2011

A NEW PERSPECTIVE FOR ERP PROJECTS: MODELLING RISK FACTOR INTERDEPENDENCE

Davide Aloini
University of Pisa,, davide.aloni@dsea.unipi.it

Riccardo Dulmin
University of Pisa,, riccardo.dulmin@dsea.unipi.it

Valeria Mininno
University of Pisa, valeria.mininno@dsea.unipi.it

A NEW PERSPECTIVE FOR ERP PROJECTS: MODELLING RISK FACTOR INTERDEPENDENCE

Aloini, Davide, University of Pisa, Largo Lucio Lazzarino 1, 56100 Pisa, IT, davide.aloni@dsea.unipi.it

Dulmin, Riccardo, University of Pisa, Largo Lucio Lazzarino 1, 56100 Pisa, IT, riccardo.dulmin@dsea.unipi.it

Mininno, Valeria, University of Pisa, Largo Lucio Lazzarino 1, 56100 Pisa, IT, valeria.mininno@dsea.unipi.it

Abstract

Risk-based management of Enterprise Resource Planning (ERP) projects has gained great attention in the related literature of the last decade. Risk management has been proposed as a potential way to deal with the ERP project complexity and improve the final effectiveness of the implementation process. Nevertheless, to approach an effective risk management process is an ambitious task for this kind of projects: in particular assessing the risks of ERP projects is a very complex problem. Due to the nature of the risk factors, in fact, strict interconnections and indirect effects on the project performance often occur; unfortunately implications of interdependency are usually underestimated because they are difficult to include in any risk assessment logic.

This work shows how Colored Petri Nets (CPN) can be used to model and assess risk in ERP projects in order to deal with the problem of risk factor interdependences. The technique is presented through an application to a real case study. Findings show the impact of interdependence and indirect links among the risk factors for a valuable ranking of risks. Furthermore, results support the utility of CPN for risk factor modeling since it allows a more structured and systematic analysis of risk factors and supports the planning for more accurate risk management actions.

Keywords: ERP projects, Risk, Interdependence, Assessment, Petri Nets.

1 INTRODUCTION

Enterprise Resource Planning (ERP) programs are integrated computer-based systems used to manage company-wise business processes. Their aim is to support the flow of information between all the business functions inside/outside the boundaries of the organization (Bidgoli & Hossein, 2004).

Implementing ERP software is usually a complex and risky project which usually imposes significant changes on business processes and work practices (Mandal & Gunasekaran, 2003). Many factors contribute to the success of the introduction project (Wright & Wright, 2001; Aloini et al., 2007) but just a few of them are technology-related factors. Many others belong to different areas such as strategic planning, project management, communication and finance.

Risk Management is considered as a possible way to support the introduction of complex information systems. Several authors (Wright & Wright, 2001; Kumar 2002; Tatsiopoulos et al., 2003; Aloini et al., 2007) studied Risk Management approaches in ERP field in order to support the implementation project and improve the success rate of these projects. According to their perspective, Risk Management in ERP projects can enable to achieve an appropriate management of all the sources of uncertainty within the project.

The main objective of this work is to develop a quantitative approach using CPNs to model ERP project risks and quantify project vulnerability for each risk factor including their interdependencies which is often a neglected issue in this topic. We show how the use of CPNs allows to include interdependences and indirect effect causalities into the final Risk Evaluation algorithm. This is a major benefit in the field of ERP Risk Management since it enables the elaboration of new quali-quantitative risk indexes for project control and governance.

2 RESEARCH FRAMEWORK

The ERP project life cycle goes through a number of typical steps. The following Implementation Roadmap is one of the most used framework to model the project life cycle both in literature and in business practice (figure 1) (for further details see Monk and B. Wagner, 2006).

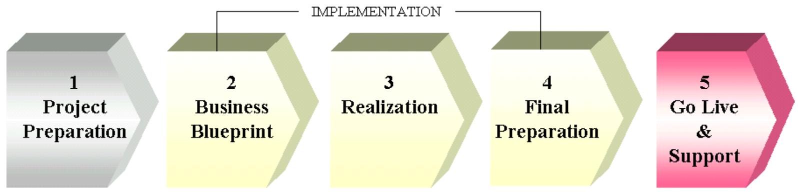

Figure 1. ERP Project life cycle (SAP Implementation Roadmap)

Factors affecting an ERP implementation project spread around all the project phases (Al-Mashari et. al., 2003). Many empirical researches have focused the attention on their identification and classification (Sumner, 2000; Tatsiopoulos et al., 2003; Wright & Wright, 2002; Scott & Vessey, 2002a; Yang et al., 2006). In a previous work, Aloini et al. (2007) reviewed a large number of articles about ERP system implementation from a Risk Management perspective identifying 19 risk factors and 10 project effects (figure 2) which we mainly refer to also in this work (due to the space limits we refer to the previous paper for a broader debate about the risk factors).

Applying a Risk Management process to ERP projects has a strategic value since it allow us to formulate appropriate risk treatment strategies and actions in the early phase of the project. This can be really critical for a successful implementation.

