Multivariate Methods in Enterprise System Implementation, Risk Management and Change Management

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Abstract. This work is a first step towards the application of multivariate methods in **Risk Management** and **Change Management** in Enterprise System Implementation (ESI). ESI is characterized by concentrated efforts to integrate, within an active work environment, an IT system such as ERP, PDM or CRM. Such projects typically experience unplanned problems and events, which may lead to major restructuring of the process. In this work, we rely on ESI theory developed by the BEST project (www.best-project.com) and more conventional Risk Management methodology. Both Change Management and Risk Management consist of data collection and data analysis. We will show that the data structures of both efforts are similar so that similar data analysis techniques are applicable. In fact one can consider Change Management as a special case of Risk Management. The paper's focus is on the application of multivariate methods in comparing risk profiles and readiness assessments at various stages of an ESI project. The techniques we introduce here are **Correspondence Analysis** and **Partial Order Mapping**. These techniques help characterize and compare ESI readiness across different parts of a company and compare risk profiles of different ESI components.
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1. Introduction

Enterprise System (ES) are software packages that offer integrated solutions to companies' information needs [Davenport (2000)]. Enterprise Systems like ERP (Enterprise Resource Planning), CRM (Customer Requirement Management), and PDM (Product Data Management) have gained great significance for most companies on an operational as well as a strategic level. An ES implementation (ESI) process, as other system development processes, is a complex and dynamic process that cannot be fixed from the start. The process is characterized by the occurrences of unplanned problems and events [Buhl et al (2004), Fan et al (2004), Wognum et al (2005)]. These situations may lead to major restructuring of the process with severe implications to the whole company.

Given the growing significance and high risk of ESI projects, much research has been undertaken to develop better understanding of such processes, in various disciplines. Yet, the literature on ESI, information technology and organizational change management does not give substantial and reliable generalizations about the process dynamics and the relationships between information technology and organizational change. In order to fill this gap, a European FP5 project, **B**etter **E**nterprise **S**ys**T**em implementation (BEST) was launched in 2002 [BEST (2004)]. The aim of the BEST project was to understand the dynamics of ESI processes, and help improve organization readiness to deal with such issues by acquiring knowledge of process dynamic from existing ESI projects. This general area is known in the literature as Change Management.

Information Technology (IT) projects carry important elements of risk, thus it is probable that progress will deviate from the plan at some point in the project life cycle [Gottfried (1989)]. Risk in a project environment cannot be totally eliminated. The objective of a risk management process is to minimise the impact of unplanned incidents in the project by identifying and addressing potential risks before significant negative consequences occur.

IT risk management should be performed in such a way that the security of IT components, such as data, hardware, software and the involved personnel, can be ensured. This can be achieved by minimising external risks (acts of God, political restrictions) or internal risks (technical problems, access safety) [Bandyopadhyay (1999)]. Risk management as a strategic issue for the implementation of ERP systems is discussed in Tatsiopoulos (2002).

Change Management can be considered a special case of Risk Management. Moreover both approaches rely, among other things, on survey questionnaires that generate data with similar structural properties. We will exploit this similarity and discuss data analysis techniques that are commonly applicable to both Change Management and Risk Management.

Assessing organizational readiness and risk profiles in an ESI is essentially a multivariate task. The approach taken in the literature has typically been to compile composite indices and generate graphical displays such as radar charts or risk maps. In this work we present data analysis techniques to sort and rank risk profiles and readiness assessments, in a truly multivariate sense. These techniques include Correspondence Analysis and a Partial Ordering Mapping method originally developed in Karlin et al (1979) and Kenett (1983) that capture the complexity of the multivariate task. The paper's focus is on the application of these multivariate methods in comparing risk profiles and readiness assessments at various stages of an ESI project. These techniques will help characterize and compare ESI readiness across different parts of a company and compare risk profiles of different ESI components.

The next section describes the BEST methodology and Risk Management techniques. Later sections present the multivariate procedures and their application to a SAP ERP implementation. We conclude with some remarks and suggestions for future research.

2. Better Enterprise SysTem implementation – the BEST approach to Change Management

ESI related organizational change is a complex and dynamic process, with high uncertainty accompanied by unexpected problems. These potential events are related to a large number of variables that belong to organizational, human and technological aspects. In addition, the relationship among these variables is often unclear. The management of the ESI process is therefore highly dependent on the ability of the people involved in the process (e.g. project manager, ES vendor, consultant, etc) to identify and solve problems [Davenport (2000), Fan (2004), Wognum (2005)].

This section presents some of the BEST project outcomes [BEST (2004)], which serve as a basis to the change management methodology we utilize in this study. The BEST project developed a general construct that can be used to capture the knowledge accumulated in existing implementation processes. This includes identification of events that occur within the implementation process, and the mapping of these events in terms of chains called Cause-Event-Action-Outcome (CEAO). Knowledge on what happens in an implementation project is documented using CEAOs and, in that way, the capability of analysts and consultants to identify and act upon unexpected or unintended events and problems is enhanced.

