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Risk management in ERP project introduction: Review of the literature

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Abstract

In recent years ERP systems have received much attention. However, ERP projects have often been found to be complex and risky to implement in business enterprises. The organizational relevance and risk of ERP projects make it important for organizations to focus on ways to make ERP implementation successful.

We collected and analyzed a number of key articles discussing and analyzing ERP implementation. The different approaches taken in the literature were compared from a risk management point of view to highlight the key risk factors and their impact on project success. Literature was further classified in order to address and analyze each risk factor and its relevance during the stages of the ERP project life cycle.

Keywords: ERP; Risk management; Literature analysis; ERP life cycle; Risk assessment

No risk, no reward.

Companies must take risk both to launch new products and to innovate themselves. "However, risk processes do not require a strategy of risk avoidance but an early diagnosis and management" [73].

1. Introduction

Unfortunately implementation difficulties still affect complex IT projects like the introduction of enterprise resource planning (ERP). The integrated e-business marketplace and external environments have highlighted the needs for companies to react quickly to customer signals and behave competitively. To achieve this, companies need effective communication systems and integrated IS that fit their business goals and processes, both inside and outside the company's boundaries. Companies must establish strong partnerships and form an effective supply chain [116].

ERP and SCM system applications are often implemented to improve a firm's performance [144]. Over the last decade, many firms world-wide have implemented enterprise ERP systems which are packaged business software systems that help in managing the efficient and effective use of resources (materials, human resources, finance, etc.) [77,87]. They assist enterprises in automating and integrating corporate cross-functions, such as inventory control, procurement, distribution, finance, and project management [130].

As estimated by AMR Research [7–10], with ERP penetration at 67% (2002), the ERP market is the largest segment of a company's applications budget (34%). The global market grew 14% in 2004 to become a US$ 23.6

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billion business, moreover the European ERP market revenues are expected to increase 7% annually through 2009.

However, ERP projects are complex; PMP [108] found that the average implementation time of an ERP project was between 6 months and 2 years and that the average cost was about US$ 1 million. Researchers have pointed out that there is a substantial difference between an ''ERP'' project and a simple ''Software'' project [24]. An ERP project involves several components of software and business systems, thereby raising organizational problems.

Despite the significant benefits that ERP software packages provide, they often cost millions of dollars to buy, several times that to install, and they often require disruptive organizational changes [155]. It is thus some companies have experienced considerable advantages while others have had to reduce their initiatives and accept minimum payoffs, or even relinquishing ERP implementation altogether [133,134]. Time and costs can be enormous [68,114]; Soh et al. observed that ERP implementation involves a large number of stakeholders and that the hidden costs during the ERP life cycle dramatically increase the total implementation cost.

IT projects have a high failure rate. According to the Standish Group International, 90% of SAP R/3 ERP projects run late [128]; a study of 7400 IT projects showed that 34% were late or over budget, 31% were abandoned, scaled or modified, and only 24% were completed on time and in budget [38].

Our work focused on the importance of ERP risk management through the ERP life cycle and resulted in guidelines for managing the risk. In particular, starting with an extensive analysis of the literature, we classified project risk factors and concentrated on the question of how they impact the best use of a company's limited resources. The main purposes of our work thus was to:

- review and analyze key articles on ERP project from a risk management point of view;
- identify risk factors and risk approaches, their relations and differences in terms of their impact on the organization;
- describe and classify important contributions to ERP risk management identifying their differences, advantages, and disadvantages;
- clarify at which stage of the ERP life cycle it is critic to manage the risks;
- identify areas needing ERP risk management deployment.

2. ERP project risk assessment

One reason often cited for any software project failure is that managers do not properly assess and manage the risks involved in their projects [90]. Most project managers perceive risk management processes as extra work and expense; thus, risk management processes are often expunged if a project schedule slips [78].

In the past, several ways were proposed in order to improve the success rate of ERP introduction, unfortunately without great effect [62,64,103]. The nature of IT project risk is determined by the risk factors [72,129,131] and by the strategic need for the project, innovation, repetition of failed experience, etc. Many processes have been developed in recent years to address the need for a more effective risk management, though they are often too general for ERP application, models including PMI 2001 [107], Standards Australia 1999 [140], SAFE methodology [47], and Risk Diagnosing Methodology [73] are typical iterative approaches to risk management problems (see Fig. 1). Main phases are:

1. context analysis;
2. risk identification;
3. risk analysis;
4. risk evaluation;
5. risk treatment;
6. monitoring and review;
7. communication and consulting.

However, ERP projects are interdisciplinary; they affect interdependencies between business processes,

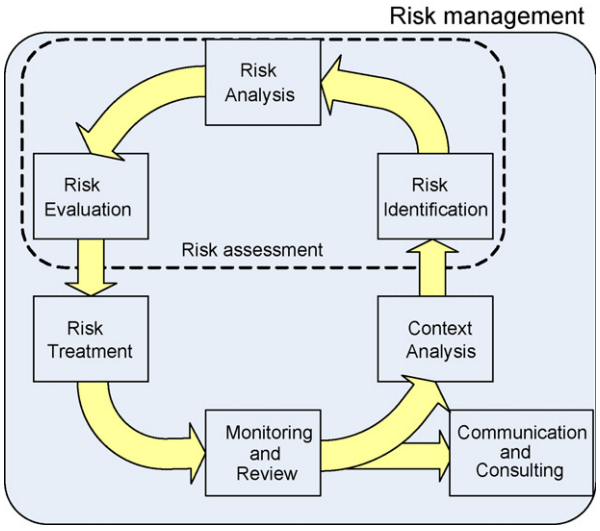

Fig. 1. Risk management phases.

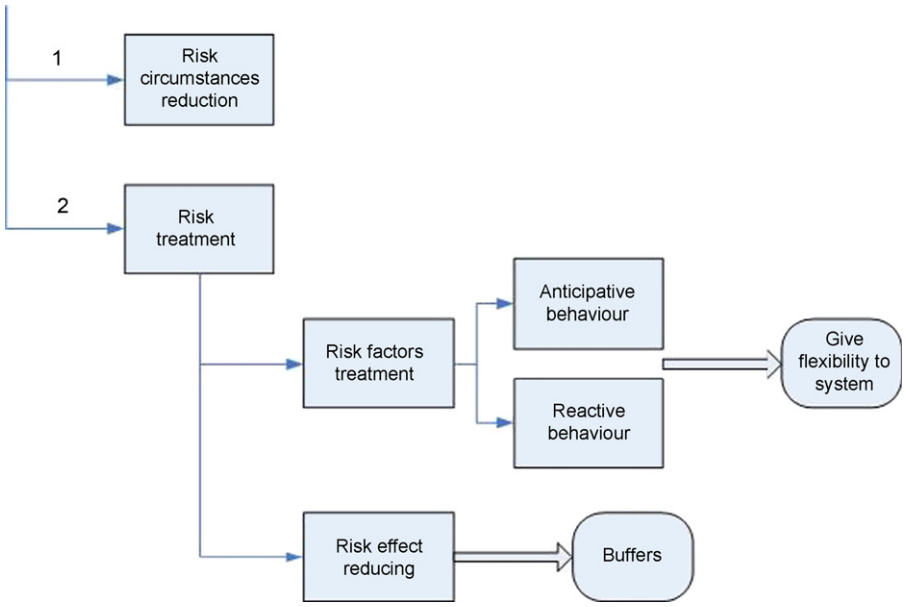

Fig. 2. Risk treatment strategy.

software and process reengineering [166,168]. Critical factors include technological and management aspects, both psychological and sociological. To be effective a risk assessment method should consider several potential aspects (technology, market, financial, operational, organizational, and business) and link them to the project life cycle. This ensures the selection of the most appropriate risk treatment strategy.