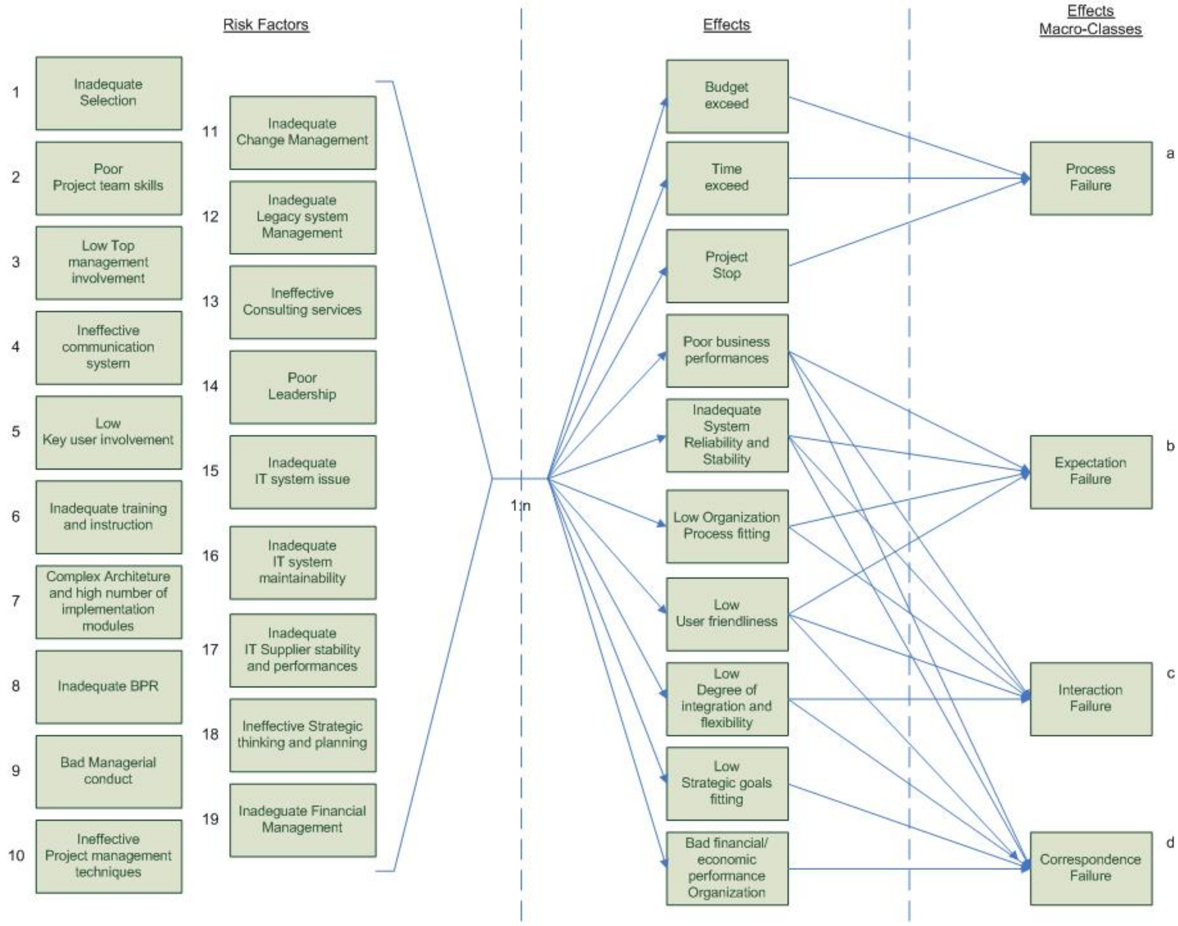

Figure 2. Risk factors, effects and project failure macro-classes (Aloini et al., 2007).

Formal, structured Risk Assessment methods are rarely applied to Risk Management in complex IT projects, such as the introduction of ERP systems. In a specific review on ERP "Risk Management", Aloini et al. (2007) state that most of the contributions concentrate on the Risk Identification and Analysis stages in a rather descriptive fashion, while only a few suggest working models or techniques for the Risk Quantification or for defining appropriate treatment strategies.

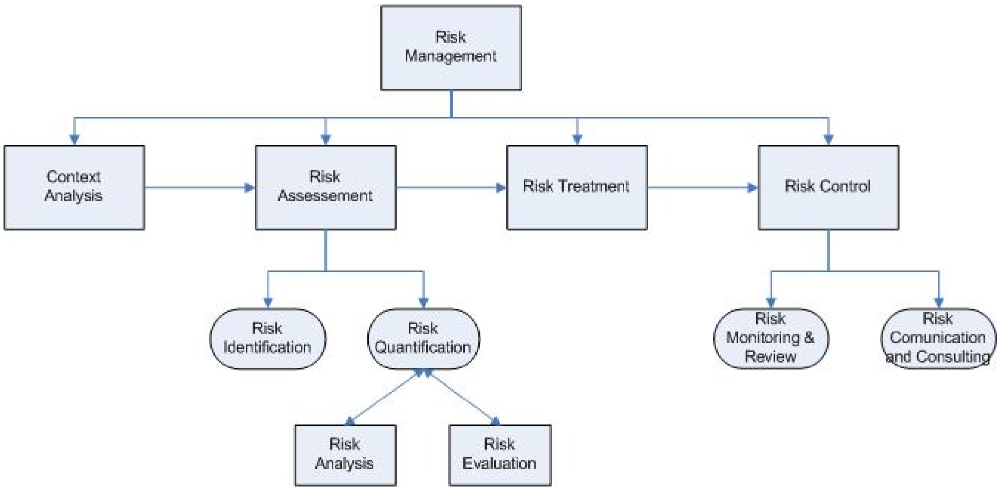

Figure 3. Risk Management framework

Refferring to the above mentioned framework (figure 3), this work deals with the Risk Assessment phase. *Risk Assessment* is a core step of the Risk Management process and usually includes: *Risk Identification* which allows the organization to early determine potential threats (internal and external risk factors) and their impact (effects) on the project success; and *Risk Quantification* which aims to prioritize risk factors according to their risk levels and consists of two main phases: *Risk Analysis and Risk Evaluation.*

