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New model of enterprises resource planning implementation planning process in manufacturing enterprises

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Abstract

This article presents new model of enterprises resource planning implementation planning process in manufacturing enterprises based on assessment of risk sources. This assessment was performed by applying analytic hierarchy process. Analytic hierarchy process method allows variation of relative importance of specific risk sources dependent on the section from which the risk source originates (organizational environment, technical issues, people issues, adoption process management, and external support). Survey was conducted on 85 manufacturing enterprises involved with an enterprises resource planning solution. Ranking of risk sources assessments returns most frequent risks of enterprises resource planning implementation success in manufacturing enterprises, and representative factors were isolated through factor analysis by risk source origin. Finally, results indicate that there are hidden causes of failed implementation, for example, risk source "top management training and education," from risk origin "adoption process management."

Keywords

Enterprises resource planning, implementation, risk, key performance indicator, analytic hierarchy process

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Introduction

Enterprises resource planning (ERP) systems today represent indispensable solutions for management of an organization. Its application has found its purpose in all forms of business, in all levels of business organization. However, despite the wide acceptance of ERP, there are still unsuccessful implementations. The scientific literature has not yet given the final word on reasons of implementation's failure of ERP system in manufacturing enterprises. International experiences vary from country to country and a common denominator of unsuccessful implementations has not yet been found. Manufacturing enterprises are characterized by complexity and overlapping of production processes, diversified processes, operating in a dynamic environment, organizational and technological complexities. Therefore, it is still unclear what are the crucial reasons for the unsuccessful implementation of ERP despite numerous benefits especially in complex organizations such as manufacturing enterprises. In

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addition, ERP solution vendors are also interested in successful implementation.

Increasing complexity of manufacturing processes as well as growth of manufacturing enterprises caused the ERP solutions to change number of modules, complexity, and so on. A quick, high-quality, reliable response is required from the new ERP solution which will monitor growing demands of production companies and at the same time eliminate all negative impacts which can result in an unsuccessful ERP implementation.

Literature review

According to number of publicized previous researches, problem of investigation reasons for enterprise resource planning (ERP) implementation failure is very important. There are a number of papers which indicate that neglecting technical and organizational factors on ERP implementation is the main reason for ERP implementation failure.[1,2]

In some publications, causes of failure of ERP were investigated and those causes are being referred to as sources of risk to ERP implantation.[3–8]

In cases of unpredicted impact of technical and organizational factors on ERP implementation success, risk of choosing inadequate ERP implementation strategy is very high. Big Bang or incremental strategy of ERP implementation is the strategy most often used in practice.[9] In application of the first strategy, a number of risk sources appear. This happens while ERP solution is implemented at once, and there is no control on risk sources. In the second strategy implementation case, there are less risk sources on ERP implementation success because ERP solution in the enterprise was introduced gradually.[6]

Salmeron and Lopez[7] show application of multicriteria approach in risk assessment in ERP maintenance. They use 25 risk factors, structure them in hierarchy, and determine their weight using pairwise comparisons on Saaty's nine-step scale.

Hakim and Hakim[5] agree that there is little evidence in literature about risk sources which cause ERP implementation failure. They developed a model for ERP implementation with focus on internal and external factors which impact different ERP implementation phases. They identified six risk categories: organizational, technical, project management, system, user, and technology categories of risks which have impact on ERP implementation success. Using SWOT analysis, they classified risks and help decision-making process about ERP implementation.

More recently, Aloin et al.[3] discussed risk assessment in ERP implementation project. They consider that risk factors in ERP implementation are a collection of many technological, managerial, psychological, and social factors. Authors also agree that application of risk assessment methods in ERP implementation is not treated in literature, although ERP is one of the most critical projects in enterprises. They identify 19 risk factors that affect ERP project introduction and develop risk map matrix for their classification.

Chang et al.[4] discussed about using fuzzy analytic hierarchy process (FAHP) for risk assessment of ERP implementation success. They assumed that management, software, users, and technology risks are main categories of risks which have impact on ERP implementation success. Using triangular fuzzy number methodology, they calculate weight of 12 risk sources (classified in four categories, mention before) and show mathematical calculation for deriving most critical risk source. In conclusion, they agree key performance indicator (KPI) as the most important indicator of enterprise's operation performance.

Another group of authors refers to the factors and causes of failure of ERP as critical success factors (CSFs). Investigations of CSFs of ERP do not differ significantly from investigating the source of risks of implementing an ERP, but the literature neither gives difference nor identifies CSFs with the risk sources. The risk is always mentioned when uncertainty is present and where risk management is necessary in order to avoid adverse consequences. The risk is usually defined as the product of probability of occurrence of undesirable events and consequences that this event may have. The consequences of unsuccessful ERP implementation are great in financial sense but also in terms of organizational culture, climate, image, and so on. So, CSFs can be perceived as sources of risk. In scientific literature, if there are significantly more papers on the CSF by successful implementation of ERP, then there is research on the sources of risk to the success of implementation of an ERP.

According to Motwani et al.[10] one of the most critical factors for ERP implementation success is clear vision and top management commitment. CSF differs phases: before, during, and after ERP implementation, and in research, they show list of these factors in different phases.

Ansarinejad et al.[11] investigated the evaluation of CSF because they noticed that in the scientific literature there is a lack of systematic effort in the classification and evaluation of the CSF. They used FAHP approach in 14 identified major CSFs and 31 CSF as subfactor. The authors note that analytic hierarchy process (AHP) method seems to perform better on the results just based on experts' absolute priorities assignation to each criterion. FAHP method can help in reducing the uncertainty that occurs in the qualitative evaluation of influential criteria. By applying the FAHP approach, Ansarinejad et al.[11] concluded that "Management and employees readiness to change" is a

high priority criterion, followed by the criterion "Top Management Support." The authors explain that these CSFs emerged as a priority for the reason that managers are often also the owners of the company, so the top management decisions from ERP procurement to the go live are crucial steps.

Mahdavian and Mostajeran[1] studied which are the most important skills that key users (power user/super user/team leader) of ERP should have. Key users of ERPs are the users who represent the main members of the ERP implementation team. The authors suggested skill measurement method and applied factor analysis. Results of the analysis show that the key users are mostly mid-level managers and that their human and conceptual skills are more important than technical skills. The authors conclude that their study confirmed that the key users are currently facing a severe skills shortage in technical, human, and conceptual skills, and it is imperative that key users go through adequate education and training.

Ram et al.[12] reviewed in which cases are the individual CSF in practice actually critical for achieving success in ERP implementation and improving output performance. The authors believe that the success in the implementation of ERP and ERP gaining performance improvement are different variables and therefore that CSFs for them are different.

In some studies, CSFs are classified according to the tactical, operational, and strategic level.[13] According to Fang and Patrecia[13] study, the first-ranked risks are top management support, business process reengineering (BPR), project team and change management, effective communication, and then all other.