Reference Framework -
The reference framework addresses the view of the overall enterprise characteristics and constitutive elements, which influence the implementation of an ES. The framework identifies important technical as well as organizational and human aspects that play a role in several processes. These processes are called dimensions and include the Business process, the Project Management process and the ES process. In addition it defines six organizational aspects: Strategy & Goals, Management, Structure, Process, Knowledge & Skills and Social dynamics. The 18 cells created by the intersection of dimension and aspect are called focus cells [Buhl et al (2004), Wognum et al (2005)].
A more detailed definition of the three dimensions is listed below:

- The *permanent business process* for which the system is implemented. The focus process consists of all activities that will be supported or affected by the new enterprise system. The business processes are permanent processes, which may be subject to change continuously. The word permanent is used to distinguish the daily tasks from the temporary tasks of an implementation project.
- The *design and tuning of the new enterprise system*. The focus process consists of all activities that are needed to adapt or tune the system and align it with the business. Design and tuning of the enterprise system is a temporary process, but may extend beyond the implementation project.
- *Project management* of the implementation process. The focus process consists of all activities needed to plan and monitor the implementation process, select and perform the implementation strategy, select the system and implement it into

the organization, compose a project team, manage project documents, etc. Project management is a temporary process.

The six aspects are further explained below:

- *Strategy and goals*. Strategy and goals are the medium- and long-term goals to be achieved and the plans for realising these goals. The strategy and goals for the enterprise system and the implementation project should match the business goals and strategy.
- *Management*. The management aspect deals with setting priorities, assigning resources and planning and monitoring processes.
- *Structure*. Structure involves the relationships between elements of the organisational system, such as processes, people and means. Structure includes tasks, authorities and responsibilities, team structures, process structure and structure of the enterprise system.
- *Process*. Process involves the steps that are needed to perform the focus process of each dimension: the primary business process and relevant support and management processes, the project process and the enterprise system design and adaptation process.
- *Knowledge and skills*. This aspect refers to the knowledge and skills that are needed to perform the focus processes in each dimension.
- *Social dynamics*. The aspect social dynamics refers to the behaviours of people, their norms and rituals. Social dynamics often become visible in informal procedures and (lack of) communication.

Combining aspects and dimensions generates the reference framework presented in Figure 1.

	Enterprise system	**Project management**	**Permanent business**
Strategy and goals			
Management			
Structure			
Process			
Knowledge and skills			
Social dynamics			

Figure 1: The BEST reference framework for enterprise system implementation processes

CEAO chains database –
CEAO chain is a mapping of a problem and solution contains of the following items: Event is defined as a problem created by decisions, actions, or by events outside the control of the organization. A cause is an underlying reason or action, leading to the event. For each event it is possible to specify one or several causes, which are linked to the event through a parent-child relationship. An Action is the solution taken to resolve the event; it includes method of performing or means used. Each action is connected to outcomes. The mapping of causes of the CEAO chains into reference framework leads to different clusters of CEAO chains. Each cluster belongs to a focus cell in the framework.

Context of the ES Implementation -
Context data provide a view of the company and ES, such as company size, type of ES, cultural region etc. It is expected that ES implementation process execution is influenced by those characteristics. Context sensitivity analysis was done in an attempt to distinguish between local pattern (occur only in specific situations due to the context characteristic), and generic pattern that can be generalized across ES implementation processes. For example, if we compare two different size companies: SME (less then 250 employees) and Large (more then 250 employees), it is expected that there are size-dependent patterns, such as greater project resources and higher complexity adoption process in a large company, that cause major differences in the ESI processes.

Readiness Scoring -
One of the goals of the BEST project has been to develop a tool to assess a company's situation at the start of an enterprise system implementation project. Such an assessment enables anticipating problems that might potentially occur and reusing the knowledge gathered in the CEAO chains. For this purpose, the causes assigned to each cell in the reference framework have been summarized. The summaries have been translated into questions, one to three questions for each cell. The questions ask for the degree of maturity of a particular situation or the degree of alignment between dimensions. For each question, a set of answer options has been generated. The answer options reflect the degree of maturity and alignment of the situation identified by the question, ranging from an immature situation or insufficient alignment to an optimal situation or optimal alignment. Each answer option has been given a score on a scale from 0-4, where the highest score indicates the highest level of maturity. The level of maturity indicates the level maturity or alignment between the different dimensions in the reference framework. For example, a high maturity level for the knowledge in the business of the enterprise system that is being implemented indicates that people in the business know and understand the enterprise system. Similarly, a low maturity level for the knowledge and skills in the permanent business to work with the system indicate that the people in the business are not fully ready to adopt the enterprise system. An assessment tool has been developed and all questions, answers and scores have been defined. After answering all questions an overall score is computed for the specific situation. The overall score is presented in a spider diagram, where the maximum score indicates the best achievable maturity level. The ac-

tual scores are presented relative to this maximum score. The spider axes are the aspects of the reference framework. An example spider is shown in Figure 2.

