumar, U. and Maheshwari (2003), Verville and Halington (2003), Yang, Wu and Tsai (2007)
Ease of use	Ayağ and Özdemir (2007), Bueno and Salmeron (2008), Pivnicny and Carmody (1989), Verville and Halington (2003), Yang, Wu and Tsai (2007), Everdingen (2000), Wei, Chien and Wang (2005), Keil and Tiwana (2006)
Flexibility	Ayağ ir Özdemir and Wei (2007), Chien and Wang (2005), Umble, Haft and Umble (2003), Sprott (2000), Bernroider and Koch (2001), Everdingen (2000)

Modularity	Bueno and Salmeron (2008), Kumar, Maheshwari and Kumar (2002, 2003)
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Source: compiled by the author, based on literature review

The most important implementation-related ERP selection criteria were are listed in Table 2.

Table 2. Implementation related ERP selection criteria in scientific literature

Criterion	Authors
Ease and speed of implementation	Fisher, Fisher and Kiang (2004), Lall and Teyarachakul (2006), Umble, Haft and Umble (2003), Wei, Chie and Wang (2005), Yang, Wu and Tsai (2007), Chen (2001), Everdingen (2000), Bueno and Salmeron (2008), Keil and Tiwana (2006), Verville and Halingten (2003), Bernroider and Koch (2001), Venkatraman (1994)
Organizational fit	Bernroider and Stix (2006), Kumar, Maheshwari and Kumar (2002, 2003), Lall and Teyarachakul (2006), Liao, Li and Lu (2007), Nah and Delgado (2006), Umble, Haft and Umble (2003), Hong and Kim (2002), Goodhue and Thompson, 1995), Kanellis (1999), Everdingen (2000),
Training quality	Fisher, Fisher, Kiang (2004), Verville and Halingten (2003), Yang, Wu and Tsai (2007), Bueno and Salmeron (2008), Everdingen et al. (2000), Kimberling (2009), Hong and Kim (2002).
End-user readiness	Bueno and Salmeron (2008), War (2005), Albadri, Abdallah (2009), Summer (2000), Wright (2002)
Sistem support quality	Fisher, Fisher and Kiang (2004), Kumar, Maheshwari and Kumar (2002, 2003), Liao, Li and Lu (2007), Rao (2000), Umble, Haft and Umble (2003), Verville and Halingten (2003), Siriginidi (2000), Bernroider and Koch (2001), Everdingen (2000), Ayağ and Özdemir (2007), Wei, Chien and Wang (2005)

Source: compiled by the author, based on literature review

Modelling the relationships between ERP selection criteria. Even taking into consideration the different nature of ERP selection criteria, all of them are related with each other. Despite wide descriptions of criteria in the scientific literature, according to us these interrelationships are not sufficiently analyzed. In this paper we conducted a survey of 12 ERP implementation experts having at least 5 year of practical work experience in ERP implementation and consulting area. Non-stochastic target sampling was selected by subjective evaluation the knowledge of experts. Each expert in the framework of his subjective opinion has evaluated the nature of relations between listed ERP selection criteria. In order to reach consensus *Delphi* technique was applied, hereby asking to fill the form twice (for the 2nd time already showing the other experts answers). Based on research results, the following types of ERP selection criteria were identified:

1. The ones who interact the others.
2. The ones who receive the interaction from the other.
3. Universal criteria with interaction in both directions.

The creation of Fuzzy Cognitive Map. Experience of all experts was valuated equally making an assumption that the strength of interaction between criteria is proportional to the number of experts who have identified that interaction. In this way, the absolute value $|w_{ij}|$ of the impact of variable C_i to the variable C_j equals to the relative number of experts that identified corresponding relation. The sign of variable w_{ij} identifies the nature of impact (positive or negative). Taking into consideration all the values of variables w_{ij} , we have identified the adjacency matrix W of the Fuzzy Cognitive Map of ERP selection criteria. In Fig. 2 the graphical version of the matrix is

displayed that was created using the *Pajek* program developed for the analysis of large networks (Batagelj and Mrvar, 2012). Software-related criteria are coded in green colour, implementation related – in blue and in ERP functionality criterion – in red. Altogether 151 links are displayed that identify the relations between each pair of criteria. The density characteristic 0,522 shows quite close connections between the elements of this graph.

In Fig. 3 the characteristics of elements of the Fuzzy Cognitive Map are displayed. Relevant importance of the apex is shown by the ratio of the centrality. The outdegree and the indegree ratios characterize the impact for (from) the other elements (Newman, 2010).

The ERP functionality importance in ERP selection process. Using the *FCMapper* (FCMapper, 2013) simulation modelling software we have evaluated the impact of changes of ERP functionality for the other criteria. The scenario of the first modelling was dedicated for “learning” process of the Fuzzy Cognitive Map - Hebo (Kosko, 1991) method was used in order to determine the initial state of variables. For all variables of the model initial value 1 was given and after 12 imitational iterations a state vector A has stabilized. Reducing the value of vector A that corresponded to ERP functionality we made the re-simulation of imitational modelling. The state of vector A is displayed in Table 3 showing that the changes of functionality in smaller or higher extend makes the influence to all other criteria. Only the criterion of technology advance is not influenced because the additional functions are realized in the framework of existing technologies. Also, in the table 3 the results of simulations are described. The increase in functionality mostly boosts the price criterion. Additional functions are mainly designed for the automation of new business process groups. They are combined into individual modules. Thus, the increase in functionality increases the number of corresponding modules. On the other hand, very functional systems are less flexible because it is necessary to take into consideration their impact on larger number of functions. The most functional ERP realize greater variety of business processes. That results in better organizational fit and stronger positions in ERP market.

The importance of ERP functionality is highlighted in practical researches of other authors as well. In Kumar's (2003) survey of Canadian companies, functionality has been the most often quoted and the most important ERP selection factor to consider, mentioned in 79% of the cases. Heck (1997) presents a similar opinion, affirming that this criterion has to comprise up to one / third of the final score used for making ERP selection decision. Anderson and Chen (1997) treat ERP functionality as the main ERP selection criterion.

Mitlöhner and Bernroider (2005) conducted research studies interviewing 209 randomly selected Austrian companies of small, medium and large size. In these studies the company with annual turnover of less than 50 million EUR and with less than 250 employees were treated as of small and medium size. The importance of criteria was assessed in the system of five points. It was finally concluded that ERP functionality and reliability are the most important criteria for the companies of all sizes.

This opinion can be supported by practical findings of the Aberdeen consultancy. In the research performed in the years 2007 and 2011, respectively 1680 and 1564

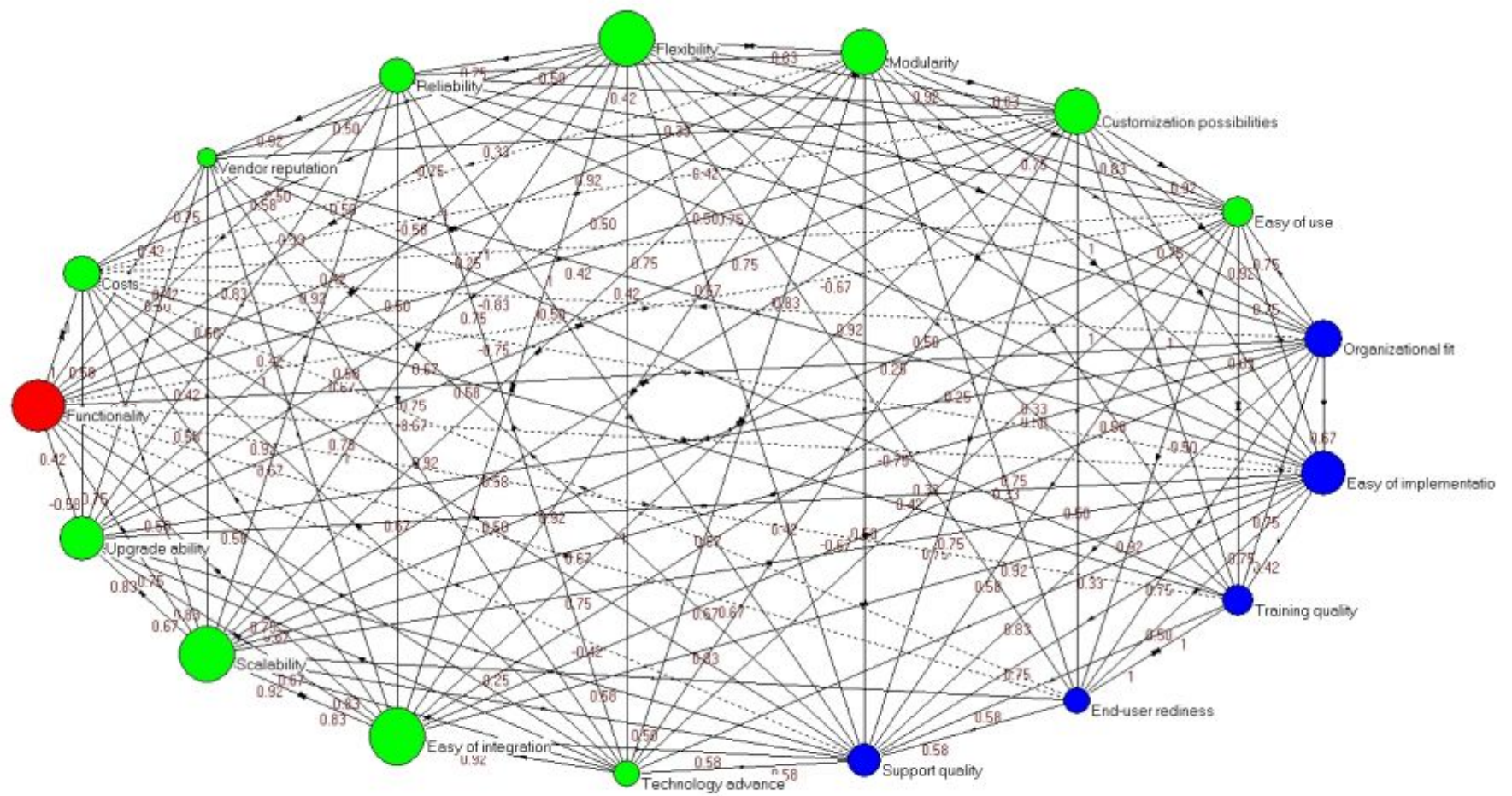


Fig. 2. Graphical display of fuzzy cognitive map of ERP selection criteria
Source: compiled by the author