Sun et al.[14] grouped CSFs in five groups in accordance with the ERP implementation stages. They classified 80 CSFs into the following stages: ERP organizational readiness, ERP selection, ERP implementation, ERP final preparation, and ERP live-run. Result of study shows that main challenges of ERP implementation are selection of an ERP system, project management senior leadership, data management, training program, and user involvement.

Shaul and Tauber[2] conducted a review of literature in the last decade of the CSF in ERP implementation. Their research represents a comprehensive taxonomy of CSFs in which he covered 341 articles in scientific literature. The research brought them to 93 CSFs classified into 15 groups: involvement, implementation strategy, support of top management, enterprise system, software maintenance, data management, project management, project tracking, enterprise system selection process, change management, project team competence, organizational experience of major change, acceptance control, education and training, vendor, environment, and user involvement. Also, the authors state that the CSF varies depending on the stage of the life cycle of the ERP. Post-implementation phase is characterized by activities such as operation, enhancement, upgrading and maintenance, and others for which the authors claim to have been insufficiently investigated. Also, the authors of the study state that the CSFs vary depending on the industry in which the company operates and that most of the identified 80 CSFs refer to companies that are not highly developed in terms of production. The authors conclude that it would be necessary to identify CSFs relative to industrial sectors. Newer scientific literature is in favor of this claim as it addresses critical CSF in various industries. For example, Kim et al.,[15] summarizing the results of research in agriculture CSF, suggest that the "top management support" and "clear goals and objectives" are the most important factor to ERP implementation. They refer to the "top management support" as the degree in which top managers endorse ERP before and after implementation but at the same time this does not include the participation of top managers in coaching and training.

Research methodology

The research was conducted on a sample of 798 small and medium manufacturing enterprises, through survey of the official companies e-mail and interviews with team leader of ERP implementation team in each company. Questionnaire was prepared with the sources of risk to the implementation of ERP based on the literature (Table 1). The questionnaire was answered correctly by 85 companies that implemented ERP. During the interviews with team leaders from the companies, the inevitable conclusion was that the 50 sources of risk should be grouped into five risk source origins.

Every interviewee was asked to carry out the evaluation of the 50 sources of risk for their company (Table 1—list of sources of risk) using the scores of 1–10 according to the intensity of risk; 1 is rated as the lowest risk, with 10 being the highest risk. All sources of risk are classified according to the type of area in which the source of risk appears/risk sources origin:[33]

1. Organizational environment;
2. Technical issues;
3. People issues;
4. Adoption process management;
5. External support.

Considering risk sources CSFs should not group according to the phases of the life cycle (as do Sun et al.[14]) because all phases of the life cycle of ERP are equally important, it was grouped sources of risks to implementation of ERP according to risk sources origin because designed groups of sources of risk enable to add a greater level of significance to some groups of sources of risk in relation to other.

Table 1. A questionnaire: list of risk sources.

Code	CSF = risk sources	References of studies that have identified the CSF
R1	Top management support	Dey et al.,[16] Dezdar and Sulaiman,[17] Schonsleben,[18] Plant and Willcocks,[19] and Snider et al.[20]
R2	Culture of organization	Dezdar and Sulaiman[17] and Motwani et al.[10]
R3	Bad ERP assessment	Hwang and Park[21] and Somers and Nelson[22]
R4	Unclear requirements of top management to the vendor for offer	Van Beijsterveld and Van Groenendaal[23]
R5	Dissatisfaction with vendor's offers	Van Beijsterveld and Van Groenendaal[23]
R6	Management have lack of information for company needs	Amini and Sadat Safavi,[24] Hwang and Park,[21] Shaul and Tauber,[2] and Sun et al.[14]
R7	Limited investment budget	Finney and Corbett[25] and Hwang and Park[21]
R8	Lack of ERP solutions on the market	Amini and Sadat Safavi,[24] Shaul and Tauber,[2] Sun et al.,[14] and Van Beijsterveld and Van Groenendaal[23]
R9	Inadequate vendors' offer	Abdelghaffar[26] and Van Beijsterveld and Van Groenendaal[23]
R10	Equipment unavailable	Abdelghaffar[26] and Hwang and Park[21]
R11	Volatility price of equipment	Hwang and Park[21]
R12	Problems with suppliers and delivery	Amini and Sadat Safavi,[24] Shaul and Tauber,[2] and Van Beijsterveld and Van Groenendaal[23]
R13	Problems with suppliers and equipment setup	Abdelghaffar[26] and Hwang and Park[21]
R14	Equipment failures	Abdelghaffar,[26] Ahmad et al.,[27] and Hwang and Park[21]
R15	Setup error caused by the human factor	Amini and Sadat Safavi,[24] Shaul and Tauber,[2] and Sun et al.[14]
R16	Lack of skilled personnel to maintain equipment	Amini and Sadat Safavi,[24] Shaul and Tauber,[2] and Sun et al.[14]
R17	Sick of professional staff	Amini and Sadat Safavi,[24] Shaul and Tauber,[2] and Sun et al.[14]
R18	Working discipline	Sun et al.[14]
R19	Unjustified of further ERP implementation	Amini and Sadat Safavi,[24] Shaul and Tauber,[2] and Sun et al.[14]
R20	ERP selecting	Dezdar and Sulaiman,[17] Finney and Corbett,[25] Somers and Nelson,[22] and Vathanophas[28]
R21	Legislation compliance	Krumbholz et al.[29] and Sun et al.[14]
R22	Communication problems with vendor	Dey et al.[16] and Schonsleben[18]
R23	The influence of legacy ERP	Amini and Sadat Safavi,[24] Krumbholz et al.,[29] and Sun et al.[14]
R24	Accuracy of data in legacy ERP	Krumbholz et al.[29] and Sun et al.[14]
R25	Technological readiness	Dey et al.[16] and Sun et al.[14]
R26	Compliance software and hardware	Amini and Sadat Safavi,[24] Shaul and Tauber,[2] and Sun et al.[14]
R27	Designing and configuring	Ram et al.[12]
R28	Dissatisfaction top management with ERP	Somers and Nelson[22]
R29	Problems with the production planning	Ram et al.[12]
R30	Gaps in current production due to implementation	Ram et al.[12]
R31	Balanced project team	Dezdar and Sulaiman,[17] Finney and Corbett,[25] Plant and Willcocks,[19] Snider et al.,[20] and Somers and Nelson[22]
R32	Team and teamwork	Dezdar and Sulaiman,[17] Finney and Corbett,[25] Plant and Willcocks,[19] Snider et al.,[20] and Somers and Nelson[22]
R33	Department support	Amini and Sadat Safavi,[24] Shaul and Tauber,[2] and Sun et al.[14]
R34	Company support-wide support	Amini and Sadat Safavi,[24] Shaul and Tauber,[2] and Sun et al.[14]
R35	Project team	Dezdar and Sulaiman,[17] Finney and Corbett,[25] Plant and Willcocks,[19] Ram et al.,[12] Snider et al.,[20] and Somers and Nelson[22]
R36	Internal support	Amini and Sadat Safavi,[24] Shaul and Tauber,[2] and Sun et al.[14]
R37	Presence of the best	Ram et al.[12]
R38	Reporting capabilities	Amini and Sadat Safavi,[24] Shaul and Tauber,[2] and Sun et al.[14]
R39	Communication	Amini and Sadat Safavi,[24] Shaul and Tauber,[2] and Sun et al.[14]
R40	Education and training of top management	Dezdar and Sulaiman[17] and Finney and Corbett[25]
R41	User involvement	Dezdar and Sulaiman[17] and Finney and Corbett[25]
R42	Education and training	Dezdar and Sulaiman[17] and Finney and Corbett[25]
R43	Minimum customization	Amini and Sadat Safavi,[24] Shaul and Tauber,[2] and Sun et al.[14]
R44	BPR with minimum customization	Amini and Sadat Safavi,[24] Hwang and Park,[21] Ram et al.,[12] Shaul and Tauber,[2] and Sun et al.[14]
R45	Clear objectives	Schonsleben,[18] Kim and Lee,[30] and Finney and Corbett[25]
R46	Business plan and vision	Dezdar and Sulaiman[17] and Finney and Corbett[25]
R47	The main strategy	Finney and Corbett,[25] Nah and Delgado,[31] and Wei[9]
R48	Project management	Dezdar and Sulaiman,[17] Finney and Corbett,[25] and Snider et al.[20]
R49	Change management and culture	Dezdar and Sulaiman,[17] Motwani et al.,[10] and Gattiker and Goodhue[32]
R50	External consultant	Finney and Corbett,[25] Snider et al.,[20] and Somers and Nelson[22]