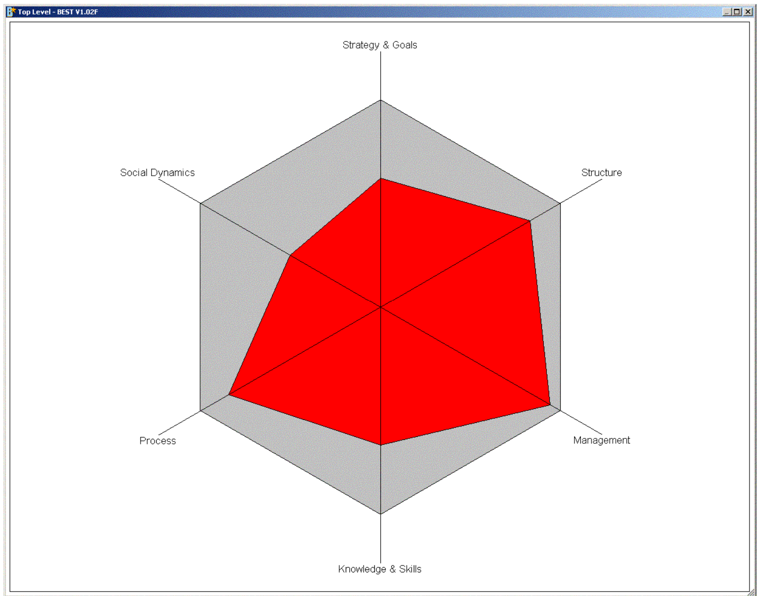


Figure 2: A spider diagram produced with the BEST assessment tool

There are several approaches for conducting an ESI readiness assessment. In typical cases the assessment is repeated in different part of an organization or for different modules of the ES. Following such assessments there is a need to compare and rank assessment profiles (spider diagrams) in order to better plan the ESI Change Management effort. The techniques we present in section 4 provide a general approach for carrying out such an analysis. In section 5 we will demonstrate their application in the context of a SAP ERP implementation.

3. Risk Management

In this section we will briefly cover the basic elements of Risk Management. The literature on the topic is extensive and we choose to focus on Risk Management in the context of an ESI such as ERP. For a more detailed treatment of this topic we refer the reader to Tatsiopoulos (2003).

The phases that constitute the risk management process are: Identification, Analysis, Control and Feedback. The tasks in each one of these phases are affected by three different areas:
i) the technology, which concerns the implementation of the ERP system (software and hardware)
ii) the processes, which are inevitably affected by the new information system
iii) the human resources, which implement the processes and use the newly integrated software system.

The technology, the processes and the human resources, form the core of any organisation and therefore contain most of the sources of risk. Each phase of the risk management process should be executed separately for each one of these three critical areas.

Risk *identification* is the first phase of the risk management process and it involves the determination of the risks that might affect the ESI project during its whole life cycle. The identification of risks is based on the use of structured questionnaires. Such questionnaires have to be designed by integrating experience acquired in similar projects with best practices in the field. Moreover, they should cover different aspects of the project and take account the three basic areas (technology, processes and human resources). Categories should be well defined and should reflect common sources of risk for the specific application being introduced. An example of categorisation could be: industry related questions, questions concerning the project scope, questions concerning the project management, questions concerning the approach, questions concerning training, support and other related issues (all of them in terms of technology, processes and human resources).

The identification is typically enhanced by a series of interviews based on the questionnaires, which are used as a tool of the risk management team. The risk management team can use this tool in order to extract as much information as possible from the project stakeholders, such as the industry's project team or the consulting organisation that is usually used for the implementation of such extended projects. The next step is the evaluation of the answers by the project team. The questions that are included in the questionnaire are related to certain risks that might affect the project. So, the answer to the questions can guide and help the risk management team to decide whether the risk exists or not. The existing risks are gathered and communicated to the project's stakeholders for analysis and evaluation.

Risk *analysis* is the phase where each identified risk is evaluated in two ways. Firstly, the probability of the risk occurrence must be defined and then, the impact that the specific risk will have on the project if it occurs has to be estimated. The impact, as well as the identification of the risks, should be quantified within the technology, processes and the human resources of the organisation. The multiplication of these two figures (probability of occurrence times impact on the project) provides the risk exposure. The outcome of the risk analysis is a risk matrix indicating the position of each risk element in terms of probability of occurrence and impact level. A sample risk matrix is presented in Figure 3.