Risk management strategy consists of two approaches (see Fig. 2). The first aims at reducing risky circumstances, while the second deals with risk treatment after a risk appears.

3. Research design

We decided only to search peer-reviewed papers having more than two pages in order to eliminate editorials, book-reviews, and viewpoints. Moreover, in recent years the number of papers has substantially increased [52]. Therefore, we used only literature published since 1999. The following method was adopted:

- Main research lines were carefully explored. Bibliographic databases were used extensively.
- Web search facilities were used and articles concerning ERP critical success factors, selection, implementation, risk management during the ERP life cycle were collected and analyzed.
- Papers without these foci were eliminated.
- Papers were classified depending on their research objective.
- Papers were analyzed to determine their main message.

The literature contributions were primarily of articles from:

- Emerald, which publishes a wide range of management titles and library-and-information services titles by publishers world-wide. Subjects covered included management, HRM, Marketing, Librarianship, Mechanical engineering, electronic and electrical engineering. Emerald contains 42,000 searchable articles from over 100 of its journals.
- Science Direct (Elsevier), the electronic collection of science, technology, and medicine full text and bibliographic information.
- Springer, the specialist publisher of the Science, Technology, Medicine (STM) sector and integrated Business-to-Business publishing houses in German-speaking and Eastern European countries.
- IEEE-Xplore, providing online delivery systems with full text access to high quality technical literature in electrical engineering, computer science, and electronics.

After extracting from these databases, the papers were reviewed to identify relevant risk factors and then the data was organized to produce a classification

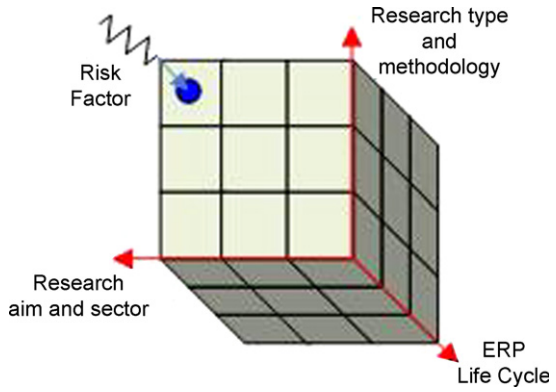

Fig. 3. Dimension of analysis.

from several perspectives, taking in to account (see Fig. 3):

1. research aim and sector;
2. research type and methodology;
3. risk factor (highlighted);
4. ERP life cycle (stadium).

To determine the research approach articles were classified using two ''double'' axis dimensions. In the first dimension, papers were reviewed, analyzed, and classified according to their ''aim and sector''; then the procedure suggested by Williams and Oumlil [163] and the methodology outlined by Hunt [66] were adapted for our research.

The ''Aim'' of the research was determined by examining the following key factors:

a. *System selection*. Including papers about the package selection process, which involved activities from *as is* and *to be* to requirements analysis, use of structured selection techniques for system selection, consulting, software testing and evaluation, vendor selection, and global cost evaluation.
b. *System implementation*. Presenting the implementation processes from the end of the selection to system testing and post-implementation. It involves contributions to identify critical issues and their impact on implementation, development of a structured technique, implementation strategies, business case, BPR, and change management.
c. *System/IT risk management*. Including specific problems related to risk management as part of a general and structured project management technique. It reports activities from the context analysis to risk treatment, review and control, with direct reference to the ERP project or more generally with pertinence to any complex IT project.
d. *General IT/system project*. Presenting general considerations on ERP and complex IT projects – their impact on the organization (those not be specifically classified in other classes). In particular this collected contributions related to the impact of introduction of the ERP, its critical success factors, success and failure drivers, both from an engineering point of view as well as sociological and managerial ones; also this contained specific case studies.

The ''Sector'' depended on contributions linked to sector scope and company size. In particular the variables defined were:

1. *Multiple sector* (MS) contributions that involve empirical articles of interest to more than one sector or conceptual ones with general applicability.
2. *Sector specific* contributions are articles which are referenced in a specific business sector. The specificity of research and the impact of corporate scope on problem settings make a size-differentiation essential. So we distinguished between:
   (a) Small and medium enterprises (S-SMEs).
   (b) Large corporate-enterprises (S-LC).

The article's *research type and methodology* was classified as either *empirical*, *conceptual/theoretical* or *conceptual/theoretical and empirical*.

Empirical articles included surveys, case studies, interviews or anecdotal information. Case studies analyzed ERP projects in particular industries or life cycle phases; these articles were typically narrow and in-depth, providing a thoroughly examination of a limited area. Anecdotal studies give 'examples' of practices, without exploring practice in any rigorous or in-depth manner.

Papers in the *conceptual/theoretical* group had their primary focus on the development of models, concepts, or ideas. They pointed out literature reviews, development of conceptual models, development of concepts or development of propositions. Articles classified as both *conceptual and empirical* in focus typically developed a number of hypotheses and tested them empirically.

For ''methodology'', the papers were classified as either *positive/descriptive or normative/prescriptive*. Articles in the *positive/descriptive* category attempted to describe, explain, predict, and understand processes, activities, and phenomena that actually existed. Articles in the *normative/prescriptive* category sought to prescribe the activities in which organizations and individuals should be engaged. The prescriptive/

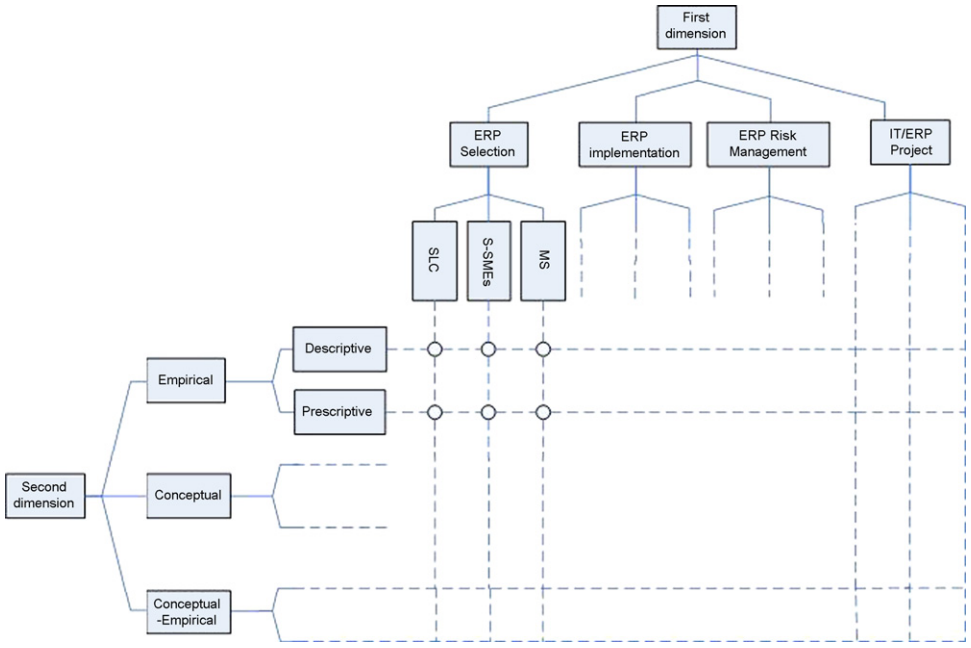

Fig. 4. Multidimensional matching—research approach.

