Changeability of ERP Systems – Literature Research

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Abstract:

Conventional wisdom shows, that Enterprise Resource Planning (ERP) systems should not be changed, because in general change is a risk factor, contributing to project failure (Brehm and Heinzl - 2001). However, some amendments in the ERP are always needed, thus providing possibilities for great success and failure stories.

In the current paper, the researcher defines the term "changeability" in relation to ERP and carries out a literature review of ERP changeability papers. The goal of the literature review is to test the usability of an existing ERP changeability framework. A second deliverable of the paper is a list of organizational impacts from the ERP changeability projects. These organizational impacts are gathered through content analysis from the reviewed articles and point out important issues resulting from ERP changeability projects, which should be taken into account by ERP professionals.

Chapter 1 – Introduction

The enterprise resource planning (ERP) is defined by Schönsleben (2012) as a concept, composed of a set of processes, methods and techniques for effective planning and control of all resources needed to take, make, ship and account for customer orders in a manufacturing, distribution or service company. Nowadays, ERP systems are implemented and integrated into various organizations and thus become a cornerstone in the organization (Motiwalla & Thompson – 2012). They are considered such an important part of the organization functioning, because they integrate multimodal application software, serving and supporting several business functions across an organization and thus integrate various business processes and optimize the allocation of available resources. This process integration is done on two levels – logical and physical. At the logical level, system integration means developing information systems that allow organizations to share data with all its stakeholders, based on their need and authorization. At physical level, system integration means providing seamless connectivity between heterogeneous application systems (Motiwalla & Thompson – 2012). In order to achieve a logical integration and a fit in the company business model, a change is needed. The change concerns the company's organizational structures, processes, employee's roles and responsibilities.

The various challenges, methods and practices in ERP software implementation have attracted the attention of numerous researchers, thus increasing the available knowledge on the subject –the search of "ERP implementation" in the academic search engine "Science Direct" returns 6398 articles as result. The reason for this interest of the academic society into the subject is related to the potential benefits, which a

successful implementation can bring to the companies – ERP are reported to save costs (Oberndorf - 1998; Light & Sawyer - 2007), improve user capabilities (Yang et al., 2005) and to reduce system development time (Yang et al., 2005). On the other hand, it is also widely known, that there are many cases when an improper implementation causes considerable issues within companies (Motwani et al. 2002). Through the popularization of the best practices and most common mistakes in ERP implementation, the researchers and the consultants learn from each other's mistake, trying not to repeat them in new implementation projects. However, in many cases before the new introduction of a system, there is an old system, which is substituted. In other cases, a new version of the ERP system is required, to keep up with the new requirements of the market. In these cases, a smaller project is initiated, to cope with the changes. These smaller projects are part of the so-called system development life cycle (SDLC) of the ERP software (Motiwalla & Thompson – 2012). This cycle is a continuous process, starting after the initial implementation of the ERP system. The cycle begins when a new business problem or opportunity is considered to exist, thus leading to a feasibility study and a system analysis. After the analysis completion, the new part of the system is designed and implemented. This cycle is repeated every time a new possibility or need for change of the ERP system appears. Thus, in every ERP changeability project we have the whole cycle present.

During these ERP changeability projects, a lot of lessons are learnt from the implementing parties. Some projects are described in research articles, emphasizing on different results, revealing problems and the success stories of ERP changeability project. That is why it is of interest to take a detailed look into the changeability of the

ERP systems, thus trying to investigate common similarities in them and to obtain a valuable knowledge for the ERP changeability itself and its results. This investigation can be done through a literature review, because this method provides the needed possibilities to summarize findings and cases, previously reported in literature. That is why, the research questions of this paper would be formulated in a way, corresponding to a literature review paper.

The first research question for the paper concerns definition of ERP changeability in the literature. In order to be precise, we define it as follows:

Research Question 1: What is ERP changeability? How is it defined in the literature?

To reach the goal of our research, we should try to investigate the ERP changeability projects and to systemize them in a framework. Thus, a framework for ERP changeability is required. To obtain it, we make it the target of the second research question, which is defined as follows:

Research Question 2: What framework for ERP changeability can be used in order to analyze ERP changeability results?

Once we have a definition of ERP changeability from the literature and an ERP framework, we may analyze the results of the research. The analysis of the ERP changeability results is the answer of the third research question, which states the following:

Research Question 3: What recommendations and applications for ERP practitioners can be derived from the analysis of the results?

The answer of this third question is the final deliverable of the current paper. Implications and recommendations regarding ERP changeability projects are important, considering the fact that the ERP market is considered to have overall value of hundreds of billion EUR (See Pui – 2001).

The rest of the paper is organized as follows. Chapter 2 discusses research design and methodology of the current research. A literature review, answering the first research question is provided in chapter 3. In chapter 4 a table with papers, found during the execution of the research is provided and analyzed. Chapter 5 discusses the paper findings and answers the second and the third research questions. In chapter 6 conclusions are drawn.

Chapter 2 – Methodology and Research Design

In this chapter the information for the methodology is provided. The key steps in the research design are explained.

For the current paper, we have decided to perform a thorough literature review and thus to answer the research questions. The reason for the selection of the literature review method is based on the fact, that it provides good possibilities to summarize report and evaluate evidence, previously reported in the literature (Denyer & Tranfield - 2009). Furthermore, the literature review is a transparent way of reporting and it is acknowledged as a key technique to obtain new knowledge on practical aspects in various management studies (Tranfield et al. 2003).