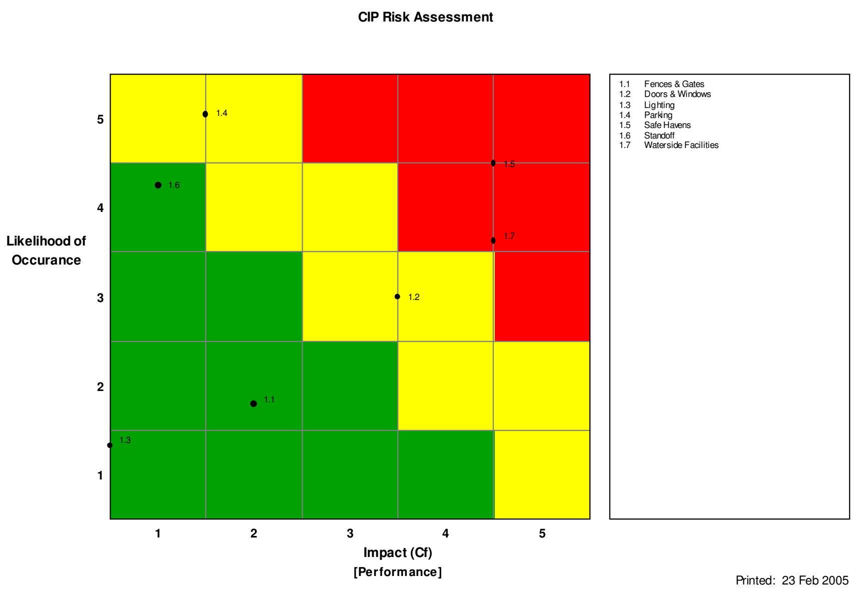


Figure 3: A sample Risk Matrix with the positioning of 7 risk elements

Risk exposure can be estimated with the use of either qualitative or quantitative data. The first approach is more frequently followed since it requires less time and data acquisition. However, if a risk is judged as significantly more important or higher than the others, it is suggested that it should be examined with the use of quantitative methods. In order to avoid any problem of communication as far as the meaning of the impact is concerned, a well-defined scale should be adopted. The accepted categorizations of probability of occurrence is to classify a probability between 0 and 0.15 to class 1, between .151 and .4 to class 2 etc… This results in the following classification scale:

Probability	0%-15%	15%-40%	40%-60%	60%-80%	80%-100%
Classification	1	2	3	4	5

The completion of risk analysis leads to the next phase of the process, which is the *control*. This is the step where the response to the identified risks, based on the available technology, processes and human resources of the organisation, is designed. The way to cope with the risk is defined and the implementation of the risk mitigation actions is assigned to the most appropriate member of the project team. In order to sort out the risks that should be treated first, the analyzed risks are prioritized in terms of their exposure. Risks with higher exposure should be handled first, before others with lower exposure. Typical risk responses include avoidance (if possible), reduction (if manageable), transfer (if applicable) and retention (if acceptable). Risk control should be sized to match the severity of the risk, be realistic within the project context, cost significantly less than the impact on the project if the risk is realised and, furthermore, be applicable within the given time frame.

The last phase of the risk management process is the *feedback*. The purpose of carrying out this phase is to ensure that the assumptions and estimates made by the risk management team are valid, during the evolution of the project. The main actions that are included in this phase are: tracking of the realisation of defined controls, estimation of the effectiveness of the realised controls, updating of risk exposure, probability of occurrence and impact and, finally, recognition of unidentified risk occurrence.

Feedback is the last phase of the risk management process but it is also the trigger that initiates the next phase, providing material for the identification of new risks. In this phase a retrospective data analysis is conducted and risk profiles by specific areas are derived. Many Risk Management software packages offer extensive filtering capabilities that support this type of analysis. Once risk characteristics such as impact and/or probability of occurrence are derived the risk analysts will want to compare results for different stratifications of the data.

From such feedback sessions **Key Risk Indicators** (KRI) can be derived. These indicators are quantitative measures that provide early warning or confirmation of risk related events. The establishment of an effective KRI metrics system is a strategic organizational project. A typical outcome of such a project is a Management Dashboard with various gages indicating the current status of various indicators. For details on how to set up such a metrics system and management dashboards in the context of software development organizations see Kenett and Baker (1999).

4. Multivariate Analysis

This section presents Correspondence Analysis and Partial Ordering Mapping, two multivariate data analysis techniques that are applicable to the data structure corresponding to Change Management and Risk Management assessments.

Correspondence analysis.
Correspondence analysis is a statistical visualization method for picturing the associations between the levels of a two-way contingency table. The name is a translation of the French "Analyses des Correspondances", where the term 'correspondance' denotes a "system of associations" between the elements of two sets. In a two-way contingency table, the observed association of two traits is summarized by the cell frequencies. A typical inferential aspect is the study of whether certain levels of one characteristic are associated with some levels of another. Correspondence analysis displays the rows and columns of a two-way contingency table as points in a low-dimensional space, such that the positions of the row and column points are consistent with their associations in the table. The goal is to have a global view of the data that is useful for interpretation.

Simple correspondence analysis performs a weighted principal components analysis of a contingency table. If the contingency table has r rows and c columns, the number of underlying dimensions is the smaller of (r - 1) and (c - 1). As with principal components, variability is partitioned, but rather than partitioning the total variance, simple correspondence analysis partitions the Pearson χ^2 statistic. Traditionally, for n observations in the contingency table, correspondence analysis uses χ^2 / n, which is termed inertia or total inertia, rather than χ^2. The inertias associated with all of the principal components add up to the total inertia. Ideally, the first one, two, or three components account for most of the total inertia.

Lower dimensional subspaces are spanned by principal components, also called principal axes. The first principal axis is chosen so that it accounts for the maximum amount of the total inertia; the second principal axis is chosen so that it accounts for the maximum amount of the remaining inertia; and so on. The first principal axis spans the best one-dimensional subspace closest to the profiles using an appropriate metric ; the first two principal axes span the best two-dimensional subspace; and so on. These subspaces are nested, meaning the best one-dimensional subspace is a subspace of the best two-dimensional subspace, and so on.

The principal coordinate for row profile i and component (axis) k is the coordinate of the projection of row profile i onto component k. The row standardized coordinates for component k are the principal coordinates for component k divided by the square root of the k^{th} inertia.

Likewise, the principal coordinate for column profile j and component k is the coordinate of the projection of column profile j onto component k. The column standardized coordinates for component k are the column principal coordinates for component k divided by the square root of the k^{th} inertia.