3 RESEARCH OBJECTIVE

This work presents an innovative application of Coloured Petri Nets (CPNs) to the Risk Assessment (RA) of an ERP project. It aims to provide a methodology including risk interdependence in the RA process by modeling and analyzing causal relationships among risk factors and between risk factors and effects.

To our best knowledge, this is still a major gap in literature. Chapman and Ward (2002) stated that the most common shortcomings in terms of potential cause of failure in Risk Management are often about a superficial Risk Analysis which misses Risk Interdependence Analysis; this is also valid within the ERP case. The complex structure of an ERP project and the high number of risk factors, in fact, increase the magnitude of risk not only referring to each single factor, but also to the interconnections between them. Such project risks are typically interdependent and, since interdependence does not require proximity, the antecedent to failure may be quite distinct and distant from actual disaster. For these reasons, before any Risk Assessment process, it is primary essential to understand and model risk factors including interdependencies in order to finally obtain a valuable ranking and an effectively guide project Risk Management activities.

The use of CPN technique in the Risk Management process can help us to fill some of previously underpinned gaps in ERP Risk Management research. The work explains how CPNs can provide an effective support for the analysis and quantification of ERP risks. It firstly aims to develop and apply methodologies for a formal and systemic Risk Management to ERP projects and then to overcome a number of limitations of the current approaches including interdependence in the RM process.

4 RESEARCH METHODOLOGY

CPNs can provide a useful support for the Risk Assessment process in order to assess the risk level of each risk factor correctly. The risk structure of an ERP project can be represented as a very complex net. As a consequence of the strong risk factor interdependence, a domino effect is likely to occur: the occurrence of a specific event in an early stage of the project could result in new emerging risk factors. For instance, a low commitment by the Top Management has usually an indirect effect on the involvement of the Key Users. As well, an inadequate selection of the project team skills can lead to wrong or underperforming Business Process Reengineering activities or also ineffective project management; finally, also communication problems can occur.

As we stated before, this condition makes it essential to understand risk factor interdependencies and to include them in the Risk Assessment process. Unfortunately, this is often hard to do. In fact, it is difficult to include dependence in the occurrence probabilities when the probability and the associated consequences are not directly measurable. Moreover, in most cases, these issues are not estimated from statistically meaningful data but rely mainly on experts' opinions.

Due to their flexibility and computational capability, CPNs can offer a great support in modelling risk factors. As a result, CPNs can provide interesting information on safety and reliability of the modelled system. Although the first applications of Petri Nets were mainly in Computer System and Communication area, later they have been extended to other fields such as Risk Management (e.g. risk, accident and system modeling) and SCM (Liu et al., 2007). Their large calculation capabilities, in fact, achieve to overcome a number of limitations of traditional methods in modeling complex systems (e.g. for the analysis of linear chain of events, branch or multilinear events, etc.).

Since their introduction, Petri nets have shown their usefulness for many practical applications in different industries/research domains (David and Alla, 2000). Most of the benefits, compared with other system modelling techniques, are generally known in literature. Among the most advanced approaches developed in accident risk of safety-critical operations literature, for example, Labeau et al. (1994) make use of the compositional specification power of Petri nets to instantiate a model, and subsequently use stochastic analysis and Monte Carlo simulation to evaluate the model. Chang and Luh (1997) and Lin and Lee (1997) argue that net models with individual tokens are useful especially for modelling different types of resources involved. Jensen (1997) presents a long list of advantages of CPNs. Many of them are valid in general for other kinds of high-level Petri Nets.

However, the reasons that make CPNs useful for ERP Risk Assessment are:

- *High flexibility in dynamic system modelling*: solving concurrency and interleaving problems, CPNs achieve to easily model complex-interconnected systems. CPNs also allow us to differentiate the system behaviour according to different classes of events. Thus, the system modelling is more effective and flexible.
- *Large number of formal analysis methods*, which are potentially useful in a Risk Assessment process: occurrence graphs, calculation and interpretation of system invariants, reduction and checking of structural properties.

Referring to Risk Assessment, four approaches are suitable in the use of Coloured/Petri nets:

- *System modelling*. Petri Nets are used to model the behaviour of the system (e.g. a manufacturing process, a project, a software system etc.)
- *Accident modelling*. Petri Nets model the accident sequence of a system. Combinations of events are systematically explored to get safety data.
- *State of space modelling*. Petri nets are used for a calculation process more than a Risk Analysis.
- *Fault and event three modelling*. It translates a known sequence of events (since the Risk Analysis has to be previously assessed) into a Petri net model.