CSF: critical success factor; ERP: enterprises resource planning.

Table 2. Average values, assessment of risk sources by ranking criteria.

Organizational environment		Technical issues		People issues		Adoption process management		External support	
Average assessment	Risk	Average assessment	Risk	Average assessment	Risk	Average assessment	Risk	Average assessment	Risk
9.04	R1	6.82	R7	2.78	R15	5.55	R38	3.52	R8
8.67	R2	3.74	R9	3.06	R16	9.88	R40	2.29	R11
4.80	R3	2.22	R10	2.98	R17	6.13	R44	2.76	R12
4.54	R4	2.12	R14	5.12	R18	6.81	R45	2.86	R13
4.27	R5	3.12	R19	5.41	R31	6.95	R46	4.74	R22
4.42	R6	5.18	R20	5.92	R32	7.38	R47	5.64	R50
4.66	R28	4.28	R21	5.49	R33	6.81	R48		
5.88	R29	7.45	R23	5.51	R34	7.74	R49		
6.09	R30	7.91	R24	6.08	R35				
		6.64	R25	5.51	R36				
		6.02	R26	6.66	R37				
		5.35	R27	7.71	R39				
		5.96	R43	7.19	R41				
				8.61	R42				

While determining such affiliation sources of risk, it took into account the fact that some sources of risk can be influenced more and some less (e.g. the external support). Also, this approach allows to accurately determine which group of sources of risk has the critical impact on the implementation of ERP. After having the results of the group of risk source that has a critical impact on the implementation of ERP, corrective actions can conduct to reduce the level of risk not only of a source of risk but the whole group, since they are related sources of risk within the group.

The results of the survey of 85 companies are shown in Table 2, as average values of each risk sources.

AHP analysis

Using the software application with AHP method, hierarchical structure is formed to perform a risk sources ranking. Figure 2 shows a diagram of the hierarchical structure consisting of influential criteria and sources of risk to the success of ERP implementation. Influential criteria are in fact risk sources origin, and weight of each influential criterion is determined on the basis of average estimates given by experts from 85 companies (Table 3).

Relative importance of influential criteria is defined as: trivial—0%, unimportant—25%, important—50%, very important—75%, and critical—100%.

These criteria have been merged with each risk source (Figure 1) and have made the connection between the criteria and risk sources. Furthermore, each risk source is assigned a grade as average values obtained from the survey (Table 2).

Table 3. Weights of influential criteria.

Criteria	Average qualitative assessment	AHP priority in accordance with qualitative assessment (%)
Organizational environment	Very important	75
Technical issues	Important	50
People issues	Very important	75
Adoption process management	Critical	100
External support	Important	50

AHP: analytic hierarchy process.

Results

Using software tools which support decision-making that has a built-in module for the application of AHP methodology, the hierarchy of criteria and alternatives is generated (Figure 1), and an evaluation of influential criteria and alternatives was performed in accordance with the results of the survey (Tables 2 and 3). The total score has been obtained and structured of the ranked risk sources in the overall "Score" as shown in Figure 2.

The results of the analysis show that for a set number of criteria defined a risk factor R40—education and training of top management is the most critical factor, with a value of 0.049; then, R49—change management and culture with a value of 0.039; and R1—top management support with a value of 0.037. Risk sources: R50—external consultant and R47—the main strategy has also value 0.037.

Risk source R40 shows that top management must have standard ERP training and make a change in the