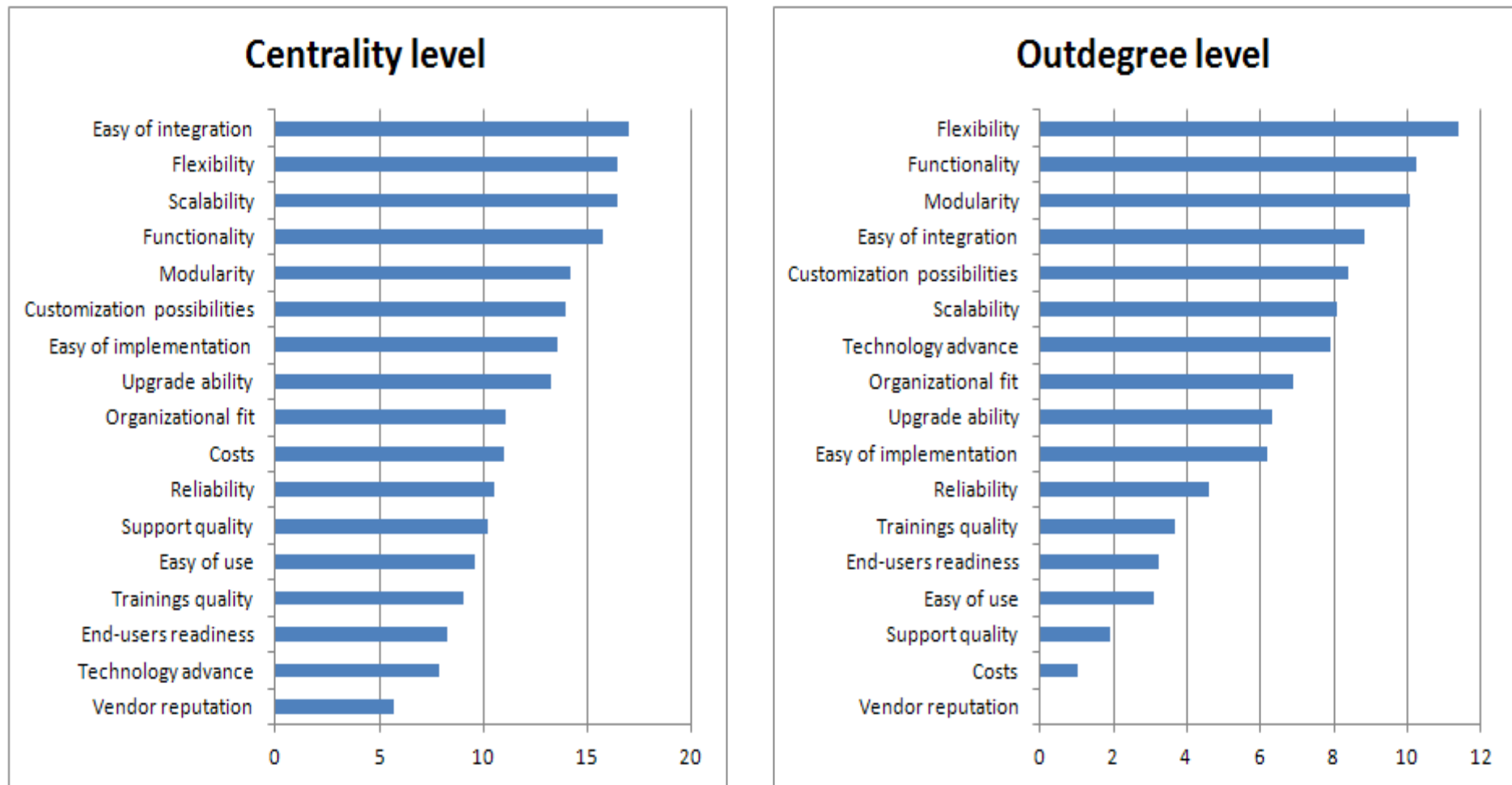


Fig. 3. Characteristics of elements of the ERP selection criteria Fuzzy Cognitive Map

Source: *compiled by the author*

Table 3. Functionality changes influence on characteristics of elements of the ERP selection criteria Fuzzy Cognitive Map

Element of the Fuzzy Cognitive Map	The final value of element		Changes in values
	(1st scenario)	(2nd scenario)	
Functionality	0.99	0.50	-0.49372705
Costs	0.91481965	0.869749	- 0.04507063
Vendor reputation	0.99517327	0.9941368	-0.00103647
Reliability	0.98891672	0.9913195	0.00240278
Flexibility	0.96348874	0.9742838	0.01079509
Modularity	0.97887051	0.967469	-0.01140153
Customization possibilities	0.99445741	0.9920011	-0.00245628
Easy of use	0.992763	0.9947647	0.00200201
Organizational fit	0.983764	0.976654	-0.00711001
Easy of implementation	0.996526	0.9975945	0.00106820
Trainings quality	0.982137	0.987106	0.00496941
End-users readiness	0.973672	0.980926	0.00725389
Support quality	0.999195	0.999346	0.00015101
Technology advance	0.500000	0.500000	0.00000000
Easy of integration	0.999509	0.999315	-0.00019389
Scalability	0.999598	0.999418	-0.00018088
Upgrade ability	0.995069	0.996293	0.00122350

Source: *compiled by the author*

companies of different size, industries and geographical regions have participated (Aberdeen Group, 2007; Aberdeen Group 2011). As a consequence, three most often cited ERP selection factors were defined. Functionality has been named as the most important criterion (in 69% and 75% of cases, respectively). In 53% of cases, the system price has been mentioned. Ease of use was the third most popular factor, cited in 42% and 51% of cases, respectively.

In other surveys Aberdeen group has evaluated the importance of ERP selection criteria on a 5-point scale (5 being the most significant and 1 the least significant). The accumulated results have shown the same three the most important ERP selection criterion. Functionality has remained the importance leader in both 2009 and 2011 years (with 4,8 and 4,27 points out of 5).

Swiss consulting company *Intelligent systems solutions* conducted a survey of 1923 users in 17 countries. In 69 percent of the cases ERP functionality has been treated as the criterion to be taken into account. It was also concluded that if the system does not meet the functionality requirements, all the other advantages don't have any importance because the functionality is the first one that should be evaluated.

Taking into consideration the results of our survey, stated findings from other practitioners, the opinion of Keil and Tiwana (2006), Kumar, Kumar and Maheshwari (2002, 2003), Liao, Li and Lu (2007), Wei, Chien and Wang (2005), Siriginidi (2000), Chen (2001), Everdingen et al. (2000) and other authors, it was concluded that **ERP functionality is the most important ERP selection criterion. This conclusion**

resulted in a work direction for our future research – the functionality analysis of contemporary ERP systems.

The definition of research object of ERP functionality. In the scientific literature on ERP selection only theoretical aspects are widely covered (Sen, et al., 2009, Nazemi, et al., 2012; Addo-Tenkorang and Helo, 2011; Shehab, et al., 2004; Schlichter and Kraemmergaard, 2010). Thus, there is a lack of reasonable comparison between currently used ERP solutions. It is possible to find the evaluation of most popular ERP solutions by tens of features (*Info-Tech Research Group, 2012, Ziff Davis, Inc., 2013*). However, currently thousands of software solutions for business process automation are proposed in the market. Therefore, it is very important to have detailed information about the functionality of these systems for the companies that are looking for best suitable solution.

Composing a statistical sample for the research studies of ERP functionality we aimed to include these groups of ERP systems:

1. Global ERP market leaders.
2. The systems from different levels.
3. By research companies the best evaluated systems.
4. Lithuanian accounting programs.

Over the last two decades, the global ERP market is constantly growing. Research companies differently estimate this market volume. The estimation size depends on the applied methodology. Based on the data from *Focus Research* (Focus Research, 2011), only for licenses in 2011 36.235 billions USD in total were spent (for comparison: in 2009 - 33.495 billions USD, 2010 - 34.596 billions USD). These figures do not include ERP implementation and maintenance services - that amount would be even higher. In the report provided by *Gartner* (Pang, et al., 2013) the marked of ERP systems was evaluated by 24,5 billion USD (increased by 2.2% from 2012).

Distribution of global ERP market was assessed by *Panorama Consulting Group* that questioned more than 1600 companies that have chosen and have implemented ERP solution during the last 5 years. The survey showed that in 2010 more than 53% of ERP market was taken by 3 vendors: *SAP, Oracle* and *Microsoft* (Panorama consulting group, 2011). In this study other major ERP vendors were identified such as *Infor, Epicor, IFS, Lawson, Consona, Activant, QAD, Adonix, Sage, Visibility, NetSuite* and *Exact*.

Consulting companies that select and implement ERP systems divide ERP systems into groups. The most popular classification divides ERP solutions into *tiers*. The size of the company (potential ERP customer) most often is taken as the main criterion. It can be measured by sales revenue, number of employees or number of ERP users. This type of classification allows quickly and accurately eliminate the majority of the systems that doesn't meet or significantly exceed company's requirements.

Research companies most often evaluate ERP systems by 2 perspectives, thus forming the system of four groups, called quadrants (see Table 4).

Availability of information about ERP functionality was one of the main criterion that determined the systems for further analysis. Detailed data about the functionality of 139 ERP solutions were gathered within a few years. Among them – systems from the main ERP market players (*SAP, Oracle, Microsoft, Infor, Sage* etc.) that are included in the ranking quadrants of all consultancies. We also have studied functional possibilities

Table 4. Classification on ERP systems by different research companies

Characteristics of ERP quadrants	Valuator			
	<i>Gartner Research</i>	<i>Info-Tech Research Group</i>	<i>Nucleus Research</i>	<i>Boston Consulting Group</i>
Object of valuation	ERP market position and changes	ERP market position	ERP market position	ERP life cycle
Horizontal axis	Complexity of the vision of ERP vendor	ERP vendor	ERP functionality	Market size
Vertical axis	Efficiency of the activities ERP vendor	ERP as a product	ERP usability	The growth of market size
Names of segments	Leaders, Challengers, Niche players, Visionaries	Champion, Innovator, Emerging Player, Market Pillar	Leaders, Facilitator, Core Provider, Expert	Baby, Star, Cash cow, Doggie

Source: compiled by the author based on (Gartner Research, 2009, Info-Tech Research Group, 2012, Boston Consulting Group, 2012, Nucleus Research, Inc., 2012).

of local accounting software implemented in the Faculty of Economics of Vilnius University - *Konto Professional* (Logas, 2012) and *Rivilė Solo Plus* (Rivilė, 2012).

The statistical analysis of the functionality of ERP systems. Classifications of ERP systems into quadrants performed by different consultancies most often rely on the subjective opinion. It is evident that the recommendations of experts prior to select the system are of crucial importance, but they should be based on the data of quantitative nature.