The contingency table can be analyzed in terms of row profiles or column profiles. A row profile is a list of row proportions that are calculated from the counts in the contingency table. Specifically, the profile for row i is (n_{i1} / $n_{i.}$, n_{i2} / $n_{i.}$, ... , n_{ic} / $n_{i.}$). A column profile is a list of column proportions, where nij, is the frequency in row i and column j of the table and $n_{i..}$ is the sum of the frequencies in row i. Specifically, the profile for column j is (n_{1j} / $n_{.j}$, n_{2j} / $n_{.j}$, ... , n_{rj} / $n_{.j}$), where $n_{.j}$, is the sum of the frequencies in column j.

The two analyses are mathematically equivalent. Typically, a researcher is interested in studying either how the row profiles differ from each other or how the column profiles differ from each other.

Row profiles are vectors of length c and therefore lie in a c-dimensional space (similarly, column profiles lie in an r-dimensional space). Since this dimension is usually too high to allow easy interpretation, one tries to find a subspace of lower dimension (preferably not more than two or three) that lies close to all the row profile points (or column profile points). The profile points are than projected onto this subspace. If the projections are close to the profiles, we do not lose much information. Working in two or three dimensions allows the data to be studied more easily and, in particular, allows for easy examination of plots. This process is analogous to choosing a small number of principal components to summarize the variability of continuous data. If d is the smaller of (r - 1) and (c - 1), then the row profiles (or equivalently the column profiles) lie in a d-dimensional subspace of the full c-dimensional space (or equivalently the full r-dimensional space). Thus, there are at most d principal components. An implementation of correspondence analysis using MINITAB version 14 (2004) is presented in Figure 4. The example used in the figure is explained in the next section. For more details on correspondence analysis see Greenacre (2003) and Fienberg (1987).

Partial Order Mapping

Partial Order Mapping is a non parametric statistical analysis of data structures in several groups of multidimensional data vectors originally proposed in Kenett (1983). The technique can be applied, for example, to the set of responses of the BEST readiness assessment tool or the responses to a risk assessment consisting of responses to questions grouped by various phases of a project.

Let $R_i=(r_{i1}, r_{i2}, r_{i3},\ldots,r_{in_i})$, be the set of relative responses to a readiness assessment questionnaire where r_{ij} is the relative number of responses to option j in the group of questions R_i , j = 1,…n_i, i=1,…k.

We will compare the set of vectors R_i, for different groups, to a "base" or "standard number-of-error distribution" in order to determine which group is closest to the standard.

Let $S_i=(s_{i1}, s_{i2}, s_{i3},\ldots,s_{ini})$, be the set of relative responses in a "base" or "standard number-of-error distribution" where s_{ij} is the relative number of responses to option j in the group of questions Si , j = 1,…n_i, i=1,…k.

The distance between R_i and S_i can be evaluated using various similarity measures.

Many similarity measures, such as the Pearson χ^2 ,the Eucledian distance, Block city (also called Manhattan), Minkowski (the geometric mean), the information number or the Tsversky similarity index have been proposed in the literature (Tversky, 1977, Raphaeli et al, 2004).

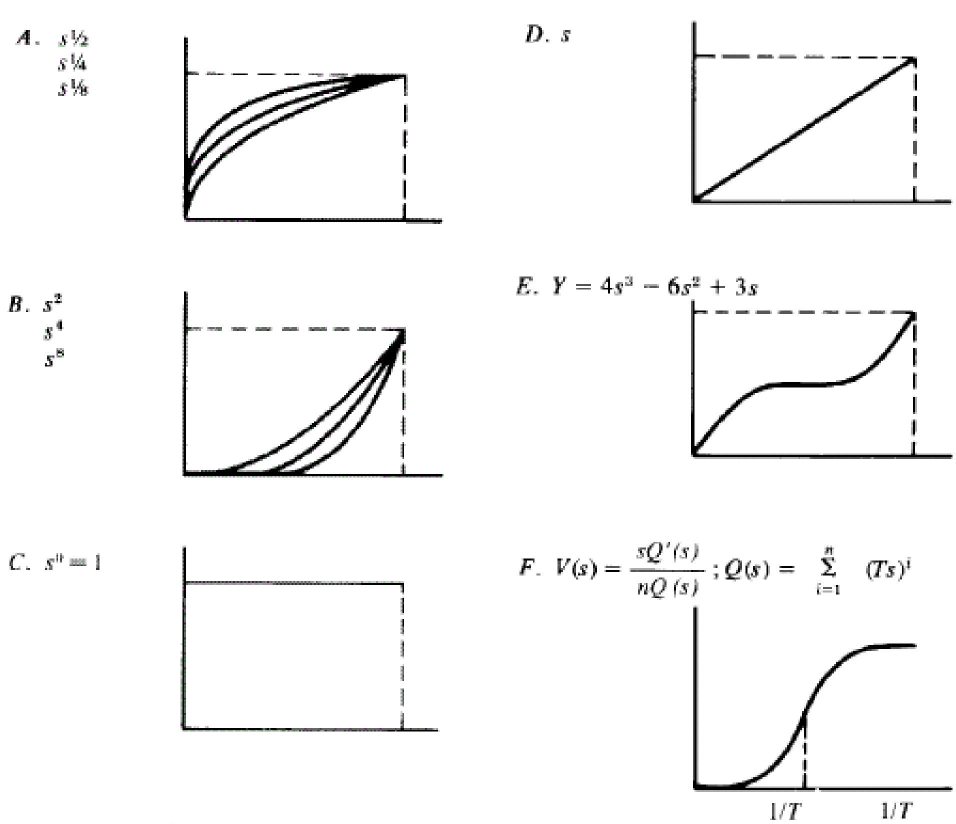
Karlin, Kenett and Bonne-Tamir (1979) propose a general family of distance measures that are computed as

$$u_{(i,j)}(s) = \sum_{k=1}^{m_i} w(s_K^{(i)}) f(|x_{k,j}^{(i)} - s_K^{(i)}|)$$

where

$$f(u-v) = |u-v|^{\mu}$$

and the weight function, *w(s),* is chosen from a large family containing qualitatively different shapes. Some examples, labelled A-F, are listed below.