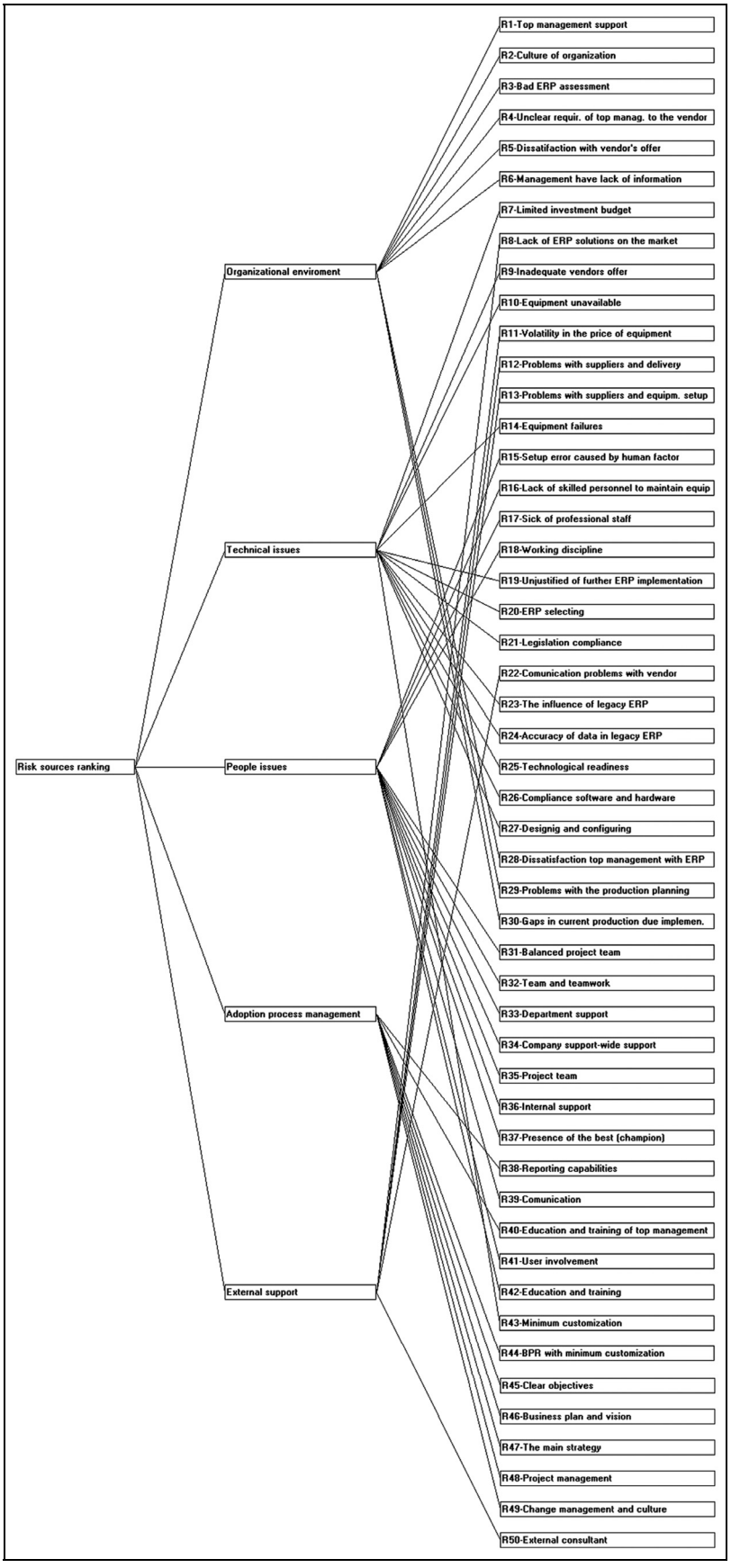

Figure 1. AHP method, diagram of ranking a risk sources.

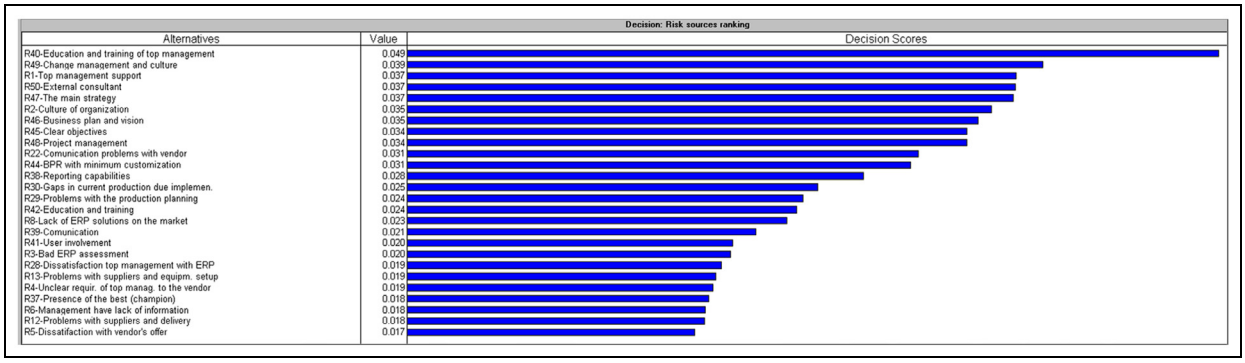

Figure 2. Ranking of risk sources by AHP method.

Table 4. The average score and average score deviation by criteria.

Criteria	Average score	Average deviation
Organizational environment	5.82	1.51
Technical issues	5.13	1.40
People issues	5.57	1.43
Adoption process management	7.16	1.39
External support	3.52	1.43

management, to accept and to train modern ways of management, to implement the ERP system at full capacity. Top management's comprehension, needs of these changes, is the basis for successful implementation of ERP.

The average score of sources of risk according to the criteria (risk sources origin/criteria) is given in Table 4. The highest average score has the source of risk criterion Adoption process management—7.16, while the criterion External support has the lowest average rating of 3.64. The largest deviation from the average score are sources of risk from the group Organizational environment.

It is found out result, either ranking criteria by average scores of sources of risk within the defined criteria (Table 3) or ranking criteria according to relevance that the experts (respondents) assigned, these criteria prior to analysis (Table 3) are the same. These comparisons indicate mindfulness (awareness) of experts involved in ERP implementation, key sources of risk.

In research conducted R1—factor of top management support is only in third place, although in most studies this factor ranked first. The question is whether, in the studies where top management support was the top-ranked factor, training and education of top management was presupposed alongside support or was training and coaching of top managers not factored in.

It is important to emphasize that the concept of support of top management and the concept of education and training are fundamentally different. Top management support applies only to support of the introduction of the ERP system by top management, decision-making on the implementation, understanding the benefits of ERP, understanding of climate change, and the culture and behavior of the organization after the introduction of the ERP project.

Comparative analysis

A comparative analysis was conducted among the sources of risk that are grouped into different risk group origins. Comparative analysis of the sources of risk aims to determine whether there is interdependence between the individual groups of sources of risk. With the sample of 85 companies and 50 sources of risk scores for each company, grouping according to the assessment in Table 2 was performed. Aggregated data are correlated, and the results are shown in Table 5.

The data indicate that there is some correlation between groups Adoption process management and

Table 5. Correlation among groups.

	Organizational environment	Adoption process management	People issues	Technical issues	External support
Organizational environment	1.00				
Adoption process management	0.27	1.00			
People issues	0.39	0.66	1.00		
Technical issues	0.42	0.31	0.40	1.00	
External support	0.39	0.30	0.44	0.60	1.00

Table 6. Organizational environment.

	R1	R2	R3	R4	R5	R6	R28	R29	R30
R1	1.00								
R2	0.34	1.00							
R3	−0.04	−0.06	1.00						
R4	−0.16	0.02	0.53	1.00					
R5	−0.09	0.00	0.50	0.48	1.00				
R6	0.13	0.18	0.34	0.08	0.29	1.00			
R28	0.06	0.03	0.01	0.15	0.17	0.02	1.00		
R29	0.24	0.23	−0.14	0.01	0.05	0.03	0.51	1.00	
R30	0.36	0.22	−0.17	−0.03	0.03	0.09	0.43	0.84	1.00

Table 7. Technical issues.