In this paper the *accident modelling* approach is chosen to achieve Risk Assessment of an ERP project. In such a context, the high variability of possible project configurations makes modelling the risks more effective than modelling the project activities. The CPN extension is here adopted in order to mark and track each risk factor and its impact on effects. According to this research perspective, using CPNs in Risk Management for IS project is a rather new topic. To our best knowledge Petri Nets application in IS field are mainly oriented to system requirement definition and/or optimization. Project management, performance and Risk Management issues are not analyzed conjointly in IS field and risks are usually addressed from an economic-financial perspective or from a software development point of view rather than from a project view.

5 CASE STUDY

The methodology was applied in an explorative attempt to support the Risk Assessment in a real ERP project. The case study regards a multinational company operating in the field of Electric Power Systems and Alternative Energy Systems. In recent decades the company, one of the world's leading manufacturers of power-conversion equipment for the telecommunications, networking, and technology markets, has undergone impressive expansion due to core business growth and the penetration of new markets, including entry into new application fields fostered by several acquisitions. Therefore, an “IT Re-alignment” project was launched in order to homogenize the information and procedural structures of the new plants with the existing corporate ones. This project also included the implementation of a new ERP system (Oracle).

The case study develops according to the following 3 main steps: *Data collection* (which includes the identification of risk factors/effects and the detection of the links between risk factors and effects)*; Modeling the risk net; Simulations and Analysis of results.*

5.1 Data collection

In order to identify the major project risks to be included in the model, the phase in which they potentially occur and their related effects, we conducted a series of interviews and meetings with the implementation project team of the company. Some members of the implementation team (Table 1) were selected and a structured interview format was defined and followed for each one. A Delphi-based process was also adopted in order to achieve convergence of the experts' judgments.

ID.	Position	Role in the ERP project team	Time with company (years)	Number of previous ERP project
1.	Senior Production Manager	Project Manager	More than 10 years	2
2.	Financial Manager	Financial Analyst	Less than 1 year	6
3.	IT Manager	Super User	Less than 1 year	6
4.	Traffic Manager	Super User	Less than 1 year	0
5.	Chief Accountant	Super User	5 years	0
6.	Sourcing Manager	Super User	5 years	
7.	Planning	Super User	6 years	0
8.	Manufacturing Engineering Manager	Super User	6 years	1
9.	Quality Manager	Super User	More than 10 years	1
10.	Production Planner	Super User	Less than 1 year	0

Table 1. Interviewed subjects

Each participant was asked to identify the experienced risk factors among a pre-defined list (figure 2) and to indicate the potential phase of occurrence. The same procedure was followed to identify the risk effects (figure 2). Respondents validated and agreed with all the risk factors reported in the list. They also indicated the related project phase. Table 2 shows the enabled risk factors according to the project phase.

Phase 1	Phase 2	Phase 3	Phase 4	Phase 5
R1	-	-	-	-
R2	R2	R2	-	-
R3	R3	R3	R3	-
R4	R4	-	R4	-
-	R5	R5	R5	-
-	R6	R6	R6	-
R7	R7	R7	R7	R7
-	R8	R8	R8	-
R9	R9	R9	R9	R9
R10	R10	R10	R10	-
-	R11	R11	R11	R11
-	R12	R12	R12	R12
R13	R13	R13	R13	R13
R14	R14	R14	R14	R14
R15	R15	R15	-	-
-	-	R16	-	R16
-	-	R17	-	R17
R18	R18	R18	-	-
R19	R19	R19	-	-

Table 2. Enabled risk factors and project stages

We also asked the project team to qualitatively assess the strength of inter-connections among the risk factors and between the risk factors and effects. Respondents were asked to quantify the relationships by a weight from 1 (very low) to 7 (very high). Then, the judgments of the experts were elaborated in order to define a unique map of relationships and the process was reiterated until a consensus was reached and all problems solved.

5.2 Modeling the risk net

Information gathered by respondents was used to model the risk network of the project by a CPN. Figure 4 illustrates the theoretical model of the project risk net. We used different types of places and transitions:

- Phase places (F1, ..., F5) define the current project phase and enable risk places. When a phase place is running, the enabled (linked) risk can receive a token. The phase places are synchronized and the phase duration are fixed according to the number of the available tokens.

- Risk places (R1, ..., R19) represent the occurrence of a risk factor. We modelled each risk factor as a state place with multiple potential inputs and outputs. A risk place can get two kinds of inputs: one from the phase place (activation token) otherwise from another risk place of the current phase. It can finally generate two kinds of output: the first is a transition risk-risk which activates another risk factor as previously stated, the second is a risk-effect transition which produces a direct impact on the project performance. Depending on this, a risk factor can get a direct or an indirect effect on the project performance. The indirect effect is caused and mediated by other risk factors.