descriptive dimension was really a continuum, because some of the articles were primarily descriptive but give some managerial implications. In order to simplify the classification and create comparable groups, articles were only divided in prescriptive and descriptive categories based on their major focus.

Bi-dimensional matching of variables was a functional requisite to our research approach. The scheme in Fig. 4 shows the interpretative criteria that we followed to determine evidence of research trends and interest in recent literature (as presented in Appendix A).

After this first "characterization of context" to identify the research approach, the review concluded with an output list of the most critical risk factors prioritized by frequency presented in the literature reviewed. Finally risk factors were framed in a life cycle interpretative scheme to highlight the important relation with the ERP introduction and development processes. For this purpose a dimension was added to show which ERP project phase was considered.

Researchers have described ERP life cycle using different models according to the target application, some with a few general stages, like the three of Deloitte Consulting's [42], while others are more analytic having five or more phases, such as Ross and Vitale's or Rajagopal models [112,117].

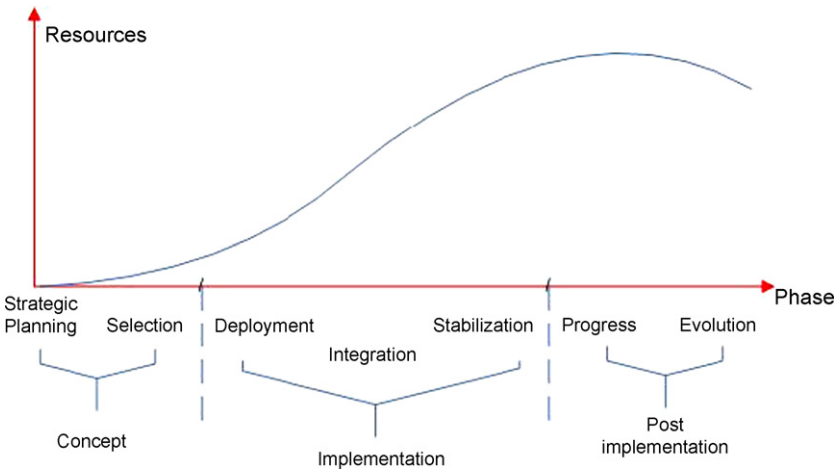

Fig. 5. ERP life cycle.

In our analysis, these literature models were analyzed and re-adapted, aggregating them into three principal phases, as shown in Fig. 5.

1. ''*Concept*'' refers to the activities of ERP introduction from strategic planning of requirements to software package selection.
2. ''*Implementation*'' includes activities from software deployment or installation to parameterization, integration, testing, and stabilization.
3. ''*Post-implementation*'' includes maintenance activities: upgrading, new-release management, and evolution maintenance.

4. ERP risk identification

4.1. Introduction

Identifying risks can be a challenge for managers, especially because there are different ways in which they can be described and categorized [17]. Often terms as ''risk factors'', ''Critical Success Factors'' and ''Uncertainty factors'' are used to convey also the same concept. So we homogenized all these factors and grouped them into similar factors.

4.2. Defining project success: literature review

Project success/failure depends on how and by whom it is determined [157]. Before investigating risk causes and effects, we therefore had to give our definition of *success*.

Lyytinen and Hirschheim [86] categorized IT project success by assessing the resulting system against the planned objectives, user expectations, project budget and goals by obtaining user's consensus on the differences. The project management literature has linked project success to general cost, time and quality of product [15,28,40,41,127,149]. Wateridge [159] when surveying the success of IS/IT projects, stated that the participants associated project success either meeting requirements; thus the ''users'' wanted ''happiness'' while the project managers were interested in being within budget and on time. Linberg [84] observed that the success of a completed project was linked to the quality of the product, while a cancelled project had one positive result: organizational learning.

Agarwal and Rathod [1] identified two different perspectives of success: *internal* linked to time, cost and scope that underlined the value of project monitoring and control processes and *external* focused on customer satisfaction and system quality. Drew Procaccino and Verner [109] in contrast with the traditional definition of project success [16,25,70,71,105], found that project managers saw success in the delivery of a system that met customer/user requirements at work (resulting in improved quality and personal achievement).

4.3. ERP project failure classification

We classified ERP project failure as one of four levels:

(a) *Process failure*, when the project is not completed within the time and budget.
(b) *Expectation failure*, when the IT systems do not match user expectations.
(c) *Interaction failure*, when users attitudes towards IT are negative.
(d) *Correspondence failure*, when there is no match between IT systems and the planned objectives.

4.4. Risk factors identification and description

The main risk effects we identified from the literature are: budged exceed, time exceed, project stop, poor business performances, inadequate system reliability and stability, low organizational process fitting, low user friendliness, low degree of integration and flexibility, low strategic goals fitting and bad financial/economic performances. The literature was then reviewed to identify the relevant risk factors, shown in Fig. 6. The 19 ERP risk factors are now discussed.

4.4.1. Inadequate selection

Implementation of an incorrect project could cause it to fail or weaken it sufficiently to affect the company's performance [59,165]. The better the ERP selection process, the greater the chance of success [147].

Several methods have been proposed for selecting a suitable ERP project [30,119,145]. Ptak [111] proposed a scoring method, Teltumbde suggested 10 criteria based on AHP, Santhanam and Kyparisis used a nonlinear programming model to consider interdependencies of criteria in the IS selection process, Lee and Kim [81] combined the analytic network process and a 0–1 goal-programming model; other models have used fuzzy multiple-criteria decision making [161].