	R7	R9	R14	R19	R20	R21	R23	R24	R25	R26	R27
R7	1.00										
R9	−0.01	1.00									
R14	0.11	−0.22	1.00								
R19	0.09	0.19	0.11	1.00							
R20	0.21	0.21	0.29	0.29	1.00						
R21	0.05	−0.12	0.32	0.25	0.42	1.00					
R23	0.31	0.00	0.13	0.23	0.24	0.24	1.00				
R24	0.24	−0.07	0.18	0.25	0.26	0.25	0.76	1.00			
R25	0.14	−0.11	0.10	0.25	0.20	0.27	0.47	0.59	1.00		
R26	0.19	−0.06	−0.09	0.25	0.19	0.23	0.42	0.39	0.55	1.00	
R27	0.06	0.09	0.00	0.18	0.39	0.26	0.39	0.42	0.37	0.44	1.00

Table 8. People issues.

	R15	R16	R17	R18	R31	R32	R33	R34	R35	R36	R37	R39	R41	R42
R15	1.00													
R16	0.56	1.00												
R17	0.22	0.41	1.00											
R18	−0.04	0.08	0.06	1.00										
R31	0.06	0.16	0.08	−0.05	1.00									
R32	0.22	0.28	0.19	0.19	0.73	1.00								
R33	0.04	0.01	0.00	0.10	0.29	0.38	1.00							
R34	0.04	0.01	−0.06	0.24	0.27	0.36	0.77	1.00						
R35	0.00	0.01	0.04	0.04	0.40	0.54	0.54	0.57	1.00					
R36	−0.08	−0.15	−0.11	0.09	0.04	0.16	0.40	0.59	0.50	1.00				
R37	−0.14	−0.05	−0.10	0.02	0.27	0.33	0.43	0.44	0.51	0.55	1.00			
R39	0.01	0.15	−0.19	−0.03	0.16	0.29	0.34	0.41	0.58	0.34	0.56	1.00		
R41	0.07	−0.01	−0.06	0.01	0.35	0.35	0.32	0.37	0.44	0.28	0.31	0.41	1.00	
R42	0.11	0.15	−0.08	0.06	0.31	0.40	0.32	0.33	0.48	0.23	0.41	0.45	0.58	1.00

People issues (0.66) and also between groups Technical issues and External support (0.6). Within each group, a correlation analysis of the sources of risk was performed. The results are shown in Tables 6–10.

Correlation analysis indicates a significant correlation between the sources of risk R29 and R30 (084), R23 and R24 (0.76), R31 and R32 (0.73), R33 and R34 (0.77), R45 and R46 (0.7), and R46 and R47 (0.77). The results do not indicate that within the group there are many correlations between sources of risk.

If correlation analysis carries out between all sources of risk (without grouping), it still gets identical correlative relationships that it already identified within the groups as confirmed by sources belonging to defined risk groups (risk sources origin).

After correlational analysis, a factor analysis was performed (Appendix 1) in order to isolate sources of risk that best represent the characteristics of the group. For the sample of 85 respondents, the factor loading greater than 0.6 is representative. By rotating factors,

Table 9. Adoption process management.

	R38	R40	R43	R44	R45	R46	R47	R48	R49
R38	1.00								
R40	0.08	1.00							
R43	0.10	−0.01	1.00						
R44	0.13	0.05	0.60	1.00					
R45	0.12	−0.07	0.34	0.38	1.00				
R46	0.06	0.01	0.26	0.32	0.70	1.00			
R47	0.07	0.02	0.29	0.36	0.62	0.77	1.00		
R48	0.02	−0.02	0.23	0.29	0.43	0.49	0.61	1.00	
R49	0.13	0.11	0.27	0.29	0.47	0.51	0.63	0.58	1.00

Table 10. External support.

	R8	R11	R12	R13	R22	R50
R8	1.00					
R11	0.02	1.00				
R12	0.24	0.36	1.00			
R13	0.08	0.35	0.56	1.00		
R22	0.05	0.21	0.26	0.29	1.00	
R50	0.02	0.02	0.06	0.10	0.19	1.00

factor matrix is transformed into simpler forms that can be interpreted. VARIMAX rotation isolates the factors with the highest factor loading that represent the characteristics of the observed groups of factors: VAR0029, VAR07, VAR0031, VAR0047, and VAR0012 per groups, respectively.

In the first group, VAR0028 (0.77) VAR0029 (0.9), and VAR0030 (0.85) have the highest factor loading, or sources of risk, R28—Dissatisfaction top management with ERP, R29—Problems with the production planning, and R30—Gaps with current production due to implementation, represent the group organizational environment, which indicates that it is necessary to observe the implementation of ERP from an angle of organizing continuity of production process.

In the second group, VAR 007 (0.9), VAR 009 (0.88), VAR 0025 (0.79), VAR 0026 (0.81), and VAR0014 (0.75) have the highest factor loading. Sources of risk, R7—Limited investment budget, R9—Inadequate vendors' offer, and R25—Technological readiness, represent technical issues factor group and indicate that accurate data must be migrated from the previously used ERP.

In the third group, VAR 0031 (0.91), VAR 0016 (0.88), VAR0015 (0.83), and VAR 0032 (0.82) have the highest load factor in the group people issues. Risk sources, R31—Balanced project team and R16—Lack of skilled personnel to maintain equipment, indicate the activities of all employees; their desire to make the project succeed is an essential factor in the implementation of ERP.

In the fourth group, VAR0046 (0.85) and VAR0047 (0.89) have the highest factor loading in the group Adoption process management. Risk sources, R46—Business plan and vision, R47—The main strategy, and R49—Change management and culture, point to the necessity of setting a clear change management strategy in accordance to the strategy and vision.

In the fifth group, VAR 0012 (0.92), VAR 0013 (0.86), and VAR 0080 (0.81) have the largest factor loading in the group External support. Risk sources, R12—Problems with suppliers and delivery and R13—Problems with suppliers and equipment setup, suggest issues to which it cannot influence and therefore it has to be careful in selecting external collaborators.

Conclusion

Analysis of the survey's results shows that the major cause of poor implementation is lack of ERP training of top management. Recognizing the risk source R40 companies have clearly shown where is the hidden cause of failed implementation and expressed a need for a new model of implementation of ERP systems, with special emphasis on the preparation of the company itself (system) for the implementation.

For ERP implementation process in production companies, is necessary to conduct education and training of top managers. Further, this research finds out the AHP risk-based model for risk assessment, of sources of risk to the implementation of ERP is suitable for facilitated monitoring, assessment, and evaluation potential sources of risk.

The new model should allow better integration of the ERP system, its sustainable development throughout the life cycle, as well as the extended application to the implementation of new systems that the company needs to take promptly and appropriately respond to market demands.