For the selection of the articles, the electronic database "Web of Knowledge" is used. It provides access to over 50 million records with user friendly navigation and quick export availability. The usage of this highly reputable source ensures trustworthiness and high quality of the collected data.
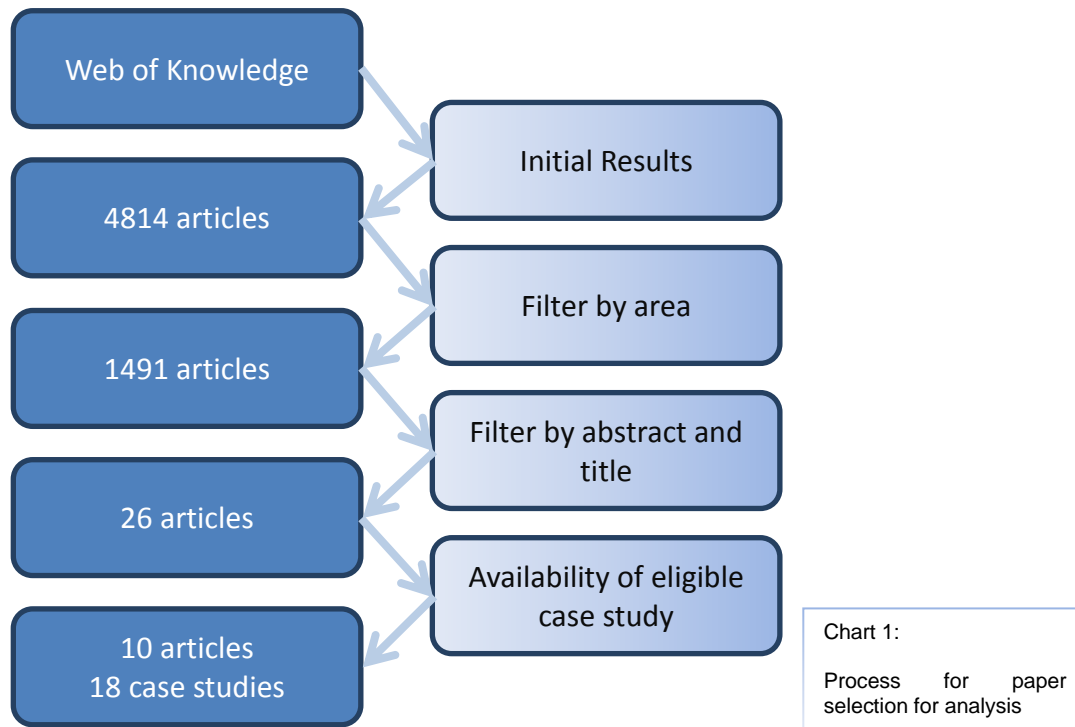
For the correct selection of papers, the following six criteria were adopted:

1. Papers written in English language;

2. Published in a journal between January 1990 and May 2013;

3. Free availability for researchers;

4. Relation to ERP and management;

5. Having case study/studies with descriptive results, concerning ERP changeability;

6. Provision of information for ERP changeability.

At the initiation of the research, as keywords were used the terms, presented in Attachment 1, combined with the word "ERP" in order to target results corresponding to the subject. These terms are selected from a draft paper of Wortmann and Maruster (2013), concerning ERP changeability. There, the authors take a look at the definition of the Merrian-Webster dictionary for changeability, which states that "changeable" is something "capable of change". Some of the words in Attachment 1 are mentioned as synonyms of changeability, others are taken as widely used in ERP discussions (such as "configuration", "modification", "customization").

The first search of the key words has encountered in total 4814 results. After removing the non-related areas, 1491 results were left. These 1491 articles were distributed unevenly between the searches. The queries of "ERP modeling" and "ERP implementation" returned 1097 articles, which were about 74% of the total results. The abstracts and the titles of the 1491 articles were scanned thoroughly and the one, related to ERP changeability were selected. Although this step takes only one sentence to be written down, it actually requires more time to be performed. The articles, which were selected after detail abstract reading were 26. These 26 articles were closely read and those, who were not corresponding to the fifth criteria for explicit presentation of one or more case studies, were removed. Thus 10 articles were selected. As far as in some of the articles more than one case study was present, 18 different changeability examples were found. The paper selection process is illustrated in chart 1:

Web of Knowledge

4814 articles

1491 articles

26 articles

10 articles
18 case studies

Initial Results

Filter by area

Filter by abstract and title

Availability of eligible case study

Chart 1:

Process for paper selection for analysis

The quality of the selected papers was good as expected, due to the fact that they were made available at the "Web of Knowledge" search engine and published in prestigious research magazines. The fact, that they provided ERP changeability case studies from different areas – education institution, production companies, sales divisions helped the researcher to obtain more general idea of different ERP changeability projects.

Once, the papers were selected, information about the different change aspects of the ERP systems is extracted from the various papers. This information is organized in a table with the following six columns: *Title*, *Description of Change*, *Agent of Change*, *Effect of Change*, *Mechanism of change* and *Organizational Impact*. The columns *Agent of Change*, *Effect of Change* and *Mechanism of change* are change aspects, proposed by the paper of Ross et al. (2008). These aspects are explicitly described in

the next chapter where the paper of Ross et al.(2008) is introduced. The column **Description of the change** contains information of the change in the ERP system. The **Agent of Change** is the driver, which actually pushes the change. The **Effect of the change** is compared to previous state of the ERP system. For the **Effect of change** column, three results are considered to be possible – increase (+), decrease (-) and no change (=) of the effect. This evaluation is subjective, due to the fact that it is evaluated only by the author and the papers do not explicitly state these results. The column **Mechanism of Change** contains one of the 13 possible ERP changeability options, described at the beginning of the next chapter. The column **Organizational Impact** contains the results of the implication of content analysis over the 10 selected articles with 18 case studies. In order to define the organizational impact, the method of content analysis is used, as proposed by Miles & Huberman (1994). The authors state that this method is applicable, when the same characteristic appears in more than one case. Thus, the task is to imagine a matrix display that best captures the dimensions the researcher is interested in and arranges all of the pertinent data in readily analyzable form. Considering the fact, that the organizational impact of ERP changeability is repeated in more than one case of the case studies, this method is appropriate. In the execution of content analysis, the researcher highlights each theme as it occurs in the raw data review. Thus, every theme is given a "theme code" (Cavana et al. - 2001). The standard steps in content analysis (Miles & Huberman - 1994) are the following three:

1. Open coding;

2. Axial coding;

3. Selective coding.

These steps are followed in the current research, in order to form & select distinctive groups for factors, which can be classified as organizational impact. A good example of a content analysis in literature review is provided by Dezdar and Sulaiman (2009). The results from the steps in *Axial Coding* and *Selective Coding* are provided in Chapter 4, Table 2. A sample of the results from the *Open Coding* step is provided in attachment 2 – "Other organizational impacts (open coding)". For the Organizational Impacts, which are taken into account in the analysis, the open coding naming is provided in six tables in chapter 4 – Tables 3, 4, 5, 6, 7, 8 and 9.

Chapter 3 – Introduction of the selected ERP changeability framework

In the current chapter ERP changeability is defined and a framework for ERP changeability is presented.

A formulation for changeability is needed in order to answer the first research question which states ***What is ERP changeability? How is it defined in the literature?***

The definition concerns three American researchers, who look into the core concept "changeability". Ross et al. (2008) describe it with three aspects: change agents, change effects and change mechanisms. ***Change agents*** are defined as forces, which instigate for the change to occur, for example humans, software, Mother Nature, etc. ***Change mechanisms*** are the particular path the system must take in order to transition from its prior to its post state, including conditions, resources and constrains. ***Change effect*** is described as the difference in states before and a change has taken place. Using these three key terms, Ross et al. (2008) define the five system parameters, describing changeability: Flexibility, Adaptability, Scalability, Modifiability and Robustness. In the context of changeability, ***flexibility*** of a system is defined by the set of changes induced by external agents that can be accommodated. ***Adaptability*** of a system is defined by the set of changes induced by internal agents that can be accommodated. ***Scalability*** is the ability to change the level of a feature. ***Modifiability*** is the ability to change the set of features itself. Ross et al. name a system ***robust,*** when it is able to remain constant in features, despite of the changes. These five parameters can increase, decrease or not change their qualities in the system, which is a subject of change.

Brehm et al. (2001) argue, that ERP package modification is posited as a factor in ERP project success and in companies' business success. Thus, they develop a fine-grained understanding of ERP package tailoring. With their paper they set the bases of understanding for ERP changeability. The terms, used prior to their paper in relation to ERP systems are two – *configuration* (also called "customization" in SAP) and *modification. Configuration* is considered as setting parameters in the package to reflect organizational features (Brehm et al. – 2001), while *modification* is related to changing the package code, and real programming inside the ERP. The authors propose the term "tailoring" in order to encompass both configuration and modification and a range of options in between. This range consists of nine ERP tailoring possibilities, presented in table 1.

As we see the different tailoring types, it can be concluded that more than one tailoring type could be used in a single ERP project. Thus, a project including both configuration and bolt-ons is something usual. With this information in mind, we argue that the current framework does not fit the goals of the paper.

N	Tailoring Type	Description
1	Configuration	Setting of parameters in order to choose between different excutions of
2	Bolt-ons	Implementation of third-party package designed to work with ERP system and
3	Screen masks	Creating of new screen masks for input and output of data
4	Extended reporting	Programming of extended data output and reporting options
5	Workflow programming	Creating of non-standard workflows
6	User exits	Programming of additional software code in an oper interface
7	ERP Programming	Programming of additional applications without changing the source code
8	Interface development	Programming of interfaces to legacy systems or 3rd party products
9	Package code modification	Changing the source-codes

Table 1 – Typology of ERP changeability types – Brehm et al. - 2001

The definitions, used by Brehm et al. (2001), concerning ERP changeability are used by other researchers as well. The draft paper of Wrotmann and Maruster (2013) proposes an ERP changeability framework based on the level of configuration and modification of the ERP system, delivered through the project. Thirteen types of possible change mechanisms are recognized. These combinations are presented in table 2 below:

Configuration		*Identification std. SW package*		*Deployment model*	*Single/Multi-site scope*
0 Vanilla-ERP	1 Configured vanilla ERP	2 Upgrade vanilla ERP to new service pack	3 Upgrade vanilla ERP to new release	9 Deployment mode from 'On premise' to ASP	11 Expansion of scope to multi-site (vanilla)
4 Vanilla ERP into modified ERP	5 Configured modified ERP	6 Upgrade modified ERP to new service pack	7 Upgrade modified ERP to new vanilla release / 8 Upgrade modified ERP to new modified release	10 Deployment mode from 'On premise' to SaaS	12 Expansion of scope to multi-site (modification)

Table 2 – Mechanisms of change, based on combination of changes between configuration and modification (Wortmann and Maruster – 2013).

The table expresses the possible changes of an ERP system, based on the mechanism of change taken into account and the current status of the system (a brief explanation of the 13 Mechanisms of change is provided in Attachment 3). For example, if a "Vanilla ERP" (*number 0* in the table) is modified, then the new system would be described by *number 4* – "Vanilla ERP into modified ERP". If number 4 is configured, then the new system is *number 5* – "Configured modified ERP". Thus, the model represents a workable and understandable example of the possible changes in ERP systems, based on two facts – the mechanisms of change of the system and its status before the change. This framework has some advantages over the one of Brehm et. al (2005) – it is easily understandable and an ERP project can be assigned to one change mechanism. Thus, this framework is the one, used in the current research.