4.4.2. Poor project team skills

It is necessary to form a skill-balanced project team having both internal and external experts, managerial

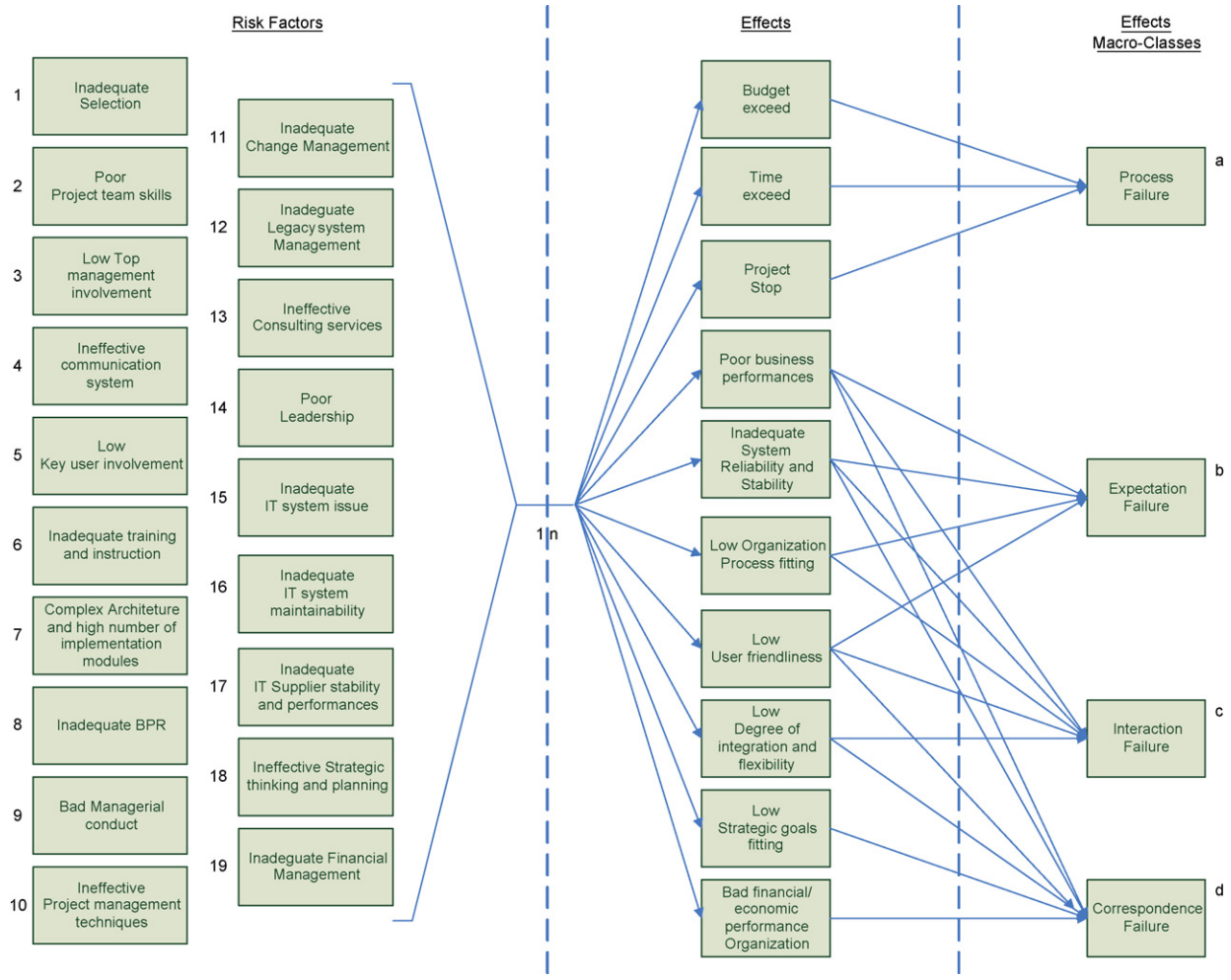

Fig. 6. Risk factors, effects and project failure.

competencies, deep knowledge of the processes, and IT skills. This project team's business and technological competence will contribute to the ERP's implementation success or failure [94,148]. The skills and knowledge of the project team are important in providing expertise in areas where team members lack knowledge [20,34]. As a project team usually disbands after installation, its role is significant in the earlier stages and less important post-installation. Some relevant elements are: key player involvement, true skill and competencies mix, ability to complete work assigned, motivation, quality of ERP professional, past accomplishments, reputation and flexibility.

4.4.3. Low top management involvement

Participation, direct top management support and commitment, are expected to influence the success of ERP adoption. Sustained management support is essential throughout the project [48,99]. Microsoft's experience underlines the importance of top management involvement in planning and implementing ERP system [43].

4.4.4. Ineffective communication system

Communication is, of course, a necessity in an ERP implementation project [143]. It provides an appropriate link and success to data for all actors [124].

4.4.5. Low key user involvement

User involvement is important in meeting expectations. Key users should be convinced of the system utility; moreover they must be confident and expert so that they can aid future users in training sessions. User commitment and a ''project champion'' (who has the vision to get the project going and pushes for the project to be accepted where there are competing priorities) are useful in the early stages of the project and during the implementation phase.

4.4.6. Inadequate training and instruction

The role of training to facilitate software implementation is well documented [101,120]. Frequently lack of user training and understanding failure of how enterprise applications change business processes is posited as responsible for many ERP implementation problems [37,162]. Computer-based training via Intranets have been found to facilitate ERP implementations [89].

4.4.7. Complex architecture and high number of implementation modules

The number of implementation modules increases project complexity [50]; key architectural considerations are important during the initiation and adoption phases to obviate the need for additional software (such as data warehousing). If not adequately planned, personalization and adaptation of tools may cause trouble [91,138].

4.4.8. Inadequate BPR

Often, packaged software is incompatible with the organization's needs and business processes [85]. The consequence is software modification, which is expensive and costs heavily in maintenance, or restructuring of the organization's business processes to fit the software [57,58]. According to IBM, its ''Method Blue'', a deep analysis of process business value and performances is necessary to prioritize activities to be supported by ERP [67].

To neglect business processes redesign is a risk in ERP project; ERP implementation and BPR activities. ERP packages offer many business practices that might be included as part of a BPR [55], but there is still likely to be a need for continuous process improvement.

4.4.9. Bad managerial conduct

Effective project implementation requires a well articulated business vision that establishes the goals and the business model behind the project [61]. Clear goals and objectives [12], should indicate the general directions of the project [33], and remain clear through all its stages.

Good management also improves user expectations [53] and helps in planning the training of people in the use of the finished system [60]. In this risk factor, we also include the use of a structured method of project development and implementation.

4.4.10. Ineffective project management techniques

The inadequate use of project management techniques significantly affects ERP project success [110]. Project management activities span the first four stages of the ERP life cycle from initiating the project to its closing [137].

Project planning and control are a function of the project characteristics, including its size, experience with the technology, and the stability and experience of the IT development group [13]. Risk management in particular is a vital procedure of advanced (goal-directed) project management [11,32]. Some ERP vendors, such as SAP and Baan, provide methodologies and applications to help conduct successful risk management. These tools can be used to drive change management [121]; the system calculates the risks and provides mitigation strategies for the project manager. But SAP and Baan, along with other ERP vendors designed these applications for their own systems; other more generic methodologies were deployed by Zafiropoulos et al. [174].

4.4.11. Inadequate change management

An ERP systems is not simple and its implementation is not purely technological. It modifies the way that the organization operates. To underestimate the effort involved in change management may result in project failure [14,141], especially in the early stages of the project [36,142].