The new model of process of planning an implementation should enable the implementation of ERP to go as painlessly as possible with as much support for the existing system of organizations and companies to improve the current way of doing business by applying full ERP system. This model will indicate the strengths and weaknesses of the company, observed risk factors, mitigate their impact or eliminate completely, and finally ensure the sustainability of ERP in the company through its continuous improvement, thereby improving the company.

This research highlighted the problem of top management in manufacturing companies. Companies where top management did not understand the significance of ERP for their business have failed to fully implement the ERP system. "Islands" in company, where the ERP system is not functioning became places from which constant dissatisfaction is spread, which require additional effort, resources, and costs of companies in ERP work with no deadlock. The new model, obtained by applying AHP method, determine the most impact risk factors, and this analysis indicated training of top management for not only on the implementation of ERP systems but also about the importance of changes in their management with immediate application of ERP system. After this training, ERP system will gain the full support of top management as to all researchers is one of the most important requirements for a successful implementation.

Future research should be focus on finding detailed model of top management training with "personalized" every model for the purpose of targeting company.

Declaration of conflicting interests

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References

1. Mahdavian M and Mostajeran F. Studying key users' skills of ERP system through a comprehensive skill measurement model. *Int J Adv Manuf Tech* 2013; 69: 1981–1999.
2. Shaul L and Tauber D. Critical success factors in enterprise resource planning systems: review of the last decade. *ACM Comput Surv* 2013; 45: 55 (39 pp.).
3. Aloin D, Dulmin R and Mininno V. Risk assessment in ERP project. *Inform Syst* 2012; 37: 183–199.
4. Chang B, Kuo C, Wu CH, et al. Using fuzzy analytic network process to assess the risks in enterprise resource planning system implementation. *Appl Soft Comput* 2015; 28: 196–207.
5. Hakim A and Hakim H. A practical model on controlling the ERP implementation risks. *Inform Syst* 2010; 35: 204–214.
6. Markus ML. Technochange management: using IT to drive organizational change. *J Inform Tech* 2004; 19: 4–20.
7. Salmeron JL and Lopez C. A multi-criteria approach for risk assessment in ERP maintenance. *J Syst Software* 2010; 83: 1941–1953.
8. Vogt C. Intractable ERP: a comprehensive analysis of failed ERP projects. *Software Eng Notes* 2002; 27: 62–68.
9. Wei C. Evaluating the performance of an ERP system based on the knowledge of ERP implementation objectives. *Int J Adv Manuf Tech* 2008; 39: 168–181.
10. Motwani J, Subramanian R and Gopalakrishna P. Critical factors for success ERP implementation: extrapolatory findings from four case studies. *Comput Ind* 2005; 56: 529–544.
11. Ansarinejad A, Amalnick M, Ghadamyari M, et al. Evaluating the critical success factors in ERP implementation using fuzzy AHP approach. *Int J Acad Res* 2011; 3: 65–80.
12. Ram J, Corkindale D and Wu M-L. Implementation critical success factors (CSFs) for ERP: do they contribute to implementation success and post-implementation performance? *Int J Prod Econ* 2013; 144: 157–174.
13. Fang L and Patrecia S. *Critical success factors in ERP implementation*. Jönköping: Jönköping International Business School, Jönköping University, 2005.
14. Sun H, Wenbin N and Rocky L. A step-by-step performance assessment and improvement method for ERP implementation: action case studies in Chinese companies. *Comput Ind* 2015; 68: 40–52.
15. Kim JH, Jung RD and Young CC. A study of success and failure in ERP implementation: the case of the agricultural products processing center. *Int J u-e-Serv Sci Technol* 2015; 8: 183–194.
16. Dey PK, Clegg BT and Bennett DJ. Managing enterprise resource planning projects. *Bus Process Manag J* 2010; 216: 282–296.
17. Dezdar S and Sulaiman A. Successful enterprise resource planning implementation: taxonomy of critical factors. *Ind Manage Data Syst* 2009; 109: 1037–1052.
18. Schonsleben P. *Integral logistics management*. Boca Raton, FL: CRC Press, Taylor & Francis Group, 2012, pp.456–461.
19. Plant R and Willcocks L. Critical success factors in international ERP implementations: a case research approach. *J Comput Inform Syst* 2007; 47: 60.
20. Snider B, Da Silveira GJC and Balakrishnan J. ERP implementation at SMEs: analysis of five Canadian cases. *Int J Oper Prod Man* 2009; 29: 4–29.

21. Hwang HJ and Park YJ. Kazakhstan perspectives on ERP System Implementation. *Int J Softw Eng Appl* 2014; 8: 223–232.
22. Somers TM and Nelson KG. A taxonomy of players and activities across the ERP project life cycle. *Inform Manage* 2004; 41: 257–278.
23. Van Beijsterveld JAA and Van Groenendaal WJH. Solving misfits in ERP implementations by SMEs. *Info Systems J*. Epub ahead of print 28 September 2015. DOI: 10.1111/isj.12090.
24. Amini M and Sadat Safavi N. Review paper: critical success factors for ERP implementation. *Int J Inform Tech Inform Syst* 2013; 5: 1–23.
25. Finney S and Corbett M. ERP implementation: a compilation and analysis of critical success factors. *Bus Process Manag J* 2007; 13: 329–347.
26. Abdelghaffar H. Success factors for ERP implementation in large organizations: the case of Egypt. *Electron J Inform Syst Develop Ctries* 2012; 52: 1–13.
27. Ahmad RMTRL, Othman Z and Mukhtar M. Integrating CSF and change management for implementing campus ERP system. *Int J Inform Syst Change Manag* 2013; 6: 189–204.
28. Vathanophas V. Business process approach towards an inter-organizational enterprise system. *Bus Process Manag J* 2007; 13: 433–450.
29. Krumbholz M, Galliers J, Coulianos N, et al. Implementing enterprise resource planning packages in different corporate and national cultures. *J Inform Tech* 2000; 15: 267–279.
30. Kim Y and Lee Z. Impediments to successful ERP implementation process. *Bus Process Manag J* 2005; 11: 158–170.
31. Nah FFH and Delgado S. Critical success factors for enterprise resource planning implementation and upgrade. *J Comput Inform Syst* 2006; 46: 99.
32. Gattiker TF and Goodhue DL. Software-driven changes to business processes: an empirical study of impacts of Enterprise Resource Planning (ERP) systems at the local level. *Int J Prod Res* 2002; 40: 4799–4814.
33. Li Y. ERP adoption in Chinese small enterprise: an exploratory case study. *J Manuf Tech Manag* 2011; 22: 489–505.