The list of functions was created in order to develop the tools that facilitate the choice of best suitable ERP system. During the creation of this list, the modular structure of ERP software, the usage of each of the modules and the most popular functions were analyzed. After that 3370 selected functions were divided into 11 groups. Fig. 4 reflects the structure of these functional groups.

Using decision support systems such as *The Accounting Library* (The Accounting Library Standard Edition v. 7.3, 2012), *TEC Advisor* (TEC Advisor, 2012), *TechMATCHPRO* (TechMATCHPRO, 2012), *Systems Analysis Tool - ERP* (Systems Analysis Tool - ERP) and the others, studying the lists of summarized functional power provided by *Technology Evaluation Centers* (Technology Evaluation Centers, 2012) and other consultancies (180 Systems, 2012, Midmarket /Enterprise ERP Solution Comparison Guide, 2010), analyzing documentations and user manuals of the systems, commercial proposals and through direct queries the database of ERP characteristics was formed. Thus, the overall number of characteristics reached 468430 (139 systems and 3370 functions). Fig. 5 shows the percentage of the function that are fully realized („Y“) in the sample of taken 139 systems. As it could be seen, contemporary ERP systems

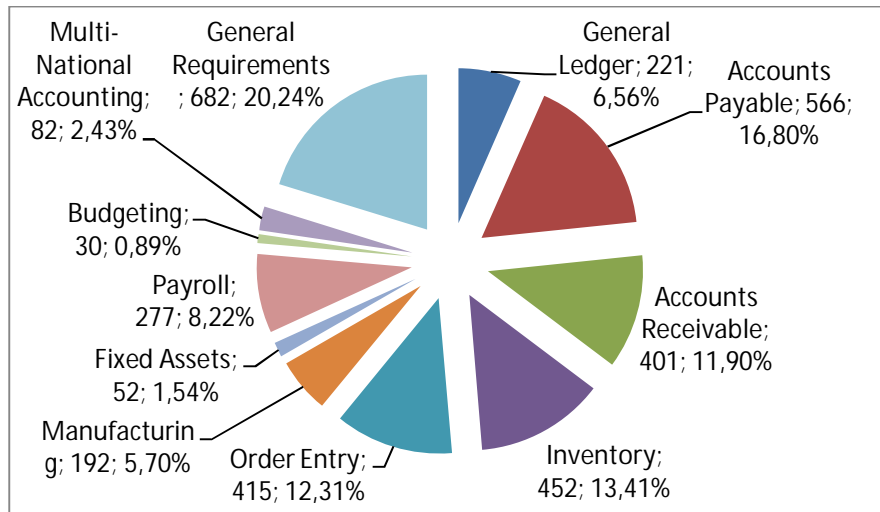


Fig. 4. The structure of the most important ERP functions list

Source: compiled by the author

are able to automate several thousands of various business processes functions. The most of these functions are implemented in the standard versions of systems. For the realization of other functions modification of software, changing the structure of standard databases, using report generators to create additional reports and other actions are needed. Some part of functions could be realized by using third party software tools. Taking into account the demands from customer's new features of the ERP solutions could be provided in future versions of the systems.

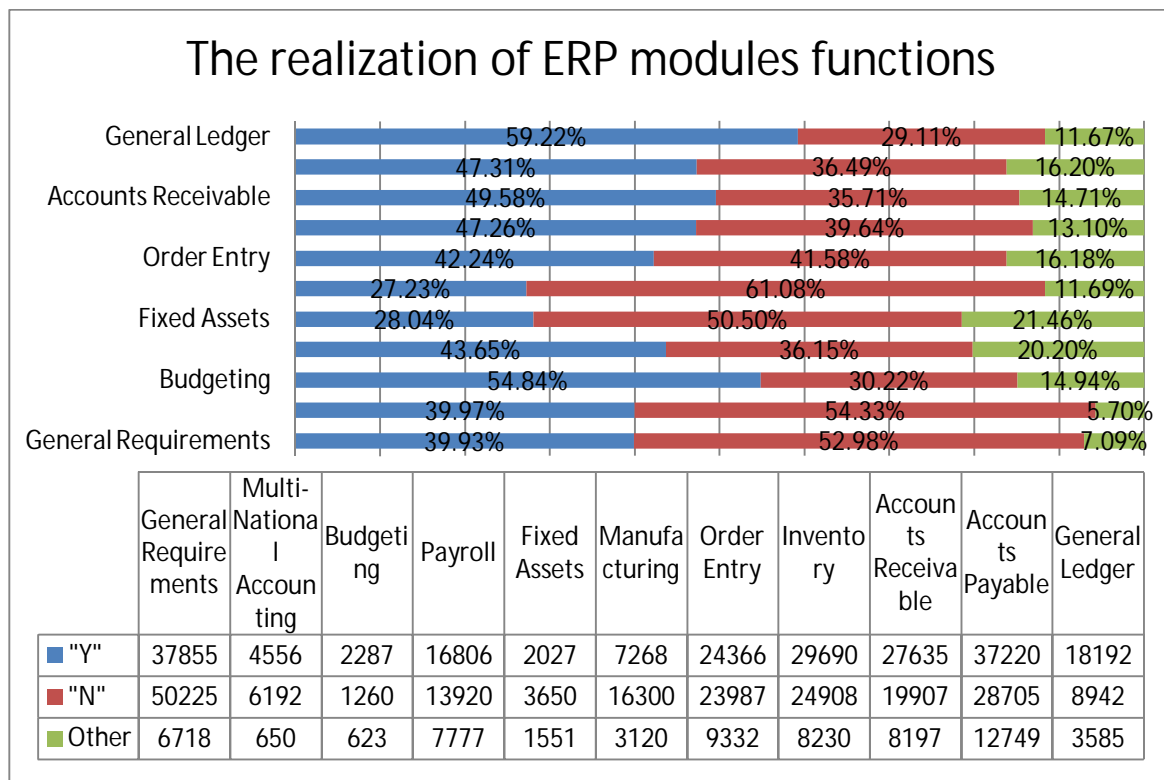


Fig. 5. Types of functions realization in different ERP modules

Source: compiled by the author

The accumulated set of more than 400000 characteristics belongs to the type of qualitative data. This type of data usually is of descriptive nature and has some limitations - mostly rely on subjective opinion of the author. In addition, the assessment of qualitative data are much more difficult comparing to the assessment of the data of quantitative origin.

The indicator of ERP functional power was introduced in order to transform qualitative data to quantitative form and to reducing the overall scope of analyzed characteristics.

However, the functional power of ERP system i - FG_i is defined as follow:

$$FG_i = \frac{\sum_{j=1}^n f_{ij}}{n} \times 100,$$

Where, f_{ij} - the score of realisation of function j (from 0 to 1) in the system i ,
 n – overall number of evaluated functions

When analyzed function i from the system j is fully implemented, then the score equals to 1. If this function is not available and will not be available in a new version of ERP solution, then the score equals to 0. In all other cases, the valuated score is determined taking into account the difficulty and related cost to realize specific function.

The importance of the same function s_j depends on the industry and on the business activities of the company. In addition, it also depends on the size of the company as well. Thus, **specialized functional power** (SFG_i) defines relevance of ERP i for the specific company and can be calculated using the formula as follow:

$$SFG_i = \frac{\sum_{j=1}^n s_j f_{ij}}{\sum_{j=1}^n s_j} \times 100.$$

In order to limit the extend of research data, we have identified 1906 functions that are necessary for the distribution companies and 2187 functions that are needed for manufacturing companies. In addition, 578 functions relevant to small-medium businesses and 1451 functions relevant to large corporations were identified that are important in order to computerize financial accounting. Forming these functional classes, we have mostly relied on a personal experience acquired during the implementation of ERP solutions in different European countries, as well as on recommendations from other ERP professionals. Especially valuable was the information collected by *Charles C. Chewning Jr* (Solutions, 2012), which shared the lists of functional requirements gathered during 3000 ERP implementation projects where *The Accounting Library Decision Support System* (The Accounting Library Standard Edition v. 7.3, 2012) was used.

Taking into considerations the importance of functions and their realization methods in all 139 analyzed ERP systems, we calculated the values of specialized functional power based on the requirements of companies in the manufacturing and distribution industries. In addition, separate values of specialized functional power were calculated to show the match of the requirements for financial accounting for both the small-medium business and large corporations.

The indicator or Specialized Functional Power and quantitative definition of its values enabled us to integrate all functional characteristics of different ERP systems and at the same time to reduce the amount of analyzed data more than 800 times.

Cluster analysis of ERP functional power. Unbiased classification of ERP systems into groups is possible only on the basis of reliable statistical methods. Cluster analysis is one of the most popular methods of multivariable analysis that deals with this issue. In this paper we have conducted 5 independent ERP allocations to the clusters in order to group ERP systems according to the following criteria:

- An integrated evaluation of ERP functional power, independently of company's business environment .
- Specialized evaluation of ERP functional power in the context of requirements that are critical for the distributors.
- Specialized evaluation of ERP functional power in the context of requirements that are critical for the manufacturers.
- Summarized evaluation of ERP functional power for financial accounting.
- Specialized evaluation of ERP functional power splitting requirements that are critical for small-medium business and large enterprises.

The definition of quantity of clusters, or the adequacy of the model are one of the main problems that are faced during cluster analysis (Guo , P., 2002). Based on the experience of *Aberdeen*, *Gartner Data Research DPU*, *Info- Tech Research Group* and other consulting companies we have identified 4 groups of ERP software. Each of the group is characterized by the values of ERP functional power and the parameter of its standard deviation. In the group of **leaders** (1st cluster) the systems with the highest value of functional power and lowest value of standard deviation are included. In the 2nd (**middlings**) and 3rd (**beginners**) cluster ERP systems are included with relatively lower functional power. The versatility of ERP systems falling into these clusters are defined by the ratio of standard deviation of its functional power. Greater deviation identifies the systems within the cluster with the higher degree of specialization. Lower deviation identifies the systems within the cluster with higher versatility. Therefore, 2nd and 3rd cluster can be relatively entitled as **the universal middlings, the niche middlings, the universal beginners and the niche beginners**. All the systems from the 4th cluster can be called the statistical outlets because values of their functional power are significantly different comparing to the other systems.

Fig. 6 presents the comparison of results of cluster analysis that were collected using various indicators of specialized functional power.

Evaluation of functional power of Lithuanian accounting software. One of the most challenging tasks preparing this research was the evaluation of functional power of Lithuanian accounting software solutions such as *Konto Professional* and *Rivile Solo Plus*. To reach the goal, thousands of functions realized in these two solutions were analyzed. The average value of integrated functional power exceeds 64% for both Lithuanian systems. This rate is high enough and allows including *Rivile Solo Plus* into the second (middlings) cluster. Due to the high standard deviation (12.0) the other Lithuanian solution *Konto professional* was assigned to the third cluster (**beginners**).