4.4.12. Inadequate legacy system management

ERP systems require people to work within the system and not around it [151]; so old information systems should be removed.

The transition phase is a critical period. Holland and Ligh stressed the need for a carefully managed view of legacy systems. Adequate treatment strategies (''migration'' or ''wrapping'') have to be considered depending on specific process and technological business needs.

4.4.13. Ineffective consulting services

The use of outside consultants is common for ERP projects [45]. Their experience, knowledge of the modules, technical and organizational acumen and experience with similar software applications [106] and manage implementations [146] play a major role in diminishing risk.

4.4.14. Poor leadership

Sarker and Lee [122] examined the role of key social enablers for successful ERP adoption: strong and committed leadership, open and honest communication, and a balanced and empowered implementation team. They found that all three may contribute to ERP success but that only the first could be established as necessary. If project managers and steering committee do not

commit to solving problems and providing direction to the project team, the risk of failure is greater.

4.4.15. Inadequate IT system issue

Technical software capabilities must be studied before implementation matters and their impact on business processes assessed; questions such as these are pivotal for ERP success. Technical aspects that are essential are: all necessary functionality, user friendliness, portability, scalability, modularity, versioning management, simple upgradeability, flexibility, security, presence of a complete guide, a procedure manual to help users, and data accuracy. Because of the integrated nature of ERP software, if some of these elements are absent or ineffective there can be a negative effects throughout the enterprise.

4.4.16. Inadequate IT system maintainability

Maintainability is the ability of equipment to meet operational objectives with a minimum expenditure of maintenance effort under operational environmental conditions in which scheduled and unscheduled maintenance is performed. ERP maintenance and upgrade activities are very important in ERP-using organizations. Annual maintenance costs are about 25% of the initial ERP costs and upgrade costs have been assessed to be as much as 25–33% of the initial ERP implementation [102].

4.4.17. Inadequate IT supplier stability and performances

ERP systems require continuous investment in new modules and upgrades to add functionality, achieve a better fit between business and system, etc. So vendor support are an important risk factor [8,9,74].

4.4.18. Ineffective strategic thinking and planning

Organization must decide why an ERP system should be implemented and what critical business goals the system will address [150]. Hence, identifying business goals, determining the strategic business issues and strategic requirement identification are essential elements of the ERP planning process.

Alignment of IT strategy with the organization's business strategy must be enabled by senior executive support. If an organization tries to install a system without establishing a clear vision, every effort can turn into a disaster [39].

4.4.19. Inadequate financial management

Although ERP system suppliers have increased their focus on SMEs, current systems are still expensive. Chen [31] stated that economic and financial strategic justifications for an ERP project prior to installation were also necessary, because a wrong global costs analysis might impact the ERP adoption, cause the failure of system implementation projects or also bankruptcy [92].

5. Results and discussion

5.1. Data collection

Data was collected by an extended review of more than 130 articles, collected using web facilities. After elimination of older and less technical material, the final sample was about 75 articles (see Appendix A).

Two of the three authors analyzed and classified, separately and independently, all the papers. Each author completed a classification/coding table, discrepancies were resolved in an open discussion with the third author and a common table was compiled (see Table A.1 in Appendix A).

The literature was divided into four groups: ERP selection, ERP implementation, ERP risk management, and general ERP projects. Each paper was then analyzed and its contributions mapped in Table 1.

As shown in Fig. 7, ERP selection and implementation, about 75% of the contributions, was the largest parts. ERP research interest has increased in recent years following the natural progress of implementation of ERP systems in companies.

Most research is related to the periphery of ERP and not on the systems themselves: implementation methods, organizational impact or comment on case studies are typical object of studies.

5.2. Research fields description and gap analysis

5.2.1. First dimension—aim and sector

Considering articles from the first analysis and going into each group identified, the review revealed the following characteristics of the research fields.

5.2.1.1. ERP selection. A number of articles described the management of the package selection process [19,29,153]. These were divided in two groups: one dealt with identification of selection criteria, while the other concerned the design or extension of specific ranking techniques.

The various selection criteria were well documented by Bernroider and Koch [23], Everdingen et al. [49], Siriginidi [113], Sprott [139], Verville and Halingten [152].

Table 1
Classification and positioning of articles

		Research aim	ERP selection			ERP implementation			ERP/IT Risk management			General ERP/IT project		
		Sector	SLC	SSMEs	MS	SLC	SSMEs	MS	SLC	SSMEs	MS	SLC	SSMEs	MS
Research type	**Research methodology**	**ID**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
Empirical	**Positive/Descriptive**	**A**	(15)		(10)(14) (16)	(54)	(59)(74)	(34)(45) (57)(60)	**H-P**		(2)(70)			**H-P**
	Prescriptive/Normative	**B**	**L-P**		**H-P**	(35)(36)	**M-P**	(37)	**L-P**		(51)			
Conceptual/ theoretical	**Positive/Descriptive**	**C**						(40)(62)			(4)(30)			(20)(64)
	Prescriptive/Normative	**D**			(12)(17) (19)(44)		(28)	(23)(24) (26)(39) (47)(50) (52)(43)						(41)(48) (49)
Conceptual/ theoretical and empirical	**Positive/Descriptive**	**E**				(22)	(56)	(55)(58) (61)(65) (72)(73)						(31)(53)
	Prescriptive/Normative	**F**	(5)(6) (13)		(9) (18)	(7)(38) (63)(67)	(42)	(8)(11) (21)(25) (27)(29) (32)(33) (68)(69)	(3)(71) (75)	**H-P**	(1)*			(46)(66)

*Reference number (see Appendix A, No.).
L-P: Low populated. M-P: Medium populated. H-P: Highly populated.

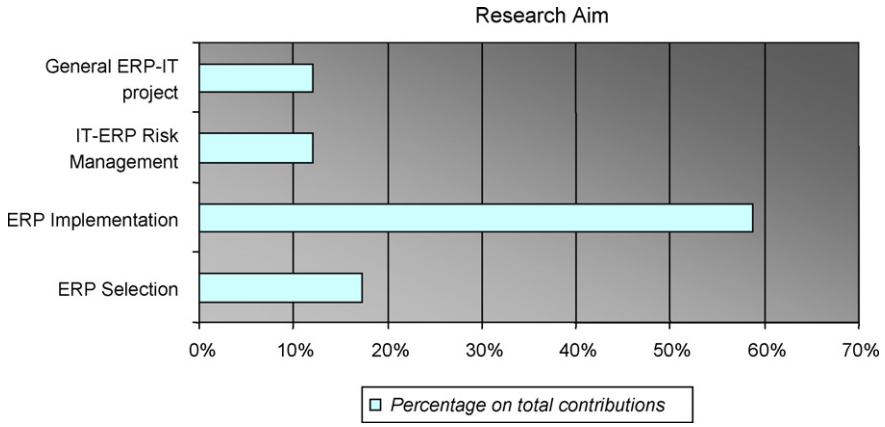

Fig. 7. Research aim—analysis of contributions.