Appendix 1

Results of factor analysis

First group of factors—organizational environment

```
FACTOR
  /VARIABLES = Var0001 Var0002 Var0003 Var0004 Var0005 Var0006 Var0028 Var0029 Var0030
  /CRITERIA = MINEIGEN (1) ITERATE (25)
  /EXTRACTION = PC
  /METHOD = CORRELATION
  /PRINT = INITIAL EXTRACTION ROTATION
  /CRITERIA = ITERATE (25)
  /ROTATION = VARIMAX.
```

Second group of factors—technical issues

```
FACTOR
  VARIABLES = Var0007 Var0009 Var0010 Var0014 Var0019 Var0020 Var0021 Var0023 Var0024 Var0025 Var0026 Var0027 Var0043
  /CRITERIA = MINEIGEN (1) ITERATE (25)
  /EXTRACTION = PC
  /METHOD = CORRELATION
```

Communalities.

	Initial	Extraction
Var0001	1.00	0.59
Var0002	1.00	0.54
Var0003	1.00	0.72
Var0004	1.00	0.62
Var0005	1.00	0.65
Var0006	1.00	0.53
Var0028	1.00	0.63
Var0029	1.00	0.85
Var0030	1.00	0.83

Total variance explained.

Component	Initial eigenvalues			Extraction sums of squared loadings			Rotation sums of squared loadings		
	Total	% of variance	Cumulative %	Total	% of variance	Cumulative %	Total	% of variance	Cumulative %
1	2.48	27.50	27.50	2.48	27.50	27.50	2.23	24.75	24.75
2	2.19	24.35	51.85	2.19	24.35	51.85	2.19	24.37	49.12
3	1.31	14.50	66.35	1.31	14.50	66.35	1.55	17.23	66.35
4	0.80	8.92	75.27						
5	0.68	7.60	82.88						
6	0.55	6.16	89.03						
7	0.49	5.45	94.49						
8	0.35	3.93	98.41						
9	0.14	1.59	100.00						

Component matrix.

	Component		
	1	2	3
Var0001	0.51	0.12	−0.56
Var0002	0.43	−0.02	−0.60
Var0003	−0.19	−0.81	−0.13
Var0004	−0.05	−0.76	0.19
Var0005	0.03	−0.81	0.06
Var0006	0.14	−0.48	−0.54
Var0028	0.60	−0.23	0.47
Var0029	0.89	−0.03	0.24
Var0030	0.90	0.01	0.12

Rotated component matrix.

	Component		
	1	2	3
Var0001	0.18	−0.17	0.73
Var0002	0.11	−0.02	0.73
Var0003	−0.17	0.83	0.06
Var0004	0.10	0.77	−0.16
Var0005	0.12	0.80	0.00
Var0006	−0.09	0.46	0.56
Var0028	0.77	0.17	−0.13
Var0029	0.90	−0.05	0.20
Var0030	0.85	−0.09	0.31

```
/PRINT = INITIAL EXTRACTION ROTATION
/CRITERIA = ITERATE (25)
/ROTATION = VARIMAX.
```

Third group of factors—people issues

```
FACTOR

VARIABLES = Var0015 Var0016 Var0017
Var0018 Var0031 Var0032 Var0033 Var0034
Var0035 Var0036 Var0037 Var0039 Var0041
Var0042
/CRITERIA = MINEIGEN (1) ITERATE (25)
/EXTRACTION = PC
/METHOD = CORRELATION
```

Communalities.

	Initial	Extraction
Var0007	1.00	0.84
Var0009	1.00	0.82
Var0010	1.00	0.71
Var0014	1.00	0.74
Var0019	1.00	0.51
Var0020	1.00	0.69
Var0021	1.00	0.59
Var0023	1.00	0.74
Var0024	1.00	0.75
Var0025	1.00	0.67
Var0026	1.00	0.68
Var0027	1.00	0.57
Var0043	1.00	0.61

Total variance explained.

Component	Initial eigenvalues			Extraction sums of squared loadings			Rotation sums of squared loadings		
	Total	% of variance	Cumulative %	Total	% of variance	Cumulative %	Total	% of variance	Cumulative %
1	3.80	29.26	29.26	3.80	29.26	29.26	2.85	21.89	21.89
2	1.55	11.92	41.17	1.55	11.92	41.17	1.89	14.55	36.44
3	1.35	10.40	51.57	1.35	10.40	51.57	1.38	10.64	47.09
4	1.17	8.97	60.55	1.17	8.97	60.55	1.62	12.50	59.58
5	1.05	8.09	68.64	1.05	8.09	68.64	1.18	9.06	68.64
6	0.86	6.61	75.25						
7	0.73	5.61	80.86						
8	0.56	4.28	85.14						
9	0.52	4.01	89.15						
10	0.48	3.68	92.83						
11	0.39	3.01	95.84						
12	0.34	2.64	98.48						
13	0.20	1.52	100.00						

Component matrix.

	Component				
	1	2	3	4	5
Var0007	−0.34	−0.14	0.13	0.22	−0.80
Var0009	0.00	0.08	−0.85	0.28	−0.12
Var0010	−0.33	0.57	−0.08	0.32	0.41
Var0014	−0.29	0.64	0.44	−0.12	−0.16
Var0019	−0.44	0.13	−0.40	−0.36	−0.15
Var0020	−0.56	0.44	−0.31	−0.16	−0.25
Var0021	−0.53	0.38	0.13	−0.38	0.00
Var0023	−0.78	−0.21	0.10	0.29	−0.02
Var0024	−0.81	−0.14	0.15	0.20	0.12
Var0025	−0.69	−0.32	0.12	−0.21	0.16
Var0026	−0.62	−0.49	−0.04	−0.23	0.03
Var0027	−0.63	−0.12	−0.28	−0.13	0.26
Var0043	−0.44	0.10	0.11	0.62	0.03

Rotated component matrix.

	Component				
	1	2	3	4	5
Var0007	0.10	0.11	0.05	0.12	0.90
Var0009	−0.11	−0.16	0.88	0.11	0.01
Var0010	−0.03	0.34	0.15	0.65	−0.39
Var0014	−0.14	0.75	−0.30	0.23	0.10
Var0019	0.33	0.42	0.44	−0.17	0.05
Var0020	0.19	0.65	0.45	0.12	0.14
Var0021	0.29	0.71	−0.05	0.02	−0.05
Var0023	0.64	0.08	0.01	0.50	0.28
Var0024	0.67	0.16	−0.06	0.50	0.13
Var0025	0.79	0.14	−0.12	0.07	0.02
Var0026	0.81	0.00	0.03	−0.08	0.14
Var0027	0.65	0.16	0.28	0.13	−0.17
Var0043	0.14	0.00	0.02	0.74	0.18

```
/PRINT = INITIAL EXTRACTION ROTATION
/CRITERIA = ITERATE (25)
/ROTATION = VARIMAX.
```

Fourth group of factors—adoption process management

```
FACTOR

VARIABLES = Var0038 Var0040 Var0044
Var0045 Var0046 Var0047 Var0048 Var0049
/CRITERIA = MINEIGEN (1) ITERATE (25)
/EXTRACTION = PC
/METHOD = CORRELATION
/PRINT = INITIAL EXTRACTION ROTATION
/CRITERIA = ITERATE (25)
/ROTATION = VARIMAX.
```

Communalities.