In this chapter we have provided a definition of changeability from the literature and we have introduced the ERP changeability framework, selected by the researcher.

Chapter 4 – Results.

*In the chapter we present the results from the data collection process in a table. After the data collection and the selection of the case studies, we execute content analysis for organizational impact of ERP changeability – **open coding, axial coding and selective coding.** The goal of this chapter, is to present the results from the content analysis and thus to provide material for the answer of the third research question of the paper – "What recommendations and applications for ERP practitioners can be derived from the analysis of the results?"*

The result of the last step of the content analysis, as described at the end of chapter 2 is 22 different general codes, mentioned between one and eight times in the different case studies. In order to shrink this number, the 80-20 Pareto rule was applied to the selection. It was decided that the first 12 criteria will be represented in the paper, as far as they represent 85% of the total mentioned criteria. Thus all criteria, which were mentioned only once, were excluded from the analysis. The 22 criteria are shown in table 2, sorted as per times mentioned. The second column, *"Organizational Impact"*, shows the name of the impact, after the axial coding. The third column, *"Times mentioned"*, refers to the times the impact is mentioned in the papers. The forth column, *"Percentage"*, calculates the total percentage of the times mentioned vs. total times mentioned. For example: the first organizational impact, *Training,* has 12% as percentage, because it is mentioned 8 times and the total mentioned organizational impacts is 68. Thus 8/68 is 0.12. On the next column, the cumulative percentage is calculated. With this cumulative percentage, we set the borders using the Paretto rule

and ABC analysis. Thus, the end of the A group is set at 53%, the end of the B group is at 85% and the one, highlighted in green is the C group of the impacts.

	Organizational Impact	Times Mentioned	Percentage	Cumulative Percentage
1	USER TAINING	8	12%	12%
2	TENSION	8	12%	24%
3	IMPROVED REPORTING	7	10%	34%
4	IMPROVED PERFORMANCE	7	10%	44%
5	BPR	6	9%	53%
6	RESISTANCE	5	7%	60%
7	JOB ENRICHMENT	5	7%	68%
8	CHAOS or Confusion	3	4%	72%
9	BAD REPORTING	3	4%	76%
10	FUNCTIONALITY LOSS	2	3%	79%
11	IT ISSUES	2	3%	82%
12	BAD PERFORMANCE	2	3%	85%
13	ADDED ABILITY	1	1%	87%
14	ADDED COSTS	1	1%	88%
15	CS IMPROVEMENT	1	1%	90%
16	DEPARTMENT POSITION	1	1%	91%
17	INCREASED MANAGEMENT	1	1%	93%
18	IT MAINTENANCE REDUCTION	1	1%	94%
19	ADDITIONAL DEMANDS	1	1%	96%
20	NO ADDED FUNCTIONALITY	1	1%	97%
21	SCALABILITY	1	1%	99%
22	UNIFICATION	1	1%	100%

Table 2 – Organizational impacts of changeability, after performing content analysis of 18 selected case studies found in 10 academic papers

The rest of the chapter will explain the formation of the groups through selective coding. Then the data will presented in Table 10, showing extraction of information, from the 10 ERP changeability papers.

The first impact, "User Training" has been formed after an analysis of the open coding results, giving information for various trainings. As it is visible, that in the open coding, sometimes two codes are given for the same article, we would like to clarify that in this

case, the article has more than one case study described in it and the codes are given per different case studies. In the case of the "User training" organizational impact, it is visible, that in eight case studies terms related to user training were mentioned.

Title	Application of SAP R/3 in on-line inventory control	Integration in ERP environments: rhetoric, realities and organizational possibilities		A decision framework for enterprise resource planning	Estimating the impact of ERP project management	ERP evaluation during the shakedown phase: lessons from an	An exploratory study of the impacts of upgrading packaged software: a	Accounting logics, reconfiguration of ERP system and the emergence of new
Open coding	User Training, PC usage training and additional training after go-live	User training	User training	Extensive retraining of the staff	Training	Premature application training, leading to lack of user ERP skills	Training and retraining	Training

Table 3 – Formation of the organizational impact USER TRAINING through open coding and selective coding.

The second organizational impact is "Tension". It is formed as a result of tension characteristics, noted as an organizational impact in 7 case studies. Nerves, visible necessity of change, stress, tension and pressure were coded and united under this group.

Title	An exploratory study of the impacts of upgrading packaged software: a	From means to ends: The transformation of ERP in a manufacturing	Application of SAP R/3 in on-line inventory control	Integration in ERP environments: rhetoric, realities and organizational	What is IT? SAP, accounting and visibility in a multinational	Accounting logics, reconfiguration of ERP system and the emergence of new	ERP evaluation during the shakedown phase: lessons from an
Open coding	Nerves during the implementation	Visible necessity of organizational and cultural change	Tension within the company; Stress of the employees	Friction between project team and lead consultants	Complaints	Tension between faculty and supporting stuff	Pressure

Table 4 – Formation of the organizational impact TENSION through open coding and selective coding.

The third most reported organizational impact noted in the research concerns improved reporting. This impact is reported in 7 case studies, as various aspects of reporting improvement – better information available, new reports available, access to more information, ability to audit processing workflow and more data availability.

Title						
A decision framework for enterprise resource planning	Integration in ERP environments: rhetoric, realities and organizational	What is IT? SAP, accounting and visibility in a multinational	Strategies for the adaptation of ERP systems			
Open coding						
Better information on customer history	End of self-made spread sheet reporting	Access to more information	Better information sharing	Improvement of the decision making processes due to available data	Ability to audit order processing workflow	Increasing speed and quality of decision making due to available data

Table 5 – Formation of the organizational impact IMPROVED REPORTING through open coding and selective coding.