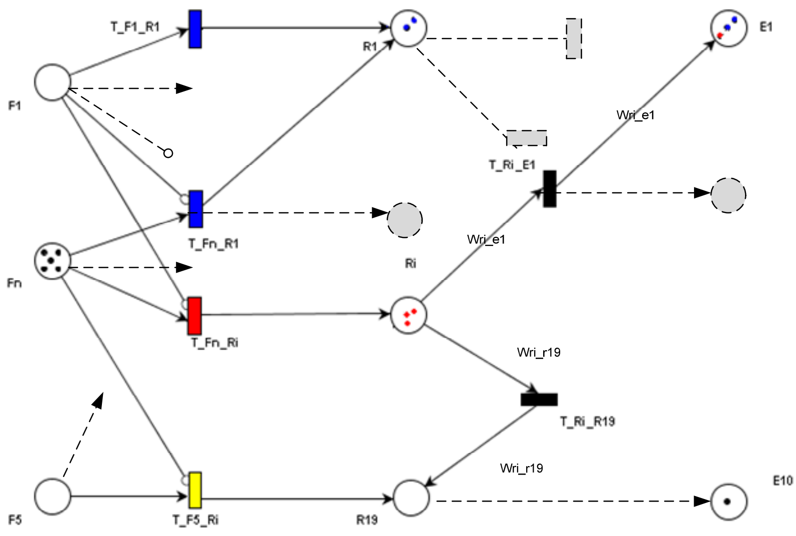

Figure 4. Theoretical model of the project risk net

Our main assumption is that in each phase the enabled risk factors have the same probability to occur. However this is not a main concern since the aim of the work is to investigate interdependences and to include interdependence and indirect effects into the final Risk Evaluation algorithm.

- Effect places (E1, ..., E10) represent the occurrence of a risk effect on the project. The effect place counts the number of tokens which arrive to the place. It also takes into account the colour of each token. They provide valuable information to synthesize the desired risk measures.

- Transitions T_Fn_Rn activate risk factors during a specific project phase and assign a colour to the risk token marking the risk factors. When a colour is assigned it never changes.

As we stated before, a risk place can generate two kinds of output transitions: Transitions T_Rn_Rn and T_Rn_En.

- Transitions T_Rn_Rn model risk factor inter-connections.

- Transitions T_Rn_En model risk factors-effects causal links.

These transitions have not the same probability to occur. On the contrary, they take into account the qualitative judgment of experts about the risk causality (see appendix A). The higher the strength of the causal link, the lower the number of token which are needed to activate the transition. Finally, the occurrence of a transition does not distinguish about the token colour. The final model consists of 38 places (drawn as circle), 323 transitions (drawn as rectangular boxes), and a number of directed arcs connecting places and transitions. Places can be marked with one or more tokens, and each token has a label (colour) indicating the risk. Transitions, instead, are branded by specific weights which define how many tokens for each colour are necessary to occur. In order to implement the model and perform the simulations we selected the package “CPN tool”. CPN Tool is a software for editing, simulating and analysing untimed and timed, hierarchical CPNs (CPN2000 project, University of Aarhus). It combines powerful functionalities with a flexible user interface, containing improved interaction techniques, as well as different types of graphical feedback which keep the user informed of the status of syntax checks, simulations, etc. (Ratzer et al., 2003).

5.3 Simulation and Analysis of results

A Petri net simulation analysis was conducted to evaluate a ranking of the project risk factors. Three scenarios (S1, S2, S3) were set according to a different length of the project phases in order (1) to consider the impact of different phase durations into the risk model, (2) to test model sensitivity to the phase length and (3) to achieve convergence. One thousand independent replications for each scenario were performed during the simulation. In each run, the risk project net was loaded with a number of tokens which is proportional to the duration of each phase. Phase were synchronized, as well. Each run produced one observation of the token distribution in the different risk effects. According to the three scenarios, the occurrence frequency of the 19 risk factors was observed for each class of effect and a final ranking was elaborated.

Findings reveal the potential significant impact of risk factor interdependence on the hazard evaluation. As usually happens in many Risk Assessment methods, event frequency was used to calculate the top event occurrence. Event frequency was computed in order to provide a final ranking of the risk factors and enable the calculation of dependence indexes to be included in the global Risk Assessment process. This is necessary in order to provide a complete and effective evaluation of risks, for example considering risk factor interdependence in the RPN evaluation (FMECA Risk Priority Number). For instance, we could modify the FMEA standard RPN index including a proxy indicator of the interdependence between each risk factor and the other ones. This would allow considering risk factor interdependence in the final RPN evaluation.

	Frequency (%)			**Dependence Impact Index**			**Dependence Impact Class**
	S1	**S2**	**S3**	**S1**	**S2**	**S3**	**From 1 to 5**
R7	7.3	7.6	7.5	0.09	0.09	0.08	5
R9	7.1	7.3	7.4	0.08	0.08	0.08	5
R13	6.9	7.1	7.3	0.08	0.08	0.08	5
R14	7.0	7.2	7.3	0.08	0.08	0.08	5
R11	6.1	6.5	6.6	0.07	0.07	0.07	3
R10	5.7	5.9	6.0	0.07	0.07	0.07	3
R3	5.3	5.7	5.8	0.06	0.06	0.06	2
R8	5.0	5.2	5.2	0.06	0.06	0.06	2
R6	4.9	5.0	5.1	0.06	0.06	0.06	2
R5	4.3	4.5	4.6	0.05	0.05	0.05	2
R4	3.7	4.0	4.0	0.04	0.05	0.04	2
R2	3.6	3.7	3.8	0.04	0.04	0.04	2
R15	3.5	3.7	3.8	0.04	0.04	0.04	2
R19	3.6	3.7	3.8	0.04	0.04	0.04	2
R18	3.3	3.5	3.5	0.04	0.04	0.04	2
R16	3.0	3.2	3.3	0.04	0.04	0.04	2
R17	2.9	3.2	3.3	0.03	0.04	0.04	4
R1	1.0	1.0	1.0	0.01	0.01	0.01	1
R12	0.0	0.0	0.0	0.00	0.00	0.00	1

Table 3. Overall risk factors Frequencies, DII and DIC

Table 3 shows the global output for the three scenarios (frequency is computed globally for all the project stages). An overall Dependence Impact Index (DII) is then calculated as a ratio of the risk factor frequency and the sum of frequencies for all the enabled risks. Risk factors were finally clustered according to their dependence risk index into five classes.