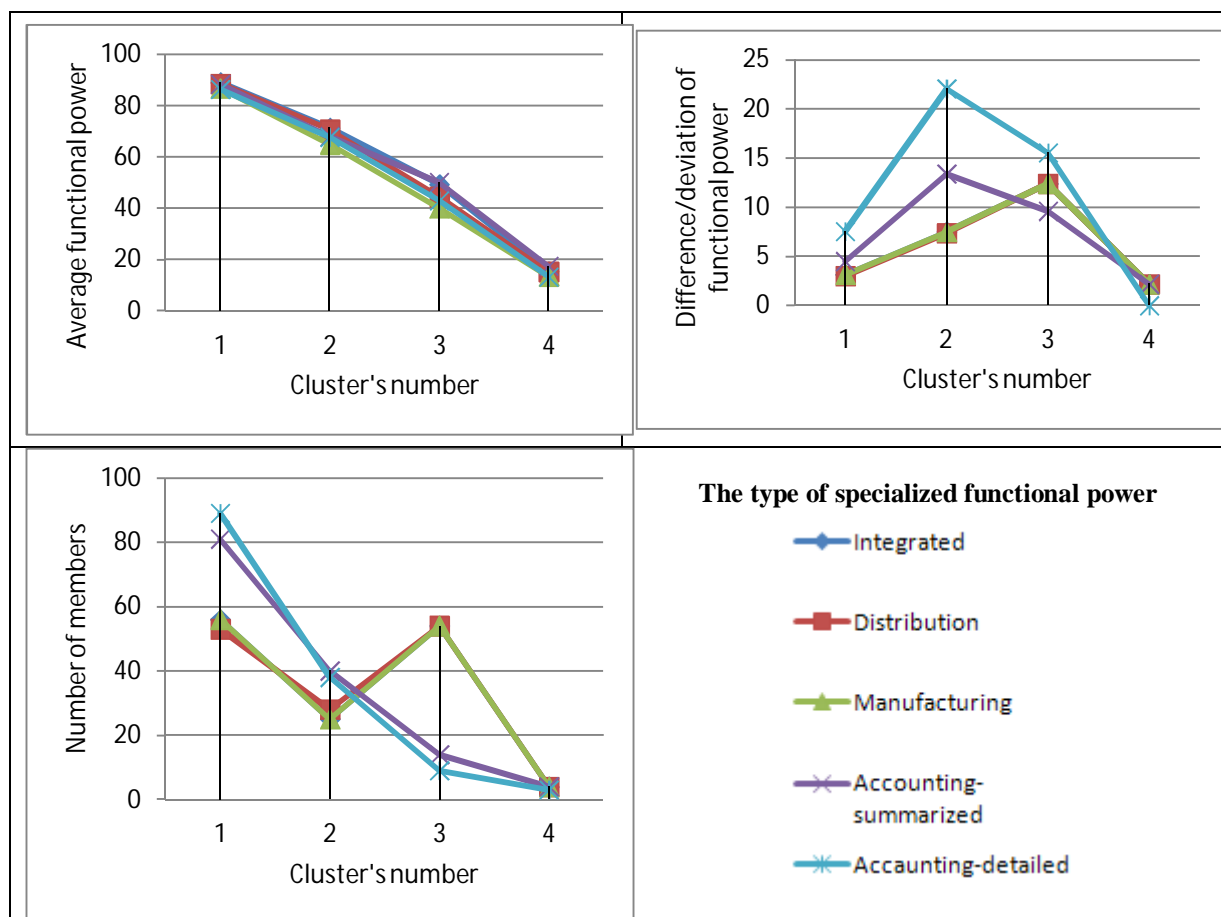


Fig. 6. Comparison of ERP clusterization according to different indicators of specialized functional power.

Source: compiled by the author

We also conducted the comparison of specialized functional power of Lithuanian accounting programs against *Microsoft Dynamics NAV* (the most popular foreign ERP software in Lithuania) and against the average value of functional power of all 139 solutions. As it can be seen in Fig. 7, the functionality of Lithuanian systems corresponds to the average level. Taking into account only the accounting needs of small-medium business, specialized functional power of *Konto Konto Professional* even exceeds the average performance of all sample by 5%.

Application of results of the research during ERP selection process. During ERP selection process it is mandatory to have good knowledge of the whole ERP market, IT development trends or unbiased opinion about advantages and disadvantages of already proposed systems. To gather such sophisticated information appropriate qualifications as well as time resources to perform all tasks are needed. The results of this research are useful for the companies trying to select ERP solution because can help mitigate the risks caused by inappropriate ERP selection as well as could provide following benefits:

- ERP selection process would become more objective;
- The needs of future end users would be assessed more thoroughly;
- The time spent for the selection of the most suitable ERP solution could be significantly reduced;

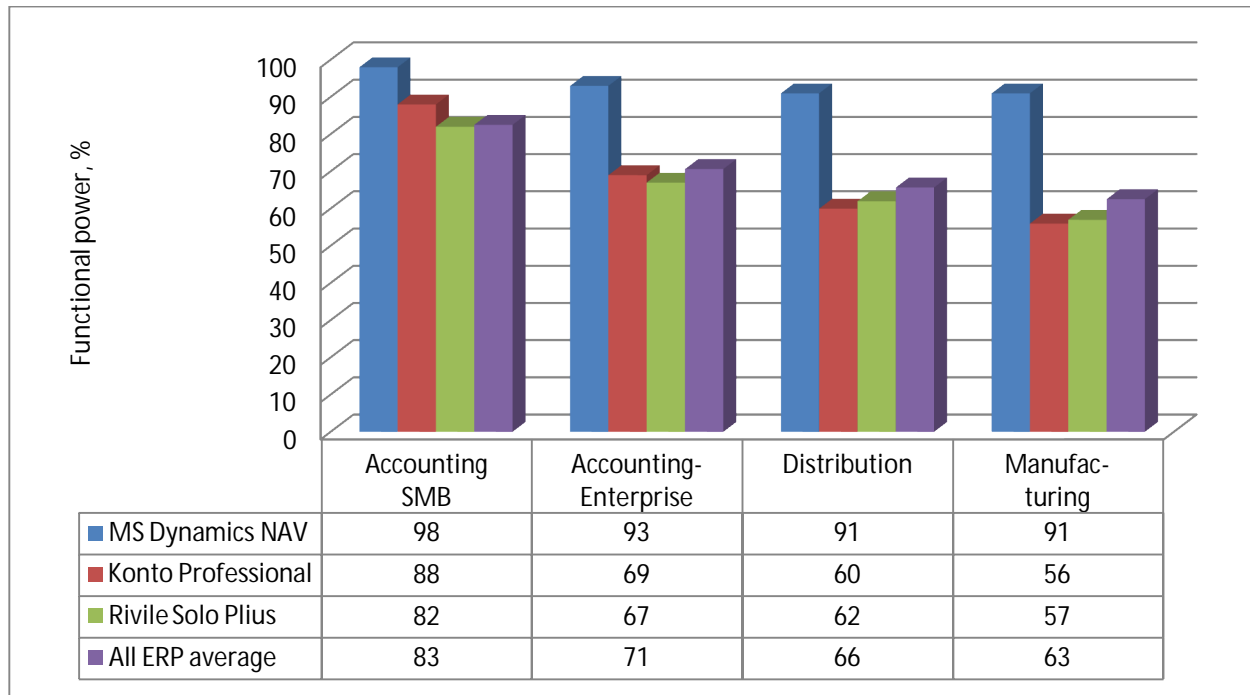


Fig. 7. Comparison of MS Dynamics NAV, Konto, Rivile Solo and all the rest analyzed ERP functional power

Source: *compiled by the author*

- The potential of already implemented ERP software could be exploited much better;
- ERP implementation process could be reasonably divided into different stages;
- It would be easier to control the work of external ERP implementation consultants.

After analysis of different ERP implementation methodologies, we have distinguished the following ERP selection process stages: project planning, requirement definition, identification of suitable ERP systems, ERP evaluation and finally, the selection of most suitable ERP solution. In Fig. 8 the tasks during each of these phases are identified. The results of this dissertation could be used in all ERP selection process marked with yellow colour.

Recommendations regarding the usage of available ERP functionality. The ERP selection is a fundamental but only the first step in order to take advantage of all benefits that are provided by ERP system. Nowadays, in response to the increasingly dynamic business environment companies are constantly changing. Therefore, the effective ongoing use of implemented ERP system is highly important.

Starting with 2006, the studies of ERP functionality annually performed by *Aberdeen Group* revealed that on average companies are using just *one-third* of existing ERP functionality. It is natural to expect that with a practical experience it more and more ERP functionality will be absorbed. However, these studies have shown the opposite result – over the time it is used less and less of ERP functionality. This phenomenon has been called **software erosion** (Thompson, 2001; Wardell, 2002).