As far as one of the goals of the ERP Systems is actually the improvement of the organizational performance, it is no surprise that in seven case studies, this characteristic has been reported. This organizational impact has been noted as stock rotation and planning accuracy improvement, administrative time reduction, forecasting improvement, lead time reduction, process automatization.

Title						
Application of SAP R/3 in on-line inventory control	Integration in ERP environments: rhetoric, realities and organizational	What is IT? SAP, accounting and visibility in a multinational	A decision framework for enterprise resource planning	Strategies for the adaptation of ERP systems (in different case studies)		
Open coding						
Stock rotation and planning accuracy improvement	Reduction of administration time	Quick closing of the accounting books, improved forecasting	Lead time reduction, improved sales planning, reduction time and costs, process automatization	Improvement of company core competences	Delivery of real-time information in decision making; improvement of delivery rate; interdepartmental integration; better resource utilization	Overall performance improvements

Table 6 – Formation of the organizational impact IMPROVED PERFORMANCE through open coding and selective coding.

The next organizational impact of ERP project in an organization is the reengineering of business processes. It has been reported in six case studies, open coded as departmental reorganization, implementation of Kanban system and BPR.

	Title	Integration in ERP environments: rhetoric, realities and organizational	Estimating the impact of ERP project management decisions on post-	From means to ends: The transformation of ERP in a manufacturing	Accounting logics, reconfiguration of ERP system and the emergence of new accounting practices	
Title	Strategies for the adaptation of ERP systems					
Open coding	BPR of processes related to customer orders	BPR	BPR	BPR in terms of Kanban system	Process Reengineering	Departamental Reorganization

Table 7 – Formation of the organizational impact BPR through open coding and selective coding.

In five case studies we have noted organizational impacts, which can be coded as "Resistance". The impacts, taken into account through the open coding process were concerning various ways of expressing strong resistance – from implementation delay to protests and obvious unwillingness to work with the newly implemented system.

	Title				
Title	Accounting logics, reconfiguration of ERP system and the emergence of new	Integration in ERP environments: rhetoric, realities and organizational	Strategies for the adaptation of ERP systems	From means to ends: The transformation of ERP in a manufacturing	ERP evaluation during the shakedown phase: lessons from an
Open coding	Strong resistance to changes	User complaints for complication and messes, resistance	Internal resistance, delaying with 2 years the implementation	Protest of the workers (resistance)	Strong resistance

Table 8 – Formation of the organizational impact RESISTANCE through open coding and selective coding.

The changes brought to an organization by the modification/customization of the ERP system have brought to the creation of some new tasks. These tasks were assigned either to current workers or new full time jobs were opened in the company. When a worker receives new type of task, this can be described with the term "job enrichment". As far as job enrichment and new job creation are two methods to deal with the new tasks, coming from the ERP system change, the organizational impact is named "Job enrichment & new positions". This impact was noted in 5 case studies.

	Title				
Title	From means to ends: The transformation of ERP in a manufacturing	Application of SAP R/3 in on-line inventory control	Strategies for the adaptation of ERP systems	Estimating the impact of ERP project management decisions on post-implementation maintenance costs: a case study	
Open coding	Switch of responsibilities	Functional changes for some workers	Increasing the employee added value through job specification enrichment	Creation of a part time specialist's to deal with ERP maintenance issues	Creation of a full-time team to deal with maintenance issues

Table 9 – Formation of the organizational impact JOB ENRICHMENT & NEW POSITIONS through open coding and selective coding.

The last five impacts, which are considered in the paper – "Chaos or Confusion", "Bad Reporting", "Functionality Loss", "IT issues" and "Bad Performance" have been mentioned in 2 or 3 case studies. Their formation through open coding is presented in attachment 2 – "Other Organizational Impacts – Open Coding".

These 12 organizational impacts are presented in table 10, grouped per study. In order to make some distinction, we have **bolded** the impacts reported in 5 or more case studies and the impacts, reported in more than 1 study are written with *italic* font. It is interesting to see, that the organizational impacts are unevenly distributed among the case studies – there are cases with only one organizational impact, while some studies report more. The other columns, present in table 12 are explicitly clarified in chapter 2 – Methodology.

Title	Description of change(s)	Agent of change		Effects of change	Mechanisms of change	Organizational Impact
		Internal or(and) External	Driver(s) of change			
1. Accounting logics, reconfiguration of ERP system and the emergence of new accounting practices	**Step 1** - implementation of ERP software and development of two new unique modules - "integrated operating platform for the 21st century"	Internal	- poor financial planning practice - integrated approach needed for future upgrades simplification	Robustness - Scalability ND Modifiability ND Flexibility – Adaptability -	1. Configured vanilla ERP	**Resistance** *Functionality Loss* **BPR** *Chaos or Confusion* *Bad Reporting* **Tension**
	Step 2 (post-implementation) - customization (bolt-on) added; - ERP System redesign, adding required possibilities by stuff	Internal	- demand for old possibilities - powerful users	Robustness + Scalability + Modifiability + Flexibility - Adaptability +	4. Change of vanilla ERP to modified ERP (bolt-on)	**BPR** Added Costs **User Training**
2. Application of SAP R/3 in on-line inventory control	- implementation of an in-house solution for bar-coding, based on SAP R/3	External & Internal	-high inventories	Robustness + Scalability ND Modifiability ND Flexibility - Adaptability -	4. Change of vanilla ERP to modified ERP	**User Training** Additional Demands **Tension** **Improved Performance** CS Improvement **Job Enrichment**
3. Integration in ERP environments: rhetoric, realities and organizational possibilities	**Case study "Cable"** - modification of ERP package to include functionality to support possibility for quantity booking	External	Functionality for booking a quantity of product at a specific price is needed	Robustness + Scalability ND Modifiability - Flexibility + Adaptability +	4. Change of vanilla ERP to modified ERP	**User Training** **Resistance** **Improved Performance** **BPR** **Tension**
	Case study "Home" *Step 1* -modification of ERP to reflect pricing structure of the company	Internal	Pricing policy adds unacceptable level of complexity for the ERP	Robustness - Scalability ND Modifiability - Flexibility - Adaptability -	4. Change of vanilla ERP to modified ERP	**User Training**