Bernroider and Koch discussed the results from an empirical study of Austrian companies concerning differences in the characteristics of the ERP system selection process between small or medium and large sized organisations. Verville and Halingten [154] investigated the decision process for selecting an ERP system through a case study. They reported that the three distinct types of an ERP system evaluation were vendor, functional and technical.

Specific frameworks for selecting suitable ERP system were presented by Wei et al. [160] and by Wei and Wang. They tested their models for ranking based on AHP and fuzzy-AHP theory. Several other contributions were recognized [18,118], for example Lee and Kim proposed an 0–1 goal-programming algorithm for selection. Main findings were:

- Contributions of both groups were homogeneously distributed among the Research Types: conceptual, conceptual and empirical, and empirical.
- Little attention has been given to SMEs except for work dealing with multi-sector analysis, which was mainly a case study analysis, hard to conceptualize and generalize.
- In recent years, most ERP system suppliers have increased their focus on SMEs but contributions, especially for small enterprises, are still limited.
- Smaller firms that are very dependent on large companies, sill be forced to using ERP packages to stay compatible with larger organisations' supply chains [35].

5.2.1.2. ERP implementation. Another section of the ERP literature deals with the implementation field [76,93]. The approaches can be divided in three arts: identification of critical success/un-success factors, design of structured implementation standard procedures and techniques, and the analysis of a specific CSF and deployment of resolving actions.

Somers and Nelson, using an information theory approach, presented problems related to identification of key players and critical activities during ERP project life cycle. Al-Mashari et al. [6] presented a taxonomy of the critical success factors in the implementation process based on a literature review.

Al-Mashari and Zairi [5], Markus et al. and Parr and Shanks [104] proposed models of ERP implementation in order to gain a deeper understanding of the process and provide guidelines for successful implementation. Al-Mashari and Zairi, for example, suggested an integrative framework for SAP R/3 implementation. Their framework was based on the premise that an effective deployment of SAP R/3 was primarily determined by the extent to which certain key elements, such as the business case, implementation strategy, change management, and BPR, were considered and fully integrated.

Sarker and Lee examined, using a case study approach, the role of three key social enablers: strong and committed leadership, open and honest communication, and a balanced and empowered implementation team. Koch [75] discussed the role of BPR in ERP implementation, while Willis and Willis-Brown [164] considered legacy system management and Aladwani [2] discussed change management impact on success.

This area is complex, however most contributions are related to CSF identification, generally they belong to a multi-sector perspective and rarely distinguish context specific models or problem solving approaches, especially for small enterprises.

5.2.1.3. Risk management and general ERP project section. Contributions are limited and concerned with organizational and business ERP impact or risk assessment models from a multi-sector perspective.

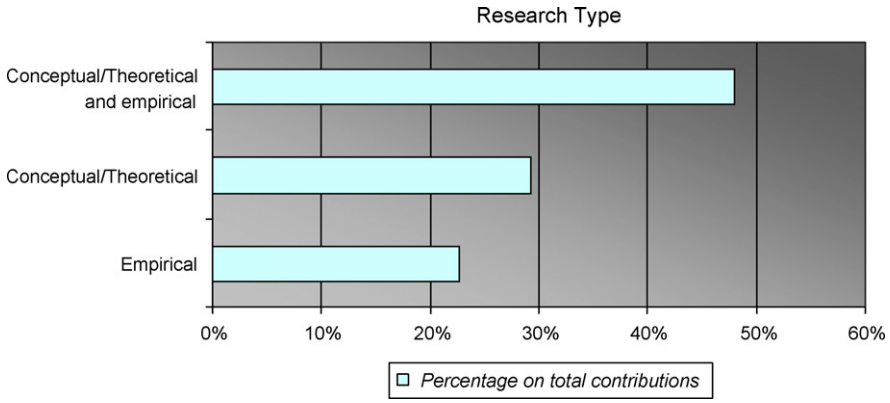

Fig. 8. Research type—analysis of contributions.

ERP project contributions are mostly linked to discussion of strategic meanings and impact of ERP systems on business, SCM design, organization and IT strategy. Beard and Sumner [21], for example, explored strategic advantages viewing ERP system from the resource based perspective, Wang and Chen [158] investigated the relationships between various governance mechanisms and their capacity to reduce project risk.

In risk management, Huang et al. [63] used a Delphi method to identify potential ERP project risk factors and an AHP-based framework to prioritize them, while Zafiropoulos et al. presented a risk management application for modelling, optimal adaptation and implementation of an ERP system. Articles proposing specific risk treatment strategies and techniques were very limited, and there were no contributions on SMEs.

With an exception for specific approaches for SLC implemented by big vendors, a lack of contributions dealing with causal connection between risk factors was found.

5.3. Second dimension—type and methodology

Analyzing data from the type and methodology point of view and considering globally contributions, showed that each field was characterized by mix of conceptual and empirical approaches with a general orientation on a multi-sector analysis and prescriptive aim (Fig. 8).

The smaller number of articles in other classes was probably linked to the attitude of researchers to develop a conceptual model and follow it up with empirical testing using a survey methodology, business case, interview, simulation, etc.

5.4. Risk factors analysis—life cycle

In order to complete a multiple perspective classification (Fig. 3), risk factors identified in the literature were analyzed and homogenized, trying to systematize the different views and interpretations of various authors. The total number of recurrences of the

Table 2
Top 10 risk factors

Risk ID	Risk factor	Total number of recurrences[a]	Frequency rate[b]	Manifestation life cycle phase
R1	Inadequate ERP selection	36	✔✔✔	Concept/selection
R18	Ineffective strategic thinking and planning strategic	31	✔✔✔	Concept/strategic planning
R10	Ineffective project management techniques	27	✔✔	Implementation/deployment
R9	Bad managerial conduction	24	✔✔	Concept/strategic planning
R11	Inadequate change management	24	✔✔	Implementation/integration
R6	Inadequate training and instruction	24	✔✔	Implementation/integration
R2	Poor project team skills	23	✔✔	Concept/selection
R8	Inadequate BPR	22	✔✔	Concept/strategic planning
R3	Low top management involvement	20	✔✔	Concept/strategic planning
R5	Low key user involvement	19	✔✔	Concept/selection

[a] The total recurrence number of a risk factor is calculated in Appendix B.
[b] The frequency rate is associated to the total recurrence number in Appendix C.

risk factors were computed to provide determine their rank by total frequency rate.

In Table 2 a top 10 card with most frequent risk factors is given. According to literature, the most researched (top 5) risk factors were: inadequate ERP selection, ineffective strategic thinking and planning, ineffective project management techniques, bad managerial conduction, and inadequate change management. In this, the selection process and strategic organization fitting is marginally linked to the technological dimension, while the other factors are more related to managerial aspects.

It appears that the first and second risk factor have been keenly studied. The ERP selection areas is largely populated with ''strategic thinking and planning'' presented in almost 40% of the papers analyzed. Moreover, it is important to note that despite of the great importance reserved to factors linked to project management and change management areas (R10, R11, are respectively the 3rd and 5th risk factor), only a few articles dealt with them.