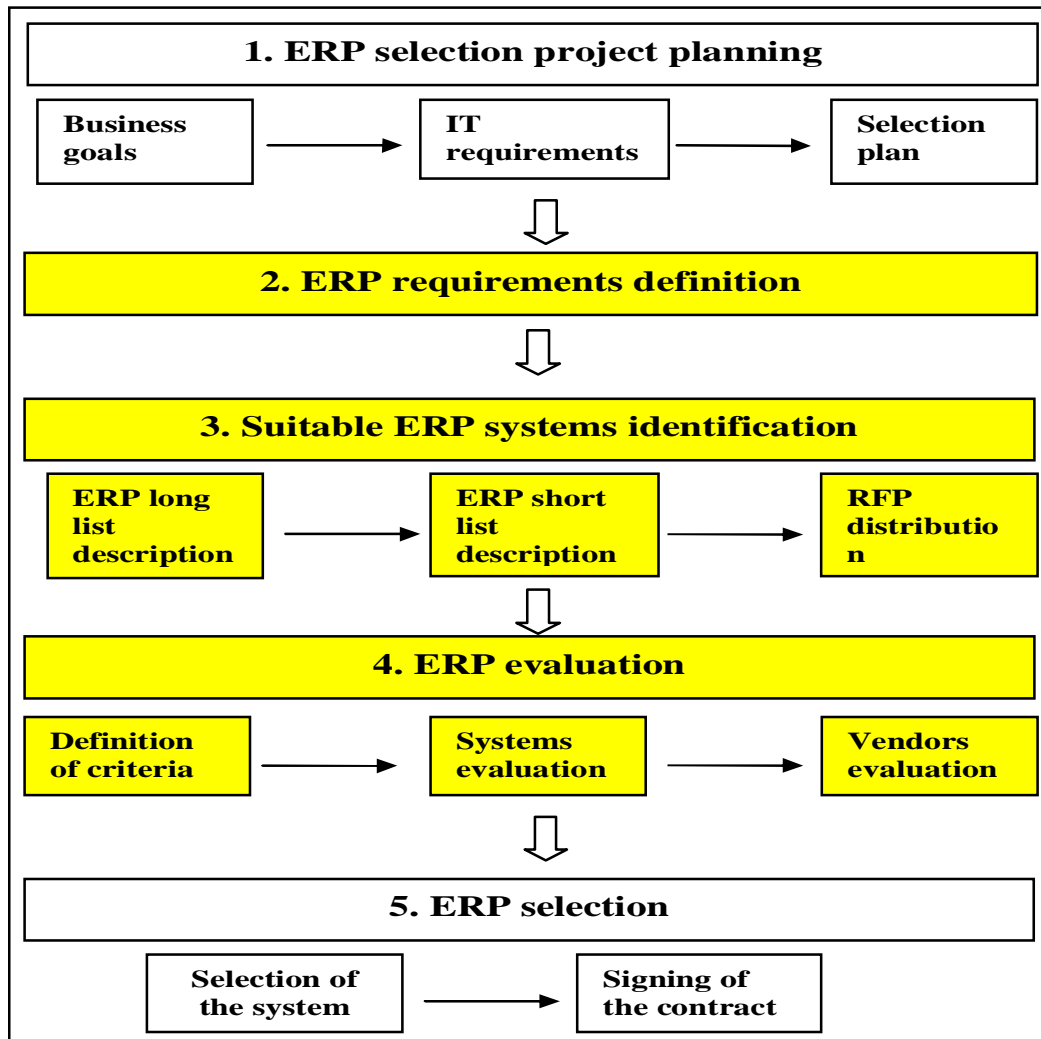


Fig. 8. Steps of the ERP selection process and their tasks

Source: compiled by the author based on (Clark, 2012), (Gartner, 2010), (Technology group international, 2011), (Gross, 2009), (IntelliThink, 2004), (Diamond & Diamond, 2004), (Fornes, 2010)

In fact, the abilities of software solutions do not change but only the users operate less and less functions that are provided.

Mathematical model of the evaluation of the use of ERP functionality. The effect of ERP erosion comes out immediately after the start of the use of new ERP solution. As the value of the system decreases very slowly (very often even invisibly) it is necessary to monitor periodically the existing ERP functionality and the degree of its usage. This monitoring is mainly performed by the experienced and highly paid external consultants who can identify changes in the use of ERP functionality that has evolved over a period of time. However, due to the high cost of such projects not many companies can afford it.

Below follows the description of our suggested methods for the evaluation of the usage of ERP functionality that simplify the whole process and allow performing such an assessment without the help from external consultancies.

The assumption was made that the utilization of ERP functionality could be reflected by the population of database tables. Depending on the acquired licence companies are entitled to use certain modules of the system. By entering various transactions the users save specific data into various database tables of ERP system. If the acquired licence does not allow perform specific functions, corresponding ERP database tables are “locked”. The ratio of total (K_{DB}) and “unlocked” (K_a) numbers of database tables reveals the purchased part of ERP functionality (TFD):

$$TFD = \frac{K_a}{K_{DB}} \times 100.$$

If the specific ERP system’s function is not used, then the relevant database table has no records and is empty. The ratio of non-empty K_{nt} and “unlocked” K_a numbers of the database tables reflects the degree of utilization of acquired ERP functionality (TFPL):

$$TFPL = \frac{K_{nt}}{K_a} \times 100.$$

The percentage of functionality in use compared with overall standard ERP functionality could be calculated as follow (FPL):

$$FPL = \frac{\sum_{j=1}^{n_r} p_j}{n_r} \times 100,$$

p_j – indicator of usage use of function j :

$$p_j = \begin{cases} 1, & \text{if the function } j \text{ is used;} \\ 0, & \text{if the function } j \text{ is not used.} \end{cases}$$

n_r - the total number of realized functions in ERP system

Since the developers of ERP solution try to satisfy the need of the largest number of companies, some of systems features that are crucially important for one company can be almost unnecessary for the other. Therefore, the equation can be adjusted adding the importance ratio of the function for the company (FPLS):

$$FPLS = \frac{\sum_{j=1}^{n_r} s_j p_j}{\sum_{j=1}^{n_r} s_j} \times 100,$$

FPLS – evaluation of ERP usage, taking into account the importance of the function for the company;

s_j – the importance of function j (0 – redundant, 1- of little importance, ..., 8 – extremely important, 9 – critically important).

Since the acquired ERP licence allows to use not all modules of the system, variable n in the FPL and FPLS calculation formulas could be replaced by the variable that defines only the number of acquired functions n_{tr} ($n_{tr} \leq n_r$).

Thus in order to keep the efficiency of funds invested in ERP solution, during corporate IT audit it is necessary focus not only on the data security ensuring tools and features, but also evaluate the usage of existing ERP functionality.

Conclusions.

1. The analysis of research papers has shown that there is no unique classification of ERP selection criteria. This could be explained by their diversity as well as by differences of scientists' research objects. Mostly, the criteria are only defined and in some cases classified on the basis of the research object. According of the nature of criteria, the authors of this paper separate them into two groups: software-related and implementation-related ERP selection criteria. Twelve software-related criteria have been identified: functionality, the total costs of the ERP implementation project, vendor reputation, ERP reliability, ease of integration with other systems, technology advance, scalability, upgrading ability, customization / parameterization possibilities, ease of use, flexibility and modularity; as well as five implementation related criteria: ease and speed of implementation, organizational fit, training quality, end-user readiness, system support quality.
2. According to the majority of research papers and practical investigations, ERP functionality is recognized as the most important and significant ERP selection criterion which is closely related to the whole outcome of the ERP selection process. The significance of other factors may vary depending on the situation in the company – future ERP users' skills, the implementation project's scope, the complexity of business processes, etc. Using data from expert survey Fuzzy Cognitive Map, evaluating relations among ERP selection criteria have been created. The characteristics of directed graph revealed that the importance of ERP functionality is determined by its influence on the other selection criteria. The size of impact was assessed quantitatively using the technique of simulation modelling.
3. In the scientific literature mostly the theoretical aspects of ERP selection topic are analyzed. Consultancies such as *SoftResources*, *K2 Enterprises*, *Ultra Consultants*, *ERPandmore.com*, *Panorama Consulting* provide only ERP selection guidelines and distribute these systems into layers according to their suitability for different companies. Although researchers from *Gartner Research*, *Info-Tech Research Group*, *Nucleus Research* and *Boston Consulting Group* describe main comparison principles, in their reports and rankings the analysis of ERP characteristics are not covered that would help to understand the reasoning why ERP software has been assigned to the relevant quadrant. The most popular ERP comparison reports provided by numerous consultancies include only small number of ERP systems and their characteristics. Considering the size of financial resources that companies invest in ERP implementation, it is crucially important for each organization to have full-scale information about the functionality of ERP solutions that are compared.

4. To ensure well-grounded ERP selection process the quantitative data of ERP functionality are crucial. To collect that data the analysis of ERP functional characteristics was performed. After analysis of ERP market, considerations of their suitability for companies of different size as well taking into account rankings of research companies, the list of 139 most widely used ERP systems was prepared. Taking into account ERP modular structure, the use of each module and most popular ERP functions, 11 most important functional groups have been identified: general ledger, accounts payable, accounts receivable, inventory, order entry, manufacturing, fixed assets, payroll, budgeting, multi-national accounting, general requirements.
5. After evaluation of summarized functional characteristics from commercial decision support systems, analysis of standard ERP functional requirements from the foreign consulting companies, studies of documentation and user manuals, commercial proposals as well as practical data about functional power of accounting software *Konto Professional*, *Rivilè Solo Plus* as well as *Microsoft Dynamics NAV 2009* and *iScala* systems used in the Faculty of Economics of Vilnius university, the list of 3370 characteristics about functional power of each of 139 ERP systems has been collected.
6. The comparison of Lithuanian accounting software *Konto Professional* and *Rivilè Solo Plus* against foreign ERP software was made. It was found that the functionality of these Lithuanian software systems corresponds to the world average level. Obtained results allowed concluding that Lithuanian systems perfectly satisfy the accounting need of small and middle size companies. They can perform these functions for the large corporations as well. In these two systems also the features that are important for distributors are well realized because the overall specialized functional power is higher than the average results of the sample of 139 systems. However, *Konto Professional* and *Rivile Solo Plus* underperform realizing the important functions for manufacturing companies because available functionality that help to describe the components in bill of materials and routings are mostly suitable only for the assembly type of manufacturing.
7. As Lithuanian accounting software is developed by small teams of programmers, it is difficult to compete in foreign market against global ERP solutions that are produced in the companies with thousands of employees. In order to compete successfully in a global market, it is recommendable to consolidate the skills and knowledge that would give the opportunity to create the products not only for local market. Unfortunately, at the moment some experienced and long-lived companies are focused on the orders from public sectors that are partially funded by European Union, but not on the creation of new competitive software solutions.
8. The analysis of activities performed during ERP selection leads to the conclusion that tools created and described in this dissertation can be used in almost all stages of this process. These tools can be integrated into the database of decision support systems developed for ERP selection. The use of corresponding databases would create the opportunities to perform certification of ERP systems. In our opinion, it is a considerable opportunity for Lithuanian ERP vendors to evaluate own

solutions in order to identify its strengths and weaknesses, thus providing directions for further developments.

9. Analysis of research publications showed that less and less installed ERP functionality is utilised over the time. However, in order to keep the efficiency of the funds invested in ERP, it is necessary during IT audit to analyze not only the data security ensuring and systems maintenance tools or processes but also to evaluate the utilization degree of current ERP solution. Tools created during doctoral studies and presented in this dissertation enable to simplify this process and provide the opportunities to evaluate the usage of functionality for the companies without the help of external consultants.
10. Contemporary ERP systems contain thousands of different features. The importance of these features should be evaluated during ERP selection process. Individual functions of the system could be integrated with company's business processes in order automatically to identify the functions that are needed for the organization. The list of functions could be assigned to each employee based on his role within organization. Thus, integration of business process with ERP functions could be another direction for further researches.

Approbation and dissemination of the scientific research results. Statements and results of the scientific research were published in 8 academic publications, of which 5 articles have been published in academic journals and 1 article in academic conference publications. Statements and results of the thesis have been presented in 2 international conferences.