	Case study "Home" *Step 2* -customization of the ERP resulting in various KPI reports	Internal	Stand-alone systems (spread sheets) by extracting data from the ERP package are developed	Robustness + Scalability + Modifiability - Flexibility - Adaptability -	5. Configured Modified ERP	Scalability Unification **Improved Reporting** Increased Management Possibilities
4. What is IT? SAP, accounting and visibility in a multinational organisation	*Step 1* -implementation of SAP in a multinational manufacturing company with sites in different countries	External	Y2K compliance	Robustness - Scalability = Modifiability - Flexibility - Adaptability -	1. Configured vanilla ERP	*Chaos or Confusion Functionality Loss Bad Reporting* Department obtains more power **Tension**
	Step 2 (post implementation) -ABAP code change, providing requested reports	Internal & External	- chaos in the accounting system due to different accounting practises - additional possibilities for account reporting required	Robustness - Scalability + Modifiability ND Flexibility = Adaptability =	5. Configured Modified ERP	**Improved Performance** **Improved Reporting**
5. A decision framework for enterprise resource planning maintenance and upgrade	-upgrade of two SAP modules into newer version	Internal & External	-Y2K compliance - Withdrawal of vendor's support for current version.	Robustness + Scalability + Modifiability ND Flexibility + Adaptability =	8. Upgrade modified ERP to new modified release	**User Training** IT Maintenance Reduction **Improved Performance** **Improved Reporting**
6. Estimating the impact of ERP project management decisions on post-implementation maintenance costs: a case study	*Step 1* -implementation of ERP system replacing student, HR and financial systems	Internal	-not integrated legacy system	Robustness + Scalability + Modifiability + Flexibility + Adaptability ND	5. Configured modified ERP	**User Training** **Job Enrichment**
	Step 2 Upgrade to a new version of the software	Internal & External	- Withdrawal of vendor's support for current version. - Need for compliance with mandated financial aid regulatory releases	Robustness = Scalability = Modifiability + Flexibility ND Adaptability ND	8. Upgrade modified ERP to new modified release	**BPR** **Job Enrichment**

7. From means to ends: The transformation of ERP in a manufacturing company	-new product & new manufacturing process require redesign of ERP	Internal	-Introduction of a new manufacturing process - management decision to exclude MRP module from ERP system	Robustness + Scalability + Modifiability ND Flexibility + Adaptability + *Note: Initially the results were very bad*	8. Upgrade modified ERP to new modified release	*Chaos or Confusion* **Tension** **Resistance** *Bad Performance* **Job Enrichment** **BPR**
8. Strategies for the adaptation of ERP systems	*Case Study 1* -implementation of ERP with customization of reports and quality control module	Internal	- 20 years old legacy system with no integration & poor documentation management	Robustness - Scalability ND Modifiability ND Flexibility - Adaptability -	5. Configured modified ERP	*IT issues* **Resistance** **Improved Performance** Added Ability **Improved Reporting**
	Case Study 2 -implementation of ERP with customization of 5 modules	Internal & External	- changing business climate and ferocious competition - process integration need	Robustness - Scalability ND Modifiability ND Flexibility - Adaptability -	5. Configured modified ERP	**BPR** **Improved Performance** **Improved Reporting**
	Case Study 3 Implementation of ERP system with customization of one module, management reports and interface	External	- process integration needed - Y2K compliance	Robustness - Scalability + Modifiability ND Flexibility - Adaptability +	5. Configured modified ERP	**Improved Reporting** **Improved Performance**
	Case Study 4 Implementation of ERP system with customization of one module, three internal systems and reports	External	- implementation of ERP forced by global competition	Robustness - Scalability + Modifiability ND Flexibility - Adaptability -	5. Configured modified ERP	**Job Enrichment** **Improved Reporting**
9. An exploratory study of the impacts of upgrading packaged software: a stakeholder perspective	Upgrade from SAP 3.0F to 4.6C. (13 version leap)	External	- mandatory upgrade undertaken	Robustness + Scalability + Modifiability = Flexibility = Adaptability -	7. Upgrade modified ERP to new vanilla release	**Tension** **User Training** No added functionality *IT issues*

| 10.
ERP evaluation during the shakedown phase: lessons from an after-sales division | Implementation of ERP in a company's after sales division | Internal | - share information need
- working procedures harmonization
- IT efficiency improvement | Robustness -
Scalability =
Modifiability =
Flexibility -
Adaptability - | 1.Configured vanilla ERP | **User Training**
CS Service Level decreased
Bad Performance
Resistance
Tension |

Table 10 – Extraction of information from various papers, concerning ERP changeability.
Legend:
+   *increased*
=   *no change*
ND   *no data*
-   *decreased*

Chapter 5 – Discussion

In the current chapter the results are discussed. The framework, concerning the second research question (RQ2: What framework for ERP changeability can be used in order to analyze ERP changeability results?) is tested with the results of the literature research. An answer to the third research question is provided (RQ3: What recommendations and applications for ERP practitioners can be derived from the analysis of the results?)

Based on the results, provided in the previous chapter, we try to formulate some applications for the proposed framework for ERP changeability. In table 10 on the previous chapter, we notice that the there is no Agent of change that dominates. The time "Internal" agent of change is mentioned is just three times more than the "External" agent of change. In table 11 is provided a summary of the total times a different agent of change is mentioned.