Finally the top 10 risk factors were analyzed in order to provide a scheme showing their positioning in the ERP life cycle (see Table 2). A general scheme of risk factor impact was developed to give show the priority and importance of risk identification and treatment in the introduction process. Except for R6 and R11, risk factors occur early and have a pervasive impact during all the ERP project life cycle.

6. Conclusion

An ERP implementation is not merely a ''computer project'', it is strategic and must be approached as such. ERP systems are integrated applications with an impact on the entire organization.

We have presented a review of recent work on ERP systems, investigating risk factors in the ERP life cycle. The different approaches were compared from a risk management point of view to highlight key risk factors and their impact on projects. Literature was further classified in order to address and analyze each risk factor.

Appendix A

See Table A.1.

Table A.1
Articles and risk factors analysis

No.	Research type and methodology	Research aim and sector	Research contents	Risk factors	Reference source
1.	Conceptual and empirical prescriptive	Risk management MS	Risk identification and treatment in IT: literature review + interview	1, 2, 4, 5, 6, 10, 11, 13, 14, 15, 16, 17	[17]
2.	Empirical descriptive	Risk management MS	Identification by Delphi method, prioritization by AHP framework	1, 2, 3, 4, 5, 6, 8, 9, 10, 11, 12, 13, 15, 16, 17, 18	[63]
3.	Conceptual and empirical prescriptive	Risk management S-LC	Literature review + case study	1, 3, 4, 5, 6, 9, 10, 11, 12, 15, 16, 17, 18	[88]
4.	Conceptual prescriptive	Risk management MS	RM tool development	10	[174]
5.	Conceptual and empirical prescriptive	ERP selection S-LC	AHP model + case study	1	[160]
6.	Conceptual and empirical prescriptive	ERP selection S-LC	Fuzzy AHP + case study	1	[161]
7.	Conceptual and empirical prescriptive	ERP implementation S-LC	OPM + case study	1, 8, 13	[132]
8.	Conceptual and empirical prescriptive	ERP implementation MS	Literature analysis + survey	1, 2, 3, 4, 5, 6, 8, 9, 10, 11, 12, 13, 15, 16, 17, 18	[137]
9.	Conceptual and empirical prescriptive	ERP selection MS	Criteria in selection + AHP	1	[145]
10	Empirical descriptive	ERP selection MS	Buying process a + case study	1	[152]
11.	Conceptual and empirical prescriptive	ERP implementation MS	Team skills	2	[153]

Table A.1 (*Continued*)

No.	Research type and methodology	Research aim and sector	Research contents	Risk factors	Reference source
12.	Conceptual prescriptive	ERP selection MS	0–1 goal programming and analytic network process + example	1	[81]
13.	Conceptual and empirical prescriptive	ERP selection S-LC	Factor identification + survey	1	[19]
14.	Empirical descriptive	ERP selection MS	Selection processes in middle and large companies	1	[23]
15.	Empirical descriptive	ERP selection S-LC	Case study	1	[154]
16.	Empirical descriptive	ERP selection MS	Survey	1	[49]
17.	Conceptual prescriptive	ERP selection MS	Selection factor	1	[113]
18.	Conceptual and empirical prescriptive	ERP selection MS	Literature review + questionnaires	1	[29]
19.	Conceptual prescriptive	ERP selection MS	Strategic selection factors	1, 18	[123]
20.	Conceptual descriptive	IT/ERP project MS	Literature review on ERP system	1, 2, 3, 4, 5, 6, 10, 14, 15, 16, 18	[52]
21.	Conceptual and empirical prescriptive	ERP implementation MS	BPR + case study	8	[75]
22.	Conceptual and empirical descriptive	ERP implementation S-LC	Impact of culture on ERP implementation	9, 11, 14	[76]
23.	Conceptual prescriptive	ERP implementation MS	Misalignment	2, 3, 4, 5, 8, 10, 11, 12, 14, 15, 16, 18	[134]
24.	Conceptual prescriptive	ERP implementation MS	CSF + case study	7	[91]
25.	Conceptual and empirical prescriptive	ERP implementation MS	Cultural dimension of ERP	5, 9, 11, 14, 18	[26]
26.	Conceptual prescriptive	ERP implementation MS	CSF + case study	7	[50]
27.	Conceptual and empirical prescriptive	ERP implementation MS	CSF + case study	2, 4, 14	[122]
28.	Conceptual prescriptive	ERP implementation S-SMEs	Agent model to manage ERP development	10	[65]
29.	Conceptual and empirical prescriptive	ERP implementation MS	SAP R/3 implementation	2, 4, 8, 9, 10, 11, 15, 16, 18	[4]
30.	Conceptual descriptive	IT/ERP project MS	Strategic advantage	18	[21]
31.	Conceptual and empirical descriptive	IT/ERP project MS	ERP role	3, 5, 6, 7, 11	[156]
32.	Conceptual and empirical prescriptive	ERP implementation MS	CSF + case study	1, 2, 3, 6, 7, 9, 10, 11, 12, 14, 18	[151]
33.	Conceptual and empirical prescriptive	ERP implementation MS	CSF + survey	1, 8	[62]
34.	Empirical descriptive	ERP implementation MS	CSF + survey	1, 3, 6, 8, 10, 13, 15, 16, 18	[46]
35.	Empirical prescriptive	ERP implementation S-LC	CSF + stakeholders analysis	3, 5, 9	[27]
36.	Empirical prescriptive	ERP implementation S-LC	Deployment + case study	1, 2, 5, 6, 9, 15	[22]
37.	Empirical prescriptive	ERP implementation MS	CSF + case study	1, 2, 3, 4, 5, 6, 8, 9, 10, 11, 13, 15, 16, 18	[97]
38.	Conceptual and empirical prescriptive	ERP implementation S-LC	CSF + case study	2, 3, 5, 6, 7, 8, 9, 11, 13, 15, 17, 18	[172]
39.	Conceptual prescriptive	ERP implementation MS	Training planning	6	[37]
40.	Conceptual descriptive	ERP implementation MS	CSF taxonomy	1, 3, 4, 6, 8, 9, 10, 11, 12, 14, 18	[6]
41.	Conceptual prescriptive	IT/ERP project MS	Business modelling + case study	1, 8	[126]
42.	Conceptual and empirical prescriptive	ERP implementation S-SMEs	ERP SME vendor perspective	1, 8, 18	[83]
43.	Conceptual prescriptive	ERP implementation MS	Strategy and context analysis	1, 18	[44]
44.	Conceptual prescriptive	ERP selection MS	CSF	1, 18	[31]
45.	Empirical descriptive	ERP implementation MS	CSF + case study	1, 2, 3, 4, 6, 8, 10, 18	[98]
46.	Conceptual and empirical prescriptive	IT/ERP project MS	Survey	9,10	[3]

Table A.1 (*Continued*)