A Partial Order Map is derived from combining a similarity index with the nonparametric sign test to compare two groups using the values of the similarity index. Using various similarity indices provides some robustness properties to the conclusions derived from the analysis.

If we have k groups, the significance of the relative position of R_i versus S_i as compared to of R'_i versus S_i is determined by performing a sign test of the two sets of k values computed using the chosen similarity index. For example, if k=6, a ratio of 6:0 or 5:1 produces an ordered relation between R_i and R'_i at a P-value of 0.13. We demonstrate the application of Partial Order Maps in the next section.

5. An application to a SAP implementation project

One of the leading ERP systems in the last few years is SAP R/3 [DiCenzo (1998)]. SAP is composed of modules, which in total cover all sectors and business processes of an enterprise. Each firm may choose to implement the whole package (Standard SAP) or certain modules to cover specific needs. Moreover, there are special modules developed to cover specific needs such as types of industries or countries legal aspects. In order to perform an effective implementation of SAP, one has to concentrate on the following subjects [Martin (2000)]:

• Business case: justification of the need for the new system and clear objectives
• Benchmarking: import the best practices to the SAP project
• Implementation strategy: align the new system with the corporate strategy
• Project management infrastructure: definition of roles and responsibilities as well as general coordination
• Change management: ability to overcome the potential resistance of people involved
• BPR: ensure that the SAP model and the enterprise model are exactly the same
• Installation: concerns all the technical aspects of SAP.

The SAP implementation methodology, called ASAP, includes five phases, with a total typical duration of 12-24 months. These phases are:
1) Project Preparation. This provided initial planning and preparation of the SAP project where the organisation was assembled, the resources allocated, detailed activities planned and the technical environment set up.
2) Business Blueprint. A detailed documentation of the business process requirements and an executive summary were produced (To-Be), following a short description of the current situation (As-Is).
3) *Realization*. The purpose was to implement the requirements based on the Business Blueprint. The main activities were the customising of the system and building the conversion, interface and add-on programs.

4) Final Preparation. This included the completion of the final preparations (including testing, end user training, system management and cut-over activities), and the final improvement of the company's readiness to go live.
5) Go live Support. A support organisation for end users had to be set up and optimise the overall system performance.

In the remaining part of this section we will demonstrate the role of correspondence analysis and Partial Order Maps to Change Management and Risk management efforts in the context of an ASAP project. The data we use is typical of ASAP projects but does not correspond to a specific organization.

At each phase of ASAP, and separately for each organizational unit, a CEAO workshop can be conducted. During these workshops past, present or future events are recorded and classified using the reference framework (see section 2). A sample CEAO chain is presented below in Figure 4.

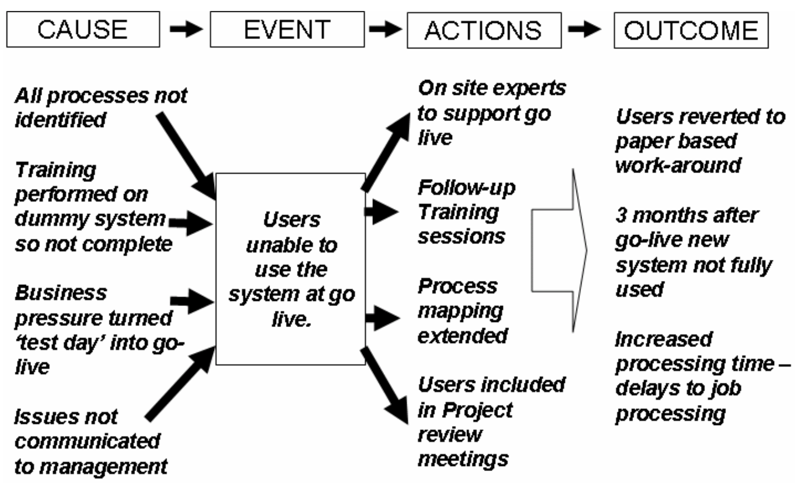


Figure 4: A sample CEAO chain [BEST(2004)]

In the example of Figure 4 the event "users unable to use the system at go live" is attributed to four causes classified as four different aspect categories. For example "Training performed on dummy system" is classified as "Knowledge and Skills". In the example analyzed below 264 causes have been classified, within the reference framework, following CEAO workshops in five divisions. The detailed statistics are presented in Table 1.