Agent of Change	Number	Total + I&E	Percentage
Internal	8	13	57%
External	5	10	43%
Internal & External	5		

Table 11 – Summary of number of "Change Agents", found in Table 10.

The reported drivers of change are various, as far as the researched businesses vary. We may recognize mandatory upgrades, Y2K fear, need for harmonization & improvement, new process introduction, existing chaos. These drivers of change trigger different changeability projects. The changeability projects, reported in the 18 case studies are with 5 different change mechanisms (see table 12). The most reported mechanism of change is "Configured Modified ERP". The other four reported mechanisms of change are "Change of vanilla ERP to modified ERP" with 4 cases, "Configured vanilla ERP" with 3 cases, "Upgrade modified ERP to new modified

release" with 3 cases and "Upgrade modified ERP to new vanilla release", which is mentioned only once.

Mechanisms of change	Number of cases
Configured Modified ERP	7
Change of vanilla ERP to modified ERP (bolt-on)	4
Configured vanilla ERP	3
Upgrade modified ERP to new modified release	3
Upgrade modified ERP to new vanilla release	1

Table 12 – Mechanisms of change in the 18 case studies

As far as, in our sample, the "Configured Modified ERP" is the most widely spread change mechanism, we shall investigate its effect of change and we will compare them with the change effects coming from the ERP changeability framework. The five change effects, as defined by Ross et al. (2008) are presented in table 13 for the seven case studies with configured modified ERP.

	Configured Modified ERP (cases)							Summary per case			
Case Nr:	1	2	3	4	5	6	7	+	-	=	ND
Robustness	+	-	-	-	-	+	-	29%	71%	0%	0%
Scalability	+	+	+	ND	ND	+	+	71%	0%	0%	29%
Modifiability	-	ND	+	ND	ND	ND	ND	14%	14%	0%	71%
Flexibility	-	=	-	-	-	-	+	14%	71%	0%	0%
Adaptability	-	=	ND	+	-	-	-	14%	57%	0%	14%

Table 13 – Summarized results of change effects from configured modified ERP cases

Legend:
+   Increased
=   no change
ND   no data
-   decreased

For each of the seven case studies we add a separate column, where the result after the ERP changeability project is noted, in terms of "Robustness", "Scalability", "Modifiability", "Flexibility" and "Adaptability". With the accumulation of these projects with similar change effects, we may compare their results with the one, proposed by the

framework which is considered by the current paper. In the part of the graph "Summary per case", a summary of the results is provided in percentage. The values, different than 0% are highlighted with a different green hue correspondingly.

In the draft paper of Maruster and Wortmann (2013), we see that the expected changed effects for Configured Modified ERP are as follows (see table 14):

Effect of change	Result
Robustness	decrease
Scalability	remains risky
Modifiability	no effect
Flexibility	decrease
Adaptability	decrease

Table 14 – Summarized results for expected change effects from configured modified ERP cases (draft paper of Maruster and Wortmann – 2013)

In table 13, we note that the level of *robustness* has decreased in 5 of the 7 case studies, which is a decrease in 71% of the researched cases. *Flexibility* and *adaptability* are also reduced in 71% and in 57% of the researched cases correspondingly. This matches the expectations of the draft paper. Regarding the other 2 change effects – *scalability* and *modifiability* no results can be drawn upon, due to the lack of sufficient information in the case studies. Thus, in order to summarize these findings, we may conclude that the proposed framework is trustworthy and workable. Furthermore, it is easy to understand and work with. However, in order to prove it completely, further research is needed, in which every mechanism of change is researched and tested separately for the expected effects.

Regarding the third research question, requiring recommendation and application of ERP practitioners, the analysis of the case studies has to offer interesting deliverables, concerning the organizational impacts of changeability, reported by the case studies.

In table 2 in the previous chapter, we have calculated the percentage of mentioning a specific organizational impact. The most mentioned organizational impact - "user training" is expected – after all, the introduction of new software must be followed by training.

The next most mentioned organizational impacts concern improved reporting and improved performance. Considering the fact that the ERP is the single biggest IT investment an organization can make (Dezdar and Sulaiman - 2009) these are expected results – organizations adopt packaged software solutions to save costs (Oberndorf - 1998, Voas - 1998, Light and Sawyer - 2007) and to improve capabilities (Yang et al. - 2005). Saving costs can be considered a result of the improved performance (Ramsey et al. – 2001) & improved reporting is part of improved capabilities.

The organizational impact "Tension" is mentioned in 39% of the articles. This percentage is not expected, due to the fact that it is unwanted and it comes as a result (or lack) of some actions of the ERP project team. It is reported quite often and some attention should be paid to it. The reasons for the tension in the case studies were different – lack of IT abilities of the employees, change of procedures they are used to deal with, change of job tasks, unwillingness to accept new procedures due to not seeing their value. These tension triggers should be avoided at any ERP projects, due to the fact that the tension is definitely a negative unwanted effect from the project.

One of every three case studies has reported as an organizational impact business process reengineering (BPR). It is interesting to see that, three case studies have

reported both BPR and tension, which comes as a result from the BPR. Thus, considering the fact that sometimes ERP projects require BPR, then the ERP project team should be more diverse and thus including business process consultants as well.

The impact of resistance is mentioned in 5 case studies. At two of them it is mentioned together with tension, in other two with "Chaos or Confusion". Thus, in some cases the resistance can be looked as the next stage of tension. This is a really unpleasant organizational result from ERP project, because it results in financial losses or/and workload increase.

As a result of ERP changeability project in 28% of the cases, new tasks are created. These tasks are either taken over by new positions or they are redistributed among the current employees. It is interesting to note, that the job enrichment is not related to tension or resistance – only in one of the cases with job enrichment there is tension or resistance reported.