No.	Research type and methodology	Research aim and sector	Research contents	Risk factors	Reference source
47.	Conceptual prescriptive	ERP implementation MS	CSF	2, 3, 4, 5, 8, 9, 10, 11, 12, 15, 18	[99]
48.	Empirical descriptive	IT/ERP project MS	ERP strategy	18	[64]
49.	Empirical descriptive	IT/ERP project MS	IT in global supply chain	18	[95]
50.	Conceptual prescriptive	ERP implementation MS	Legacy system management	12, 18	[164]
51.	Empirical prescriptive	Risk management S-LC	FMEA application on ERP	10	[170]
52.	Conceptual prescriptive	ERP implementation MS	Change management	11	[2]
53.	Conceptual and empirical descriptive	IT/ERP project MS	CAD CAM and ERP integration	1, 3, 4, 5, 6	[135]
54.	Empirical descriptive	ERP implementation S-LC	CSF	3, 4, 6, 15, 18	[56]
55.	Conceptual and empirical descriptive	ERP implementation MS	CSF + case study	1, 2, 3, 5, 6, 8, 9, 11, 13, 15, 16	[69]
56.	Conceptual and empirical descriptive	ERP implementation S-SMEs	CSF	1, 15, 16, 18	[115]
57.	Empirical descriptive	ERP implementation MS	Structured implementation approach	10	[104]
58.	Conceptual and empirical descriptive	ERP implementation MS	CSF	3, 5, 6, 8, 9, 10, 15, 16, 17	[175]
59.	Empirical descriptive	ERP implementation S-SMEs	CSF	1, 2, 3, 4, 6, 8, 11, 18	[93]
60.	Empirical descriptive	ERP implementation S-LC	Implementation case study	2, 3, 8, 10, 11, 12, 13, 18	[61]
61.	Conceptual and empirical descriptive	ERP implementation MS	CSF + survey	1, 2, 3, 4, 5, 6, 8, 9, 10, 11, 12, 13, 17, 18	[136]
62.	Conceptual descriptive	ERP implementation MS	CSF	1, 2, 4, 5, 10, 11	[54]
63.	Conceptual and empirical prescriptive	ERP implementation S-LC	Disciplines of implementation	2, 6, 9, 11, 12, 18	[80]
64.	Conceptual descriptive	IT/ERP project MS	Functionality	5	[125]
65.	Conceptual and empirical descriptive	ERP implementation MS	CSF	2, 5, 6, 9, 10, 15, 16	[167]
66.	Conceptual and empirical prescriptive	ERP project MS	Governance	9, 14	[158]
67.	Conceptual and empirical prescriptive	ERP implementation S-LC	CSF + case study	4, 6, 8, 9, 10, 11, 12	[173]
68.	Conceptual and empirical prescriptive	ERP implementation MS	CSF + case study	2, 4, 6, 9, 10, 11, 14, 18	[96]
69.	Conceptual and empirical prescriptive	ERP implementation MS	ERP failure in China	1, 2, 8, 9, 14, 17	[169]
70.	Empirical descriptive	IT/ERP project MS	Organization ERP's strategy	18	[51]
71.	Conceptual and empirical prescriptive	IT/ERP project S-LC	ERP maintenance + case study	15, 16	[102]
72.	Conceptual and empirical descriptive	ERP implementation MS	Environment of ERP introduction	18, 19	[171]
73.	Conceptual and empirical descriptive	ERP implementation MS	Organization size + survey	7	[79]
74.	Empirical descriptive	ERP implementation S-LC	Continuous BPR project + case study	2, 9, 11	[100]
75.	Conceptual and empirical prescriptive	Risk management S-LC	Risk factor identification technique	10	[82]

Appendix B

See Table B.1.

Table B.1
Risk factor frequency for each researched area

ID risk factor	ID[a] class															
	A1	A3	A4	A5	A6	A9	B4	B6	B9	C6	C9	C12	D3	D5	D6	D12
R1	1	3		1	2	1	1	1		2		1	4		1	1
R2				2	2	1	1	1		1		1			1	
R3			1	1	3	1	1	1		1		1			1	
R4			1	1	1	1		1		2		1			1	
R5						1	2	1		1		2			1	
R6			1	1	2	1	1	1		1		1			1	
R7															2	
R8				1	3	1		1		1					2	1
R9				1		1	2	1		1					1	
R10					4	1		1	1	2	1	1		1	2	
R11				2	1	1		1		2					3	
R12					1	1				1					2	
R13					2	1		1								
R14										1		1				
R15			1		1	1	1	1				1			2	
R16					1	1		1				1			1	
R17						1										
R18			1	1	3	2		1		1	1	1	2		4	2
R19																

ID risk factor	ID[a] class													
	E4	E5	E6	E12	F1	F3	F4	F5	F6	F7	F9	F12	Total	Freq. Rate
R1		1	2	1	3	2	1	1	4	1	1		36	✓ ✓ ✓
R2			3				2		7		1		23	✓ ✓
R3			3	2			1		2	1			20	✓ ✓
R4			1	1			1		4	1	1		18	✓ ✓
R5			4	2			1		2	1	1		19	✓ ✓
R6			4	2			3		3	1	1		24	✓ ✓
R7			1	1			1		1				6	✓
R8			3				3	1	5				22	✓ ✓
R9	1		4				3		6	1		2	24	✓ ✓
R10			4				1		4	2	1	1	27	✓ ✓
R11	1		2	1			3		5	1	1		24	✓ ✓
R12			1				2		2	1			11	✓
R13			2				2		1		1		10	✓
R14	1								5		1	1	10	✓
R15		1	3				1		2	2	1		18	✓ ✓
R16		1	3						2	2	1		14	✓
R17			2				1		2	1	1		8	✓
R18		1	2				2	1	5	1			31	✓ ✓ ✓
R19			1										1	✓

[a] ID class: Each column matches lines and columns of above table (e.g. column A1 of Table 2 matches line A and column 1 of Table 1).

Appendix C

See Tables C.1 and C.2.

Table C.1
Risk factors identification and rate

Risk ID	Risk factor	Frequency rate
R1	Inadequate ERP selection	✓✓✓
R2	Poor project team skills	✓✓
R3	Low top management involvement	✓✓
R4	Ineffective communication system	✓✓
R5	Low key user involvement	✓✓
R6	Inadequate training and instruction	✓✓
R7	Complex architecture and high number of implementation modules	✓
R8	Inadequate BPR	✓✓
R9	Bad managerial conduction	✓✓
R10	Ineffective project management techniques	✓✓
R11	Inadequate change management	✓✓
R12	Inadequate legacy system management	✓
R13	Ineffective consulting services experiences	✓
R14	Poor leadership	✓
R15	Inadequate IT system issues	✓✓
R16	Inadequate IT system manutenibility	✓
R17	Inadequate IT Supplier stability and performances	✓
R18	Ineffective strategic thinking and planning Strategic	✓✓✓
R19	Inadequate financial management	✓

Table C.2
Rating

ID	Rate degree	Value
✓	Low	<15
✓✓	Medium	>15 and <30
✓✓✓	High	>30

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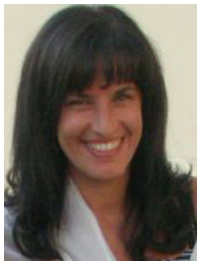

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