Rows: Aspect   Columns: Division

	DivA	DivB	DivC	DivD	DivE	All
Knowledge & Skills	7	1	16	6	9	39
	13.73	7.14	34.04	8.33	11.25	14.77
Management	16	4	11	13	12	56
	31.37	28.57	23.40	18.06	15.00	21.21
Process	0	2	1	15	23	41
	0.00	14.29	2.13	20.83	28.75	15.53
Social Dynamics	16	4	12	15	9	56
	31.37	28.57	25.53	20.83	11.25	21.21
Strategy & Goals	5	0	0	5	15	25
	9.80	0.00	0.00	6.94	18.75	9.47
Structure	7	3	7	18	12	47
	13.73	21.43	14.89	25.00	15.00	17.80
All	51	14	47	72	80	264
	100.00	100.00	100.00	100.00	100.00	100.00

Cell Contents: Count
% of Column

Table 1: Classification of 264 CEAO chains by Aspect and Division

Running a correspondence analysis, as described in section 4, yields Figure 5. From that analysis we can characterize Division C as being affected mostly by Knowledge and Skills CEAOs, Division E is mostly affected by Strategy and Goals and Processes, Division D by Structure and Divisions A and B by Management and Social Dynamics. Such an analysis provides invaluable feedback to the organization's management that has to determine if these signals as due to the personal management style of the division managers or specificities in the activities of the divisions. The insights gained by such an analysis should lead to proactive actions for improving the organization's preparedness to an ERP implementation.

Labels in Figure 5
K&S: Knowledge and Skills
Mgmt: Management
P: Process
SD: Social Dynamics
S&G; Strategy and Goals
S: Structure

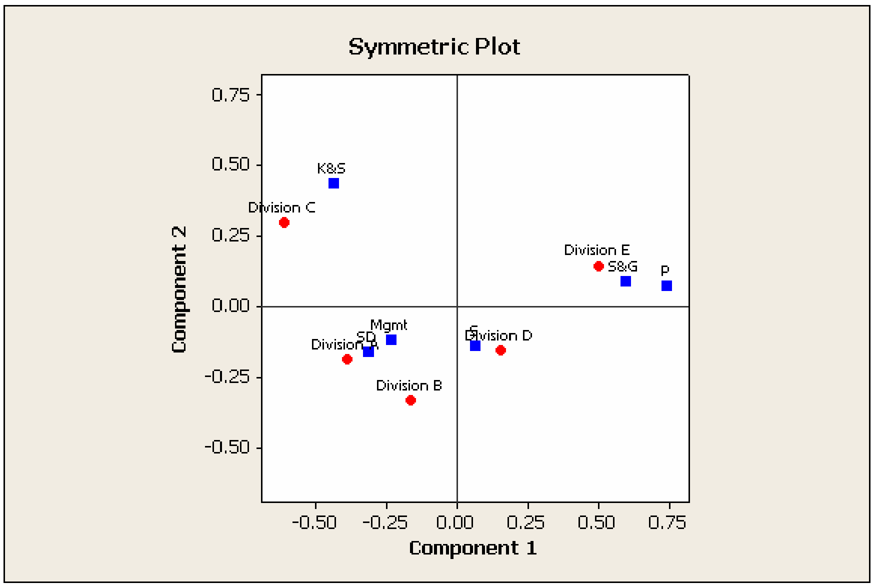


Figure 5: Correspondence analysis of CEAO chains in 5 divisions by aspect

A similar analysis can be conducted when risks are attributed to different risk categories and risk elicitation is done in different parts of the organization or for different modules of the SAP system.

In parallel to the mapping of CEAO chains to the reference framework or of risks to various classification groups, Change management and Risk Management projects typically include conducting assessments relying on multipart survey questionnaires.

BEST readiness assessment responses are weighted to produce a score for each aspect dimension. The results are presented using a spider diagram as already shown in Figure 2 above. Tools such as TRIMS (2004) generate a list of risks that the organization has to deal with.

Typical ASAP sample risks that are elicitated using risk assessment questionnaires are:
1) Users will not be able to respond to such a big change
2) Software problems may cause delays at the implementation
3) The scope of the project is too big to be implemented in time
4) The functional complexity will prevent the implementation
5) The unavailability of key staff will affect the delivery time of the project
6) Delays due to third parties will cause a general delay of the project

The information below consist of the risk ID and the Risk Description followed by the Probability of occurrence (%), the Average impact (in days) and the Average exposure (in days)

R1 The scope of the project is too big to be implemented in time	*30 50 15*
R21 The unavailability of key staff will have an impact on the delivery time	*50 85 42.5*
R8 Users will not be able to respond to such a big change	*50 70 35*

The probability of occurrence is classified according to the following index:

Probability	10%	30%	50%	70%	90%
Classification	1	2	3	4	5

The number of risks, by classification of their probability of occurrence, at various phases of the ASAP implementation project and for the different SAP modules are listed in Table 2 below. In the HR module, for example, there are 14 risks in the realization phase that have a probability of occurrence below 15% and 6 risks with a probability of occurrence above 80%.