The present analysis ranks the risks considering only the impact of interdependence among risk factors and between risk factors and effects for the global project risk, and excluding any other information of the independent occurrence probability of each risk factor and severity of effects.

Despite conclusive indications cannot be achieved since generalization is obviously compromised by the nature of the case study which is mostly demonstrative/explorative, interesting information can be gathered comparing the case study results with evidences from literature. We can notice that the most relevant risks reported in the case study are: R7 (Complex architecture and high number of implementation modules), R9 (Poor managerial conduct), R13 (Ineffective consulting services) and R14 (Poor leadership). These risk factors seem to be the most critical issue in terms of interdependencies. Findings contrasts with CSF-ERP risk related literature (Huang et al., 2004; Zafiropoulos et al., 2005; Aloini et al., 2007). Among the most cited RFs, in fact, we often find: inadequate ERP selection, ineffective strategic thinking and planning, ineffective project management techniques, bad managerial conduct, and inadequate change management (Table 4). It is evident that these factors are not coherent with the actual results of the dependence analysis. However, we cannot affirm that dependence dimension is more relevant/important than the other ones such as the likelihood of occurrence or the severity of effects due to a risk factor. The significant difference between these two class of results over-stresses the importance of considering also the dependence effect in the final risk evaluation since “Dependence” could differently contribute to the final risk ranking and modify the expected output.

ID	**Risk factor**	**Rate**	**Life cycle phase**
R1	Inadequate selection	36	Concept/Selection
R18	Ineffective strategic thinking and planning	31	Concept/Strategic Planning
R10	Ineffective project management techniques	27	Implementation/Deployment
R9	Poor managerial conduct	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

Table 4. Top ten risk factors (source: Aloini et al., 2007)

The following graphs in figure 5 shows measured risk factor frequencies for each project phase. Here, relative frequencies of risk factors are computed taking into consideration tokens which are enabled in each project stage. Partial rankings are sensibly different in each phases. In phase 1 the top risk factor is the Inadequate Selection (R1), in the second phase Ineffective communications system (R4), in the third one Inadequate IT system issue (R15), in phase 4, instead, the most frequent risk factors are Inadequate training and instruction (R8) and Inadequate BPR (R6), as well in phase 5 Poor managerial conduct (R7). Whether not generalizable, this information can be useful to managers in order to differentiate the risk management strategy and the treatment actions according to a specific project phase.