Articles in academic journals

1. Ratkevičius D. Programiniai verslo valdymo sistemų atrankos veiksniai – Buhalterinės apskaitos teorija ir praktika. Kaunas : Lietuvos buhalterinės apskaitos tyrėjų ir švietėjų asociacija, 2011 m., Nr. 9, p. 97 -112.
2. Ratkevičius D., Skyrius R., Ratkevičius Č. ERP selection criteria. Practical and theoretical view – Ekonomika, mokslo darbai: Vilniaus universitetas.
3. Ratkevičius Č., Ratkevičius D. “Microsoft Dynamics” verslo valdymo sistemų tinkamumo studentų mokymui tyrimas – Informacijos mokslai: Vilniaus universitetas, t. 61, 136-143 p.
4. Ratkevičius Č., Ratkevičius D. Verslo valdymo sistemų funkcionalumo panaudojimo vertinimas – Informacijos mokslai: Vilniaus universitetas.
5. Ratkevičius D. Neprograminiai verslo valdymo sistemų atrankos veiksniai – Socialinių mokslų studijos, 2011, 3(4), p. 1359-1374, Vilnius: Mykolo Romerio universitetas.

Articles in academic conference material

6. Ratkevičius D. Neprograminiai verslo valdymo sistemų atrankos veiksniai. National scientific conference "Business, Management and Education 2010", conference proceedings [CD]. Vilnius: Technika. 2011.
7. Ratkevičius Č., Ratkevičius D. Verslo valdymo sistemų finansinės apskaitos funkcinių galimybių analizė. International scientific conference „Apskaita, auditas, analizė: mokslas inovacijų ir globalizacijos kontekste“, Vilnius

University, Faculty of Economics, 2012 m. March. Research paper 2012, D. 2, p. 591-598.

Presentations in scientific conferences

8. Ratkevičius D., Ratkevičius Č. Why we have chosen Microsoft Dynamics business applications for students training at Economics Faculty of Vilnius University? International conference "Microsoft Dynamics Academic Preconference Europe 2010". UK, London, 2010 October.

About the author

About the author

Donatas Ratkevičius was born on 28 June 1983, Vilnius (Lithuania).

Education

2008 – 2012	Doctoral studies, Economic Informatics, Vilnius University, Lithuania
2005 – 2007	Master in Accounting and Audit, Vilnius University, Lithuania
2003 – 2004	Erasmus student in the University of Paris 12, France
2001 – 2005	Bachelor in Management of Information systems, Vilnius University, Lithuania

Professional Background

2011- Currently	JSC <i>IBM Lietuva</i> , Senior SAP consultant
2010- 2011	SIA <i>Lattelecom Technology</i> , SAP consultant
2007- 2010	JSC <i>VINS</i> , Consultant

DISERTACIJOS SANTRAUKA

Temos aktualumas. Kompiuterinė verslo valdymo sistema (VVS) yra neatsiejama šiuolaikinių įmonių valdymo priemonė. Pradėtos kurti beveik prieš penkis dešimtmečius atsargų apskaitos ir medžiagų poreikio planavimo programos išsivystė į universalias integruotas programinės įrangos (PI) sistemas, automatizuojančias pagrindinius gamybos, logistikos, finansų, marketingo, žmogiškųjų išteklių ir kitus įmonės verslo procesus.

Tinkamai pasirinkta ir įdiegta VVS įmonėms suteikia šiuos privalumus: palengvina valdymo sprendimų priėmimą, supaprastina finansų valdymą, pagerina klientų aptarnavimą ir jų išlaikymą, pagreitina veiklos operacijų vykdymą, sumažina valdymo personalo ir atsargų poreikį, sutrumpina gamybos ciklą, padidina pajamas, suteikia augimo ir plėtros galimybes (Hawking, et al., 2004), Eresource Infotech, 2013). Ilgą laiką sietos tik su didžiausiomis privataus ar viešo sektoriaus organizacijomis VVS su laiku tapo prieinamos ir vidutinio dydžio, o tam tikri modifikuoti variantai – net smulkioms įmonėms.

VVS įdiegimas ir efektyvus panaudojimas šiais laikais tapo viena iš įmonių egzistavimo rinkoje sąlygų. Tai patvirtina ir didžiulės lėšos, kurios yra skiriamos šių sistemų įsigijimui ir įdiegimui. 2012 metais įmonės VVS šiam tikslui vidutiniškai išleisdavo po 7,1 mln. USD (Panorama Consulting Solutions, 2013). Tačiau tai – nors ir stambi, bet nevienkartinė investicija. Įmonėms plečiant savo veiklą, keičiasi jų veiklos pobūdis, organizacinė struktūra bei verslo procesai, kurių neatitinka naudojamos VVS funkcinės galimybės. Todėl periodiškai įmonės yra priverstos atnaujinti arba pakeisti turimas VVS.

Įdiegtos VVS efektyvumas priklauso nuo sistemos charakteristikų bei jos naudotojų poreikių atitikimo lygmens (Aloini, et al., 2007). Pasirinkus netinkamą VVS tenka atlikti daugiau papildomų jos pritaikymo įmonės poreikiams darbų. Tokiu būdu pailgėja sistemos diegimo laikas, ją nepatogu naudoti, kas gali paskatinti naujos sistemos paiešką. Taigi, VVS atranka gali nulemti viso sistemos diegimo ir jos panaudojimo projekto sėkmingumą. Tai – kompleksiškas tęstinis procesas, apimantis ne tik galutinius konkrečių sistemų parametrų palyginimus, tačiau ir išankstinius paruošiamuosius darbus, įvertinant įmonės verslo viziją, aktualius bei numatomus sistemos funkcinius poreikius, identifikuojant galimus projekto trikdžius.

VVS – tai sudėtingos sistemos, kurių atranka reikalauja nemažai įvairių žinių apie šių programinių produktų rinką, jų privalumus ir trūkumus, IT plėtros tendencijas, verslo procesus ir kt. Dabartinė VVS rinka kiekvienu atveju dažnai siūlo keliolika panašaus funkcionalumo produktų, tačiau būtent nedideli skirtumai tarp jų gali ženkliai įtakoti bendrą sistemos eksploatacijos įmonėje efektyvumą. Atsižvelgiant į didžiulę pasaulinėje VVS rinkoje siūlomų sistemų įvairovę, aukštą jų kainą ir su nesėkmingu sistemos pasirinkimu susijusią riziką, bet kokių priemonių, skirtų šio proceso palengvinimui, sukūrimas yra ypatingai aktualus.

Mokslinė problema ir jos ištyrimo lygis Lietuvoje ir pasaulyje. VVS atrankos, kaip vieno jos diegimo etapo problematikos aktualumą galima pagrįsti dideliu šios tematikos praktinės ir mokslinės literatūros straipsnių skaičiumi (Güngör Sen, et al., 2009). Šie straipsniai publikuojami leidiniuose, skirtuose informacinių sistemų, finansinės apskaitos, įmonių valdymo, gamybos technologijų, informatikos ir kitų sričių

specialistams. Tai rodo, kad VVS ir jų atrankos problematika yra tarpdalykinė sritis (Schlichter & Kraemmergaard, 2010). Mokslinį susidomėjimą šia sritimi skatina praktinis poreikis. Daugumoje publikacijų VVS atrankos tematika vyrauja vadybinis arba praktinis požiūris, todėl jų kiekis moksliniuose leidiniuose yra santykinai mažesnis lyginant su straipsnių profesiniuose žurnaluose skaičiumi (Sarpola, 2003), (Dong, et al., 2002), (Esteves & Pastor, 2001), (Shehab, et al., 2004), (Schlichter & Kraemmergaard, 2010), (Addo-Tenkorang & Helo, 2011), (Nazemi, et al., 2012).

Nors vadybos informacinių sistemų srityje dirbo L. Simanauskas (Simanauskas, 2008), Z. Brazaitis (Brazaitis, 1998), R. Skyrius (Skyrius, et al., 2008), O. Barčkutė (Barčkutė, 2008), N. Paliulis (Paliulis, et al., 2004), (Paliulis & Astrauskienė, 2003), P. Domeika (Domeika, 2008) ir kiti Lietuvos mokslininkai, tačiau VVS atrankos tematika čia dar mažai nagrinėta. Be M. Strončiko (Strončikas, 2008) ir O. Kovalevskij straipsnių (Kovalevskij, 2009) šia tema išleistos tik kelios šio darbo konsultanto Č. Ratkevičiaus praktinio pobūdžio publikacijos (Ratkevičius, 2003), (Ratkevičius, 1998), (Ratkevičius, 1997).

Išsamią užsienio mokslinių žurnalų, konferencijų medžiagos ir techninių ataskaitų, skirtų programinės įrangos atrankai, analizę atliko Sen, C. G., Baracli, H. ir Sen, S (Sen, et al., 2009). Literatūros analizė apėmė bendro pobūdžio publikacijas šia tema (Brownstein & Lerner, 1982), (Edmonds & Urban, 1984), (Frankel, 1986), (Anderson, 1989), (Eskenasi, 1989), (Williams, 1992), (Lai, et al., 1999), (Lai, et al., 2002) bei straipsnius, skirtus standartinės programinės įrangos (Subramanian & Gershon, 1991), (Adeli & Wilcoski, 1993), (Jeanrenaud & Romanazzi, 1994), (Kontio, et al., 1995), (Morisio & Tsoukias, 1997), (Tran & Liu, 1997), (Febowitz & Greenspan, 1998), (Maiden & Ncube, 1999), (Jung & Choi, 1999), (Kunda & Brooks, 1999), (Ochs, et al., 2000), (Alves & Castro, 2001), (Sedigh-Ali, et al., 2001), (Morera, 2002), (Miller & Yeoh, 2006), (Shyur, 2006), VVS (Teltumbde, 2000), (Erol & Ferrell, 2003), (Wei & Wang, 2004), (Cil, et al., 2005), (Wei, et al., 2005), (Wybo, et al., 2005), (Ayag & Ozdemir, 2007), (Sarkis & Sundarraj, 2006) bei kitos verslui skirtos specializuotos PĮ atrankos klausimais (Sarkis & Talluri, 2004), (Huang, et al., 2007), (Talley, 1983), (Dominick & Kuan, 1986), (Meier, 1989), (Sahay & Gupta, 2003), (Colombo & Francalanci, 2004), (Thomaidis, et al., 2006), (Lin, et al., 2007), (Salhie, 2007). Šiuose moksliniuose darbuose siūlomi PĮ atrankos kriterijų prioretizavimo ir galutinio sprendimo priėmimo būdai dažniausiai yra paremti daugiakriterinių sprendimų priėmimo metodais. Beveik visi autoriai pabrėžia, kad vertinimo kriterijai turi būti matuojami, tačiau daugumoje siūlomų metodų, kriterijų nustatymas grindžiamas subjektyviais duomenimis, netaikant mokslinio ar sisteminio metodo. Tokiu būdu, naudojami netinkami atrankos proceso kriterijai daro tiesioginę neigiamą įtaką galutiniam pirkimo sprendimo priėmimui.