HR	Project Preparation	Blueprint	Realisation	Final Preparation	Go Live	Second wave
1	18	25	14	5	9	3
2	16	12	9	2	6	4
3	5	4	3	7	6	9
4	2	4	2	2	2	2
5	4	5	6	10	9	6

Finance	Project Preparation	Blueprint	Realisation	Final Preparation	Go Live	Second wave
1	26	32	28	6	21	3
2	13	7	3	4	5	5
3	2	6	4	2	7	3
4	2	4	4	1	3	1
5	4	12	10	5	7	4

Logistics	Project Preparation	Blueprint	Realisation	Final Preparation	Go Live	Second wave
1	55	67	51	20	42	11
2	20	9	15	8	20	13
3	7	7	2	4	13	6
4	4	6	4	2	3	5
5	5	9	7	8	5	3

CRM	Project Preparation	Blueprint	Realisation	Final Preparation	Go Live	Second wave
1	33	44	33	13	38	9
2	16	9	16	6	5	14
3	4	4	4	4	4	2
4	1	2	2	2	2	2
5	6	8	3	2	7	1

Table 2: Number of ASAP implementation risks (1-5) by phase and by module

Table 2 is an empirical compilation of risks by probability of occurrence, by phase and by SAP module. In comparing the different modules one might want to normalize the total number of risks which are only a reflection of the scope of the module. A better comparison is focused on the relative frequency of risks by probability of occurrence category. SAP modules can be thus compared in order to better assign management attention and experienced personnel. We focus here on a multivariate comparison of the relative frequency vectors using Partial Order Maps discussed in the pervious section.

We apply Partial Order Maps twice to rank SAP modules. The first time relative to the project overall risk structure (Figure 6), the second time relative to the SAP HR module (Figure 7).

In the analysis conducted here we use the χ^2 Statistic; other similarity metrics can also be considered as mentioned in section 4. Since there are 6 project phases, the analysis consists of computing 6 values of χ^2 by comparing the distribution of probability of occurrence of risks in the individual SAP modules versus the overall distribution. Using the sign test on the results in Table 3 we can determine the relative distances of the various SAP modules from the overall average. The results, using a 5:1 ratio to determine significance, are presented in Figure 8. Rerunning the analysis by putting the HR module in the center as the base, produces the Partial Order Map presented in Figure 9.

From Figure 8 we determine that the HR module risks have a significantly different risk structure, in terms of probabilities of occurrence, from the other modules, relative to the overall risk structure. When zooming in on the HR module we position the Finance module closer to the HR module than the Logistics and CRM modules.

This analysis of risk structures leads to in depth inquiries on what can cause these differences and what can be done to properly mitigate them.

	HR	Finance	Logistics	CRM
Project Preparation	2.22	0.48	0.93	0.65
Blueprint	2.78	1.82	1.41	0.87
Realisation	2.28	5.21	1.52	2.55
Final Preparation	5.01	0.49	0.89	2.44
Go Live	5.38	0.94	2.81	3.89
Second wave	4.96	1.08	0.82	4.18

Table 3: χ^2 values of ASAP implementation risks by phase and by module vs. the overall average

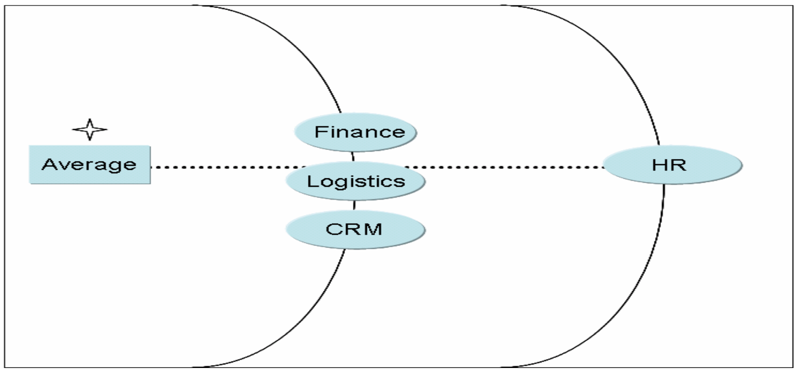


Figure 6: Partial Order Map of SAP modules risks versus the overall risk structure

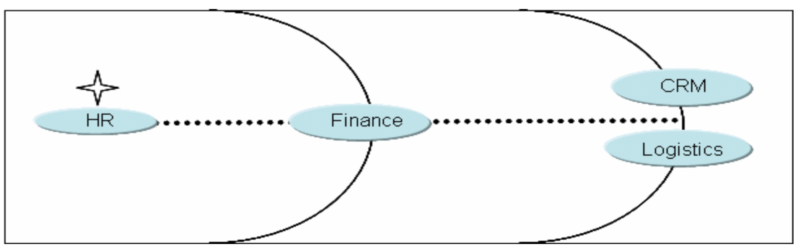


Figure 7: Partial Order Map of SAP modules risks versus the HR module

A similar analysis can be conducted if we compare responses to questions in the BEST readiness assessment questionnaire. Specific responses are compared using a distance measure and partial ordering of various subsystems or organizational divisions can be generated similar to the maps presented in Figures 6 and 7.

6. Concluding remarks and suggestions for future work

In this work we apply multivariate data analysis techniques to support the management of Enterprise System Implementations related risk management and organizational change management processes. The assessment in both approaches relies on similar data structures derived from multicomponent questionnaires. The reporting ,again, is similar in that it typically relies on graphical summary displays. Applying the techniques of Correspondence Analysis and Partial Order Maps presented in section 4 provides additional insights and data analysis capabilities. We demonstrated their application in the context of a SAP implementation and suggest that this can be generalized to a general theory linking generic data structures and multivariate data analysis.

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