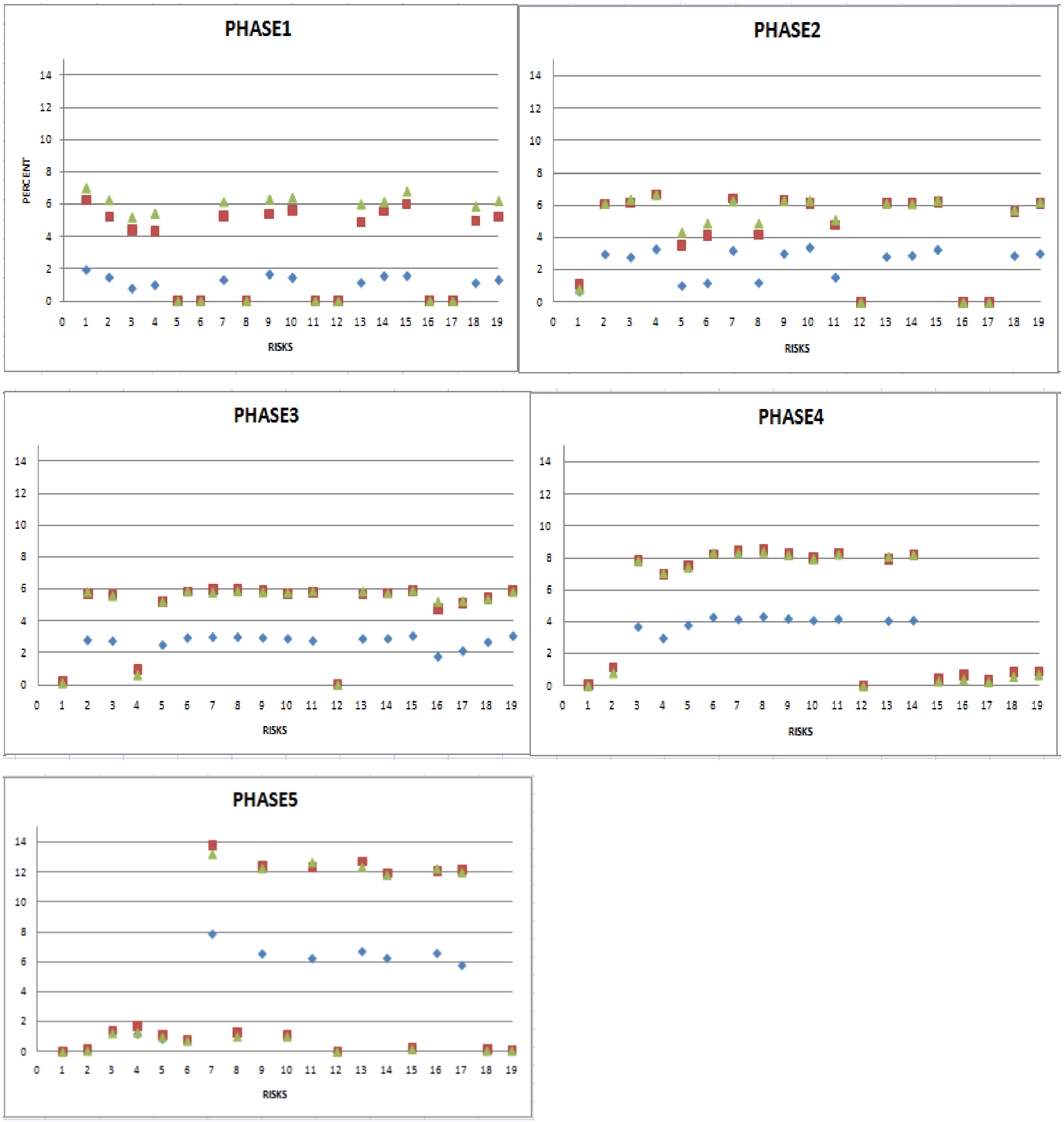

Figure 5. *Measured risk factor frequencies for each project phase.*
(Blue point - S1; Red point –S2; Green point –S3)

Finally, figure 6 shows the partial ranking of the risk factors for each project stage (in the scenario S3). The figure clearly shows that the risk frequency (when a risk becomes evident/manifest and have an effect on the project) significantly increases in the last phase of the project. This is coherent with the effect of interdependence. Since risk factors can enable other risks in the project and the system has its own memory, many risks which has been cumulating during the previous project finally happens during the latest stages of the project (such as phase 5).

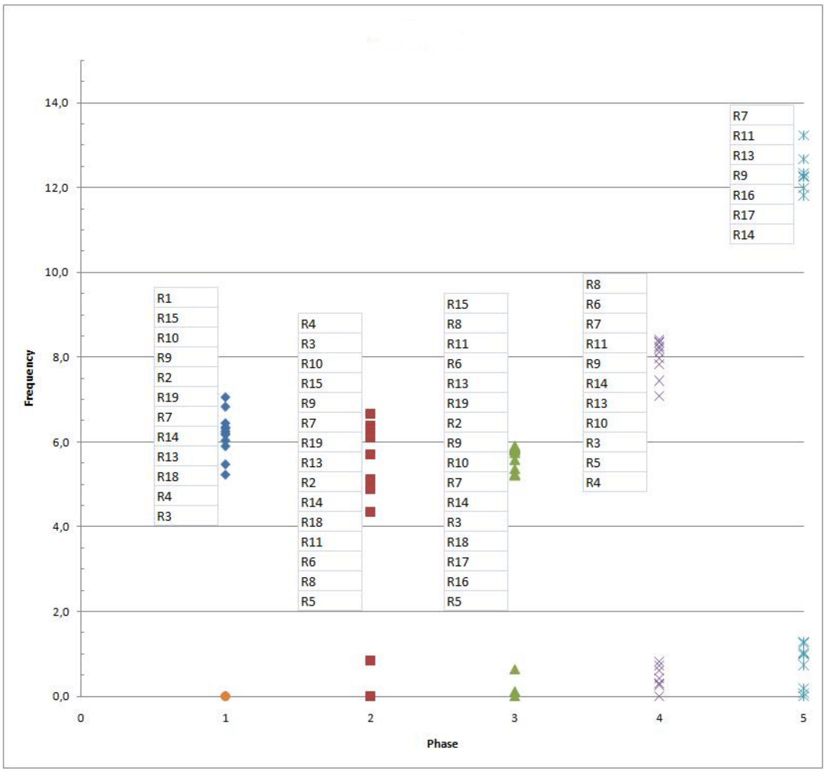

Figure 6. Ranking of the risk factors for each project phase (Scenario S3)

6 CONCLUSION

In this article we presented an innovative approach to obtain a more systematic evaluation of risks within an ERP project. At its heart we used CPN theory to model and structure the relationships among risks factors, and between risk factors and effects, and to convert them to quantitative indexes of dependence. This is a first attempt to apply Petri nets to the Risk Assessment process in this class of projects. Formal Risk Assessment methods, in fact, are rarely applied for Risk Management in complex IT projects such as ERP introduction. The research hints at the advantage of including “risk dependence” in the Risk Evaluation algorithm in order to support managers in Risk Quantification and mitigation activities. It also starts closing an existent gap that exists in ERP Risk Management since contributions in Operational Risk Management which investigate and model risk factors interdependencies are, at our best knowledge, absent in ERP literature. While some (very few) authors, in fact, suggests conceptual relationships between ERP CSF, nobody have tried to model these interdependencies into a broader model of risks to be used in a risk assessments process. The choice of using CPN has got value also in this sense allowing to model a very complex systems (the ERP implantation project). An exploratory case study was also presented to demonstrate the utility and applicability of CPNs in this field. Results support the value of the technique to synthesize dependence indexes and show the strengths of the technique in risk factor modeling. Furthermore, simulations highlight the relevance of the indirect links for a valuable ranking of risks in respect to the classical approaches presented in literature.