VVS atrankoje naudojami kriterijai yra labai skirtingo pobūdžio. Dažnai vertinimas yra grindžiamas kokybiniais elementais, kurie sunkiai gali būti modeliuojami naudojant klasikinius matematinius metodus. Be to, sprendimo priėmimo dažniausiai susiduriama su riboto informacijos kiekio problema, o vertinimo procesas dažnai tampa subjektyvus, nes yra tiesiogiai susijęs su vertintojo profesine kompetencija. Todėl, siekiant sumažinti riziką, susijusią su VVS atranka, kylančią dėl turimos informacijos netikslumo ir priimto sprendimo neapibrėžtumo, labai svarbu specialistus, dalyvaujančius šiame procese aprūpinti objektyviais duomenimis apie šiuolaikinių sistemų charakteristikas.

Tyrimo objektas – šiuolaikinių VVS funkcinės savybės.

Tyrimo tikslas – atlikti VVS funkcinių galimybių analizę ir kiekybinį jų vertinimą, tokiu būdu, palengvinant įvairią veiklą vykdančioms įmonėms pasirinkti sistemą, geriausiai atitinkančią jų poreikius. Šiam tikslui pasiekti keliama tokie **uždaviniai**:

1. Išanalizuoti VVS atrankos kriterijus, nustatyti jų tarpusavio sąryšį ir įvertinti kriterijų svarbą.
2. Išskirti svarbiausias VVS funkcijas, realizuojančias įvairią veiklą vykdančių įmonių verslo procesus.
3. Atlikti šiuolaikinių VVS funkcinių galimybių statistinę analizę suskirstant sistemas į klasterius pagal jų universalumą ir tinkamumą didmeninės prekybos, gamybinėms įmonėms ir įvairaus dydžio įmonių finansinės apskaitos vykdymui.
4. Palyginti lietuviškų apskaitos programų ir užsieninių VVS funkcinę galią.
5. Sukurti VVS funkcinių galimybių panaudojimo vertinimo modelį.
6. Numatyti darbo rezultatų praktinio pritaikymo galimybes VVS atrankos ir jų eksploatacijos metu.

Tyrimo metodai. Rengiant disertaciją naudota sisteminė ir palyginamoji mokslinės bei praktinės literatūros šaltinių (straipsnių, tyrimų, rekomendacijų, apžvalgų) VVS atrankos ir diegimo temomis analizė ir apibendrinimai. Literatūros analizės pagrindu identifikuotų VVS atrankos veiksmų sąryšių empirinis tyrimas vykdytas remiantis Delphi apklausos metodu. Naudojant neraiškaus pažinimo projekto (angl. Fuzzy Cognitive Map) metodiką sukurtas šių veiksmų tarpusavio sąveikos modelis, kurio vizualizavimas atliktas Pajak programa. VVS funkcionalumo poveikio dydis kitiems modelio elementams buvo įvertintas imitacinio modeliavimo, naudojant FCMapper (v. 1.0) sistemą, būdu. Susisteminus ir išanalizavus sukauptus duomenis apie VVS funkcijas ir jų realizavimo būdus šie kokybiniai rodikliai naudojant autoriaus sukurtą matematinį funkcinės galios vertinimo modelį buvo transformuoti į kiekybinius. Tokiu būdu suformuota VVS charakteristikų duomenų bazė apdorota IBM *SPSS Statistics* (v. 20) ir *Statgraphics Centurion XVI* programinėmis priemonėmis naudojant statistinius klasterinės analizės metodus. Darbe taip pat naudojamos literatūros analizės metu išskirtos arba darbo autoriaus sudarytos matematinės formulės, kurių pagrindu buvo atlikti skaičiavimai.

Tyrimo šaltiniai. Disertaciniame darbe buvo naudota mokslinė ir praktinė literatūra, užsienio konsultacinių kompanijų sukurtos VVS atrankos ir diegimo metodikos. Ekspertinės apklausos metu remtasi empiriniais 12 VVS diegimo praktikų pastebėjimais.

VVS charakteristikų duomenų bazė sudaryta naudojantis šiais informacijos šaltiniais:

1. Užsienio konsultacinių kompanijų *Technology Evaluation Centers*, *Axia Consulting*, *Custer Consultants*, *Infotivity Technologies*, *CTS*, *On-Line Consultant Software* ir *Solutions* sudarytais standartiniais VVS funkcinių reikalavimų sąrašais.
2. Komercinių sprendimų paramos sistemų *The Accounting Library*, *TEC Advisor*, *TechMATCHPRO*, *Systems Analysis Tool* – ERP duomenimis, bei *Technology*

Evaluation Centers ir kitų konsultacinių kompanijų sudarytais apibendrintais įvairių VVS funkcinų galimybių aprašymais.

3. Analizuojamų VVS dokumentacija bei vartotojų instrukcijomis.
4. Komerciniais pasiūlymais įmonėms, besirenkančioms VVS, bei bendradarbiavimo pasiūlymais, skirtais konsultacinėms kompanijoms, diegiančioms šias sistemas.
5. VU Ekonomikos fakultete įdiegtų *Konto Professional* ir *Rivilė Solo Plus* finansinės apskaitos programų ir *Microsoft Dynamics NAV 2009* bei *iScala* sistemų praktinės funkcinų galimybių analizės duomenimis.
6. Atsakymų į betarpiškas užklaudas, skirtas VVS gamintojams, informacija.

Darbo mokslinis naujumas ir teorinė reikšmė. Mokslinis disertacijos naujumas išryškėja, nagrinėjant teorinių ir empirinių tyrimų rezultatus:

- Autoriaus išanalizuoti VVS atrankos kriterijai ir pasiūlyta jų klasifikacija išskiriant programinius ir neprograminius veiksnius yra originali praktinėje ir mokslinėje literatūroje pateiktų požiūrių sinergija.
- Ekspertinės apklausos duomenų pagrindu sukurtas VVS atrankos veiksmų sąryšių neraiškaus pažinimo projektų modelis, kurio parametrai patikslinti imitacinio modeliavimo metodu.
- Šiuolaikinių VVS funkcinės savybės nėra sistemiškai nagrinėtos nei Lietuvoje, nei užsienyje. Siūlomose pavienėse VVS atrankos metodikose dažniausiai tik paviršutiniškai atsižvelgiama į diegiamos sistemos ar įmonės kontekstą, pateikiant bendro pobūdžio rekomendacijas. Autoriaus pasiūlytas VVS funkcinės galios rodikliai suteikia galimybes kiekybiškai įvertinti analizuojamų sistemų charakteristikas.
- Pirmą kartą atliktas plačiausiai pasaulyje naudojamų VVS funkcinų galimybių kiekybinis įvertinimas pagal kelis tūkstančius požymių, bei palygintas Lietuvoje ir užsienyje sukurtų apskaitos programų funkcionalumas.
- Panaudotas klasterinės analizės metodas homogeniškiems VVS bruožams, „paslėptiems“ tarp didelio skaičiaus heterogenišku jų funkcinų savybių, identifikuoti. Analizuotos sistemos suskirstytos į grupes pagal jų tinkamumą skirtingą veiklą vykdančioms įmonėms.
- Sukurtas VVS funkcinų galimybių panaudojimo vertinimo modelis.

Praktinė darbo reikšmė. Šio darbo rezultatai turi ne tik teorinę, bet ir praktinę naudą. Jie buvo panaudoti vykdant mokslinių tyrimų ir technologinės plėtros projektą „Verslo valdymo sistemų platformos: kompleksinio integruoto taikomųjų programų kūrimo rinkinio esminių pokyčių moksliniai taikomieji tyrimai ir technologinė plėtra“ (projekto Nr. VP2-1.3-ŪM-02-K-02-119).

Svarbiausių VVS atrankos kriterijų išskyrimas ir jų tarpusavio sąryšių empirinio tyrimo duomenys gali būti naudojami modeliuojant automatizuotą VVS atrankos sprendimų paramos sistemą, kurios pagrindas – šiame darbe sukaupta analizuojamų sistemų funkcinų galimybių duomenų bazė (DB). Nuolat atnaujinant šios DB turinį galima išlaikyti informacijos aktualumą.

Šio darbo rezultatai gali būti naudingi konsultantams, bei įmonių, besirenkančių VVS, vadovams. VVS funkcinų galimybių DB ir jos pagrindu atliktos statistinė analizės

rezultatai gali būti naudojami formuluojant VVS keliamus reikalavimus, identifikuojant tinkamas sistemas ir atliekant jų palyginimą atitikimo įmonės poreikiams požiūriu.

Be to, disertacijoje atliktais VVS funkcinės galios įvertinimais gali pasinaudoti VVS gamintojai, palygindami savo sukurtas sistemas su rinkoje konkuruojančiais produktais ir, tokiu būdu, nustatydami savo programinių produktų silpnąsias ir stipriąsias puses.

Pagal šiame darbe sudarytą metodiką galima nuolat kontroliuoti įsigytos VVS funkcinę galimybių panaudojimo laipsnį. Mažėjanti šio rodiklio reikšmė indikuoja sistemos erozijos procesą ir suponuoja papildomų esamų ir naujų jos vartotojų mokymų ar kitų efektyvesnio sistemos funkcinę galimybių panaudojimo priemonių taikymo būtinumą.

Darbe pateikta medžiaga aukštųjų mokyklų dėstytojais galės papildyti dėstomų dalykų, susijusių su vadybos informacinėmis sistemomis, programas.