	Initial	Extraction
Var0015	1.00	0.70
Var0016	1.00	0.79
Var0017	1.00	0.49
Var0018	1.00	0.48
Var0031	1.00	0.84
Var0032	1.00	0.83
Var0033	1.00	0.63
Var0034	1.00	0.79
Var0035	1.00	0.68
Var0036	1.00	0.65
Var0037	1.00	0.57
Var0039	1.00	0.67
Var0041	1.00	0.52
Var0042	1.00	0.57

Total variance explained.

Component	Initial eigenvalues			Extraction sums of squared loadings			Rotation sums of squared loadings		
	Total	% of variance	Cumulative %	Total	% of variance	Cumulative %	Total	% of variance	Cumulative %
1	4.70	33.60	33.60	4.70	33.60	33.60	1.26	8.97	8.97
2	2.12	15.17	48.77	2.12	15.17	48.77	1.87	13.33	22.30
3	1.27	9.09	57.85	1.27	9.09	57.85	3.87	27.68	49.97
4	1.12	8.03	65.88	1.12	8.03	65.88	2.23	15.91	65.88
5	0.94	6.71	72.59						
6	0.80	5.70	78.30						
7	0.72	5.12	83.42						
8	0.57	4.05	87.47						
9	0.47	3.37	90.84						
10	0.41	2.92	93.76						
11	0.35	2.47	96.23						
12	0.20	1.42	97.65						
13	0.20	1.39	99.05						
14	0.13	.95	100.00						

Component matrix.

	Component			
	1	2	3	4
Var0015	0.07	−0.69	−0.06	0.46
Var0016	0.11	−0.80	−0.11	0.36
Var0017	−0.04	−0.62	−0.32	−0.10
Var0018	0.13	−0.07	−0.62	−0.26
Var0031	0.54	−0.36	0.33	−0.56
Var0032	0.67	−0.47	0.08	−0.40
Var0033	0.72	0.07	−0.32	−0.04
Var0034	0.77	0.14	−0.42	0.02
Var0035	0.82	0.04	0.01	−0.02
Var0036	0.60	0.39	−0.31	0.19
Var0037	0.70	0.27	0.03	0.11
Var0039	0.67	0.12	0.20	0.40
Var0041	0.64	−0.01	0.34	0.02
Var0042	0.66	−0.10	0.33	0.14

Rotated component matrix.

	Component			
	1	2	3	4
Var0015	−0.09	0.83	0.01	0.00
Var0016	0.02	0.88	−0.01	0.11
Var0017	0.40	0.52	−0.17	0.18
Var0018	0.67	0.03	0.17	0.02
Var0031	0.00	0.02	0.09	0.91
Var0032	0.15	0.23	0.28	0.82
Var0033	0.27	0.02	0.71	0.23
Var0034	0.32	0.01	0.82	0.15
Var0035	−0.03	0.02	0.71	0.42
Var0036	0.11	−0.15	0.78	−0.10
Var0037	−0.14	−0.13	0.71	0.19
Var0039	−0.41	0.11	0.69	0.11
Var0041	−0.33	0.01	0.46	0.44
Var0042	−0.36	0.15	0.50	0.41

Fifth group of factors—external support

```
FACTOR
  /VARIABLES = Var0008 Var0011 Var0012 Var0013 Var0022 Var0050
  /CRITERIA = MINEIGEN (1) ITERATE (25)
  /EXTRACTION = PC
  /METHOD = CORRELATION
  /PRINT = INITIAL EXTRACTION ROTATION
  /CRITERIA = ITERATE (25)
  /ROTATION = VARIMAX.
```

Communalities.

	Initial	Extraction
Var0038	1.00	0.48
Var0040	1.00	0.56
Var0044	1.00	0.33
Var0045	1.00	0.64
Var0046	1.00	0.73
Var0047	1.00	0.80
Var0048	1.00	0.56
Var0049	1.00	0.60

Total variance explained.

Component	Initial eigenvalues			Extraction sums of squared loadings			Rotation sums of squared loadings		
	Total	% of variance	Cumulative %	Total	% of variance	Cumulative %	Total	% of variance	Cumulative %
1	3.57	44.66	44.66	3.57	44.66	44.66	3.55	44.36	44.36
2	1.11	13.90	58.56	1.11	13.90	58.56	1.14	14.20	58.56
3	0.95	11.88	70.44						
4	0.78	9.73	80.17						
5	0.66	8.31	88.48						
6	0.40	4.96	93.44						
7	0.34	4.21	97.65						
8	0.19	2.35	100.00						

Component matrix.

	Component	
	1	2
Var0038	0.16	0.67
Var0040	0.03	0.75
Var0044	0.53	0.22
Var0045	0.79	−0.09
Var0046	0.85	−0.10
Var0047	0.89	−0.07
Var0048	0.74	−0.13
Var0049	0.77	0.10

Rotated component matrix.

	Component	
	1	2
Var0038	0.09	0.69
Ver0040	−0.04	0.75
Var0044	0.50	0.27
Var0045	0.80	−0.02
Var0046	0.85	−0.02
Var0047	0.89	0.01
Var0048	0.75	−0.06
Var0049	0.75	0.18

Communalities.

	Initial	Extraction
Var0008	1.00	0.30
Var0011	1.00	0.40
Var0012	1.00	0.93
Var0013	1.00	0.80
Var0022	1.00	0.49
Var0050	1.00	0.66

Total variance explained.

Component	Initial eigenvalues			Extraction sums of squared loadings			Rotation sums of squared loadings		
	Total	% of variance	Cumulative %	Total	% of variance	Cumulative %	Total	% of variance	Cumulative %
1	2.11	35.14	35.14	2.11	35.14	35.14	1.30	21.68	21.68
2	1.06	17.73	52.86	1.06	17.73	52.86	1.15	19.18	40.86
3	1.00	16.67	69.54	1.00	16.67	69.54	1.14	18.94	59.80
4	0.74	12.39	81.92						
5	0.67	11.14	93.06						
6	0.42	6.94	100.00						

Component matrix.

	Component		
	1	2	3
Var0008	0.28	−0.14	0.45
Var0011	0.63	−0.05	0.10
Var0012	0.80	0.47	0.24
Var0013	0.79	−0.42	0.05
Var0022	0.56	0.02	−0.42
Var0050	0.23	0.02	−0.78

Rotated component matrix.

	Component		
	1	2	3
Var0008	0.36	0.18	−0.37
Var0011	0.49	0.39	0.07
Var0012	0.29	0.92	0.02
Var0013	0.86	0.22	0.14
Var0022	0.32	0.28	0.56
Var0050	0.03	−0.01	0.81