Despite these merits, the research is not without limitations. The main limitation of this work concerns with its exploratory nature. This condition does not allow to attempt any generalization of the results but provides evidence of the applicability of CPN technique and its potential in this field. Other critical factors are the data availability and the quality of the value of expert judgments in respect to the project risk relationships. Future research should investigate new ways and means of obtaining data and determine if the expert judgment is a good estimator of unobservable relationships. In addition, a main assumption of this work is that RFs, which are enabled in a project phase, have the same probability to occur. For this reason the final ranking of risks does not take into account the unconditional occurrence probability of each risk factor. Whether this does not impact on the purpose of investigating the role of interdependence, further developments should aim to overcome this limitation integrating dependence and unconditional probabilities in the Risk Evaluation algorithm. Finally, another important direction for future research concerns the validation and refinement of the method and its inclusion in a formal ERP Risk Management tool. In this regard, Action Research seems to be a promising approach, since it is well suited to the aims of providing an effective, practical means to improve the development and test such methodologies.

On the whole, this research sets a step ahead towards a more quantitative method for Risk Management of an ERP project. Managers should continuatively assess risks in order to improve the final project performance and achieve the project success. A more complete and correct assessment of the risk using CPN theory can support their efforts.

References

Aloini, D., Dulmin, R. and Mininno, V. (2007). Risk management in ERP project introduction: Review of the literature. Information & Management, 44, 547–567.

Bidgoli and Hossein, (2004). The Internet Encyclopedia, Volume 1, John Wiley & Sons, Inc. pp. 707.

Chang, J. W.; Luh, Y. P. (1997). Integration of scheduling and control in job shop, Journal of the Chinese Institute of Engineers 20(1), 67–76.

Chapman, C.B. and Ward, S.C. (2002). Managing Project Risk and Uncertainty: A constructively simple approach to decision making, Chichester, John Wiley & Sons.

Huang, S.-M., Chang, I.-C., Li, S.-H. and Lin, M.-T. Assessing risk in ERP project: identify and prioritize factors, Industrial Management and data System, 104 (8), 2004, 681-688.

Jensen, K. Coloured Petri Nets, vol.1, Springer Verlag, Berlin Heidelberg, 1992

Jensen K. (1997). Coloured Petri Nets: basic concepts, analysis methods and pratical use. Second Edition, Springler, New York.

Kumar, R.L. Managing risks in IT projects: an options perspective, Information & Management, 40, 2002, 63–74.

Labeau, P.E. Smidts, C.and Swaminathan, S. (2000). Dynamic reliability: towards an integrated platform for probabilistic risk assessment. *Reliability Engineering and System Safety*, 68, 219–254.

David, R. Alla, H. (1994). Petri Nets for the modeling of dynamic systems – A survey, *Automatica*, 30(2), 175–202.

Lin, J. T.; Lee, C. C. (1997) A Petri Net-Based integrated control and scheduling scheme for fl exible manufacturing cells, Computer Integrated Manufacturing Systems 10(2), 109–122.

Monk, E. and Wagner, B. Concepts in Enterprise Resource Planning, 2nd Edition, Editor, Mac Mendelsohn, Canada: Thomson Course Technology (2006).

Ratzer, A.V.,Wells, L., Lassen, M.C., Laursen, M., Qvortrup, J.F. Stissing, M.S., Westergaard, M. Christensen, S. and Jensen, K. (2003). CPN Tools for Editing, Simulating, and Analysing Coloured Petri Nets. W.M.P. van der Aalst and E. Best (Eds.): ICATPN 2003, LNCS 2679, 450–462.

Scott, J.E. and Vessey, I. (2002). Managing risks in enterprise systems implementations, Communication of the ACM, 45 (4), 74-81.

Sumner, M. (2000). Risk factors in enterprise-wide/ERP projects, Journal of Information Technology (Routledge, Ltd.), 15 (4), 317-327

Tatsiopoulos, I. P., Panayiotou, N. A., Kirytopoulos, K. and Tsitsiriggos, K. (2003). Risk Management as a Strategic Issue for the Implementation of ERP Systems: A Case Study From the Oil Industry, International Journal of Risk Assessment And Management, 4 (1).

Yang, C.-C., Huang, J.-T., Lin, M.-Y. and Lin, W.-T. (2006). A study on applying FMEA to improving RP introduction: An example of semiconductor related industries, in Taiwan. International Journal of Quality & Reliability Management, 23 (3), 298-322.

Wright, A. M. and Wright, S. (2001). Information system assurance for ERP systems: Unique risk considerations, Journal of Information Systems, 16, 5-15.

Zafiropoulos, I. Askounis, D. and Metaxiotis, K. (2005). Dynamic risk management system for the modelling, optimal adaptation and implementation of an ERP system, Information Management & Computer Security, 13 (3), 212–234.