Darbo struktūra ir apimtis. Šio darbo struktūrą nulėmė tyrimo tikslas ir užsibrėžti uždaviniai. Disertaciją sudaro įvadas, keturios dėstomosios dalys, išvados, literatūros sąrašas ir priedai. Disertacijos apimtis – 268 puslapiai, joje pateiktos 20 lentelių, 39 paveikslai ir 55 priedai. Rengiant darbą buvo panaudoti 287 literatūros šaltiniai

IŠVADOS IR PASIŪLYMAI:

1. Mokslinės literatūros analizė parodė, jog vieningos VVS atrankos kriterijų klasifikacijos šiuo metu nėra. Tai gali būti paaiškinama atrankos veiksnių įvairove bei skirtingais tyrimų objektais. Dažniausiai kriterijai tiesiog išskiriami, tam tikrais atvejais grupuojami atsižvelgiant į tyrėjo interesų sritį į dvi, tris ar keturias stambias grupes. Išnagrinėjus skirtingų autorių pateikiamus VVS atrankos kriterijų aprašymus ir išanalizavus jų esmę bei prigimtį darbo autoriaus nuomone, tikslingiausia apjungti programinius veiksnius, susijusius su pačia sistema, ir neprograminius veiksnius, susijusius su jos diegimu. Programinių VVS atrankos kriterijų grupei priskirti šie veiksniai: sistemos funkcionalumas, patikimumas, pritaikomumas, naudojimo paprastumas, lankstumas, moduliškumas, integracijos ir plėtros galimybės, versijų atnaujinimas, jos gamintojo reputacija, technologijų naujumas bei įsigijimo išlaidos. Neprograminių atrankos veiksnių grupę sudaro VVS diegimo paprastumas ir trukmė, organizacinis atitikimas, vartotojų pasirengimas, jų mokymų efektyvumas ir sistemos priežiūros kokybė.
2. Apibendrinus įvairių užsienio autorių mokslinių šaltinių ir praktinių tyrimų rezultatus galima teigti, kad sistemos funkcinės savybės yra vienas svarbiausių VVS atrankos kriterijų. Ekspertinės apklausos metodu įvertintų VVS atrankos veiksnių tarpusavio poveikio duomenys sudarė sąlygas sukurti šių veiksnių sąryšio neraiškaus pažinimo žemėlapių modelį, kurio orientuoto grafo elementų charakteristikos parodė, kad sistemos funkcionalumo svarbą labiausiai apsprendžia jo poveikis kitiems modelio elementams. Šio poveikio dydis šiame darbe kiekybiškai įvertintas imitacinio modeliavimo būdu.
3. Mokslinėje literatūroje VVS atrankos tematika dažniausiai analizuojami teoriniai šio proceso aspektai. *SoftResources*, *K2 Enterprises*, *Ultra Consultants*, *ERPandmore.com*, *Panorama Consulting* konsultacinių kompanijų aprašomi

skirtingi VVS skirstymai į lygius pagal jų tinkamumą įvairaus dydžio įmonėms nėra argumentuoti. Nors *Gartner Research, Info-Tech Research Group, Nucleus Research ir Boston Consulting Group* tyrėjai ir pateikia naudojamų VVS palyginimo principų aprašymus, tačiau publikuojamuose vertinimuose nenurodo atskirų sistemų charakteristikų, apsprendžiančių jų priskyrimą skirtingiems reitingavimo kvadrantams. Įvairių konsultacinių kompanijų publikuojami populiariausių VVS palyginimai apima tik nedidelį sistemų ir jų charakteristikų skaičių. Atsižvelgiant į tai, kad VVS įsigijimas yra didelės apimties finansinė investicija, įmonėms, besirenkančioms sistemą, geriausiai atitinkančią jų poreikius, labai svarbu turėti išsamesnę informaciją apie šių sistemų funkcines galimybes.

4. Argumentuotam VVS atrankos proceso atlikimui būtini duomenys, kurie kiekybiškai išreiškia įvairių sistemų funkcionalumą. Tokių duomenų surinkimui šiame darbe atliktas rinkoje siūlomų VVS funkcinių charakteristikų tyrimas.
 - Išanalizavus pasaulinę VVS rinką, atsižvelgus į šių sistemų klasifikaciją pagal jų tinkamumą įvairaus dydžio įmonėms ir atsižvelgus į tyrimo kompanijų sudarytų reitingų duomenis funkcinių galimybių analizei pasirinktos 139 plataus spektro užsienio ir Lietuvos gamintojų sukurtos apskaitos programos ir VVS.
 - Atsižvelgiant į modulinę VVS struktūrą, atskirų modulių panaudojimo laipsnį bei dažniausiai įdiegiamų modulių funkcijas išskirta 11 pagrindinių šių sistemų funkcinių grupių: *Didžioji knyga, Mokėtinų sumos, Gautinų sumos, Atsargos, Užsakymai, Gamyba, Ilgalaikis turtas, Biudžetas, Darbo užmokestis, Tarptautinė apskaita ir Bendrieji reikalavimai*.
 - Pasinaudojus komercinių sprendimo paramos sistemų duomenimis, konsultacinių kompanijų sudarytais apibendrintais įvairių VVS funkcinių galimybių aprašymais, studijuojant VVS dokumentaciją, vartotojų instrukcijas, komercinius pasiūlymus, tiriant VU Ekonomikos fakultete įdiegtų *Konto Professional, Rivile Solo Plus* finansinės apskaitos programų ir *Microsoft Dynamics NAV 2009* bei *iScala* sistemų funkcines savybes sukaupti duomenys apie 3370 funkcijų realizavimo būdus analizuotose sistemose.
5. Atlikta išsami 468430 kategorinių rodiklių apie VVS funkcines galimybes analizė.
 - Nustatyta, kad šiuolaikinėse VVS labiausiai išvystytos finansų apskaitos funkcijos, kurios realizuotos *Didžiosios knygos, Mokėtinų sumų, Gautinų sumų* ir *Biudžeto* moduluose. Blogiausiai išvystytos ilgalaikio turto apskaitos ir gamybos valdymo funkcijos.
 - Siekiant surinktiems duomenims suteikti kiekybinių rodiklių pobūdį bei sumažinti analizuojamų duomenų apimtį pasiūlytas integruotas VVS funkcinės galios rodiklis, kurio reikšmė priklauso nuo įvairių funkcijų atlikimo būdų vertinamoje sistemoje. Sudarytas šio rodiklio įvertinimo matematinis modelis ir jo panaudojimas įgalino integruoti tiriamų sistemų funkcines charakteristikas ir tuo pačiu daugiau, nei 800 kartų sumažinti analizuojamų duomenų apimtį.
 - Atlikta šiuolaikinių VVS funkcinių galimybių statistinė analizė įgalino suskirstyti tiriamas sistemas į klasterius pagal jų universalumą ir

tinkamumą didmeninės prekybos, gamybinėms įmonėms ir įvairaus dydžio įmonių finansinės apskaitos vykdymui.

6. Atliktas lietuviškų apskaitos programų *Konto Professional* ir *Rivilė Solo Plius* bei užsieninių VVS funkcinės galios palyginimas. Nustatyta, kad lietuviškų sistemų funkcinės galimybės atitinka vidutinį pasaulinį lygį. Gauti rezultatai leidžia padaryti išvadą, kad lietuviškos sistemos puikiai realizuoja mažų ir vidutinio dydžio įmonių finansinę apskaitą. Jos gali gerai atlikti šias funkcijas ir didelėse korporacijose. Šiose apskaitos sistemose taip pat išvystytos funkcijos, svarbios didmeninės prekybos įmonėms. Apskaitos programų *Konto Professional* ir *Rivilė Solo Plius* daugelio modulių specializuota funkcinė galia, įvertinta pagal tokių įmonių reikalavimus, viršija visų analizuotų VVS šio rodiklio vidurkio reikšmę. Tačiau šiose programose nepakankamai gerai realizuotos gamybinėms įmonėms svarbios funkcijos. Lietuviškos apskaitos programos, sudarydamos galimybę aprašyti gaminio sudėtį, tinka tik surinkimą arba komplektavimą vykdančioms įmonėms.
7. Kadangi lietuviškas programas kuria ir tobulina nedideli programuotojų kolektyvai, todėl jiems sudėtinga konkuruoti tarptautinėse rinkose su užsienietiškomis sistemomis, kurias gamina po kelis šimtus ir tūkstančius darbuotojų turinčios įmonės. Siekiant sėkmingai konkuruoti globalioje rinkoje Lietuvos apskaitos programų gamintojams rekomenduotina konsoliduotis ir, tokiu būdu didinant savo potencialą, kurti produktus, skirtus ne tik vietinei, bet ir pasaulinei VVS rinkai. Deja, šiuo metu kai kurios ilgametę VVS projektavimo ir diegimo patirtį turinčios vietinės įmonės yra susikonscentravusios į valstybinių projektinių užsakymų, finansuojamų iš Europos Sąjungos fondų, vykdymą, o ne naujų, konkurencingų programinių produktų kūrimą.
8. Veiklų, atliekamų VVS atrankos metu, analizė leidžia padaryti išvadą, kad šiame darbe sukurtos ir aprašytos priemonės gali būti naudojamos beveik visuose šio proceso etapuose. Šias priemones galima integruoti į sprendimų paramos sistemos, skirtos VVS atrankai, duomenų ir modelių bazes. Tokių bazių panaudojimas sudaro sąlygas šių sistemų sertifikavimui. Mūsų nuomone, tai - puiki galimybė lietuviškų apskaitos programų ir VVS gamintojams įvertinti savo sukurtų sistemų galimybes bei nustatyti jų stipriąsias ir silpnąsias puses, tokiu būdu numatant tolesnio vystymo kryptis.
9. Užsienio mokslininkų tyrimai parodė, kad laikui bėgant išnaudojama vis mažiau turimos VVS galimybių. Taigi, siekiant išlaikyti į VVS investuotų lėšų efektyvumą, atliekant įmonių IT auditą būtina ne tik analizuoti duomenų saugumo užtikrinimo funkcijas ir priemones, bet ir vertinti turimų VVS funkcinių galimybių panaudojimo laipsnį. Šiame darbe sukurtos priemonės leidžia žymiai supaprastinti šį procesą ir sudaro sąlygas pačioms įmonėms be išorinių konsultantų pagalbos atlikti tokius vertinimus.
10. Šiuolaikinės VVS realizuoja kelis tūkstančius funkcijų, kurių poreikį ir svarbą įmonei būtina įvertinti sistemos atrankos metu. Atskirų sistemos funkcijų susiejimas su verslo procesais, kuriose jos naudojamos, suteiktą galimybę automatiškai išskirti įmonei reikalingas funkcijas ir jų svarbos įvertinimo darbus paskirstyti už atitinkamas veiklas atsakingiems darbuotojams. Toks verslo procesų ir juos realizuojančių VVS funkcijų integravimas yra perspektyvi šio darbo tolesnio vystymo kryptis.

Mokslo tyrimo rezultatų aprobavimas ir sklaida. Mokslinio tyrimo teiginiai ir rezultatai paskelbti 8 mokslinėse publikacijose, iš kurių 5 straipsniai paskelbti mokslo žurnaluose ir 1 straipsnis – tarptautinių mokslinių konferencijų recenzuotame leidinyje. Mokslinio tyrimo teiginiai ir rezultatai pristatyti 2 tarptautinėse konferencijose.