The impact "Chaos or Confusion" is present in three case studies. In two of them tension and resistance are mentioned and in one of them only tension. In order to present a comprehensive map of the studies, where *resistance*, *tension* and *chaos* are mentioned, diagram 1 is created. In the diagram we see the number of studies, reporting tension, chaos and resistance together and separately. We note that 2 studies have reported the three organizational impacts, and other three studies have reported two of the three impacts. Only one impact was reported by 3 other studies.
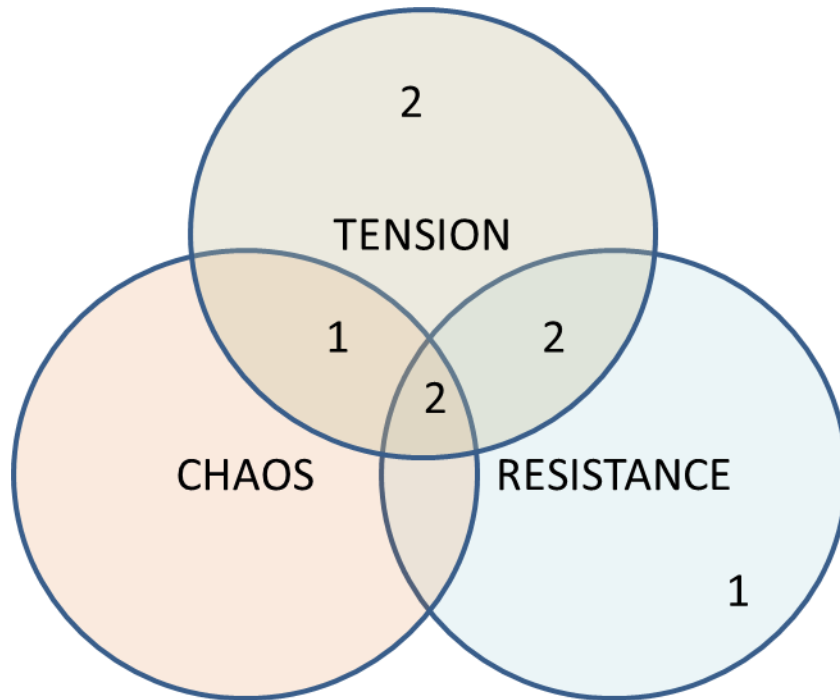
Thus, in the diagram, we see that tension, resistance and chaos are indeed often related, but in some cases tension may not escalate to something else.

The organizational impact of ERP change results in bad reporting in 2 of the 18 case studies. In both cases we have also tension and in one case resistance. Thus, we may argue about a possible relation between quality of reporting and tension.

Bad performance and functionality loss are reported in total in four case studies – each impact is reported twice. When we take a look at the other organizational impacts, reported in the same case studies, we see that tension has been reported in all of them as well, resistance in 3 of them and chaos in two of them, as shown in table 14.

	Functionality Loss	Bad Performance
Case Study 1	Tension - Resistance - Chaos	Tension- Resistance
Case Study 2	Tension - Chaos	Tension- Resistance

Table 14 – Presence of Tension, Resistance and Chaos in case studies, where functionality loss and bad performance are reported.

With table 14 and its results, it is visible that in the analyzed cases tension and negative organizational impacts go together.

The last organizational impact, concerning IT issues is present in 2 cases. These are isolated IT technical problems – difficulties of data transfer and some hardware malfunctions.

After analyzing the results from the organizational impacts from the case study, we may formulate an answer of the third research question, concerning recommendations and applications for ERP practitioners. We have come up with findings, which should be taken into account. The first is the fact that in 7 out of 18 case studies we have some organizational result, related to tension. In some of the studies it escalates to resistance against the new software package modification and even to a chaos within the company. As far as this is a strongly unwanted impact for any organization, actions should be taken into account to prevent such results. In order to provide a list of such stress reduction actions we need a separate paper as far as these actions may vary widely, depending on the company environment & culture and the exact causes of the stress and tension (Steinischa et al. – 2013).

The second finding concerns possible explanation of the first one - in half of the cases, impacts related to tension are reported together with loss of functionality or bad performance. Due to the relation, professionals should expect organizational tension if the ERP project goes wrong. In order to limit the negative impacts over the company in this case, the employees should be informed of possible negative results and tension avoiding techniques should be applied.

A third finding of this paper, is a possible list of expected organizational impacts, after an ERP changeability project. These impacts can be generalized into positive and negative, based on their influence over the company. The impacts, which cannot be classified into one of these two groups, are put in a separate group, "Neutral".

Positive Impacts	Negative Impacts	Neutral Impacts
Improved Reporting	Tension	User Training
Improved Performance	Resistance	BPR
	Chaos or Confusion	Job enrichment
	Bad reporting	
	Functionality loss	
	IT issues	
	Bad performance	

Table 15 – Organizational Impacts of ERP changeability project.

It is interesting to note, that if we go back to Table 10 and check the cases, containing negative impacts, we would always find more than one reported. Thus, we may conclude that these negative impacts are interrelated. It is probably interesting to try to make a further analysis of the negative organizational impact, dividing them into a primary (reason) and secondary (result) – e.g. – bad performance is the reason for tension. However, with the reported case studies, we have noted that this is not always the case – an ERP changeability project may lead to bad performance, which may lead to tension, which leads to even worse performance, which leads to chaos. This scenario is described in paper №7 from Table 10 – "From means to ends: The transformation of ERP in a manufacturing company" (The sequence of the negative organizational impacts is presented in Table 16). However, we see exactly the opposite type of primary organizational impact in Paper №1 in the same table – "Accounting logics, reconfiguration of ERP system and the emergence of new accounting practices". There

we have at first resistance against the idea of changing the system and then we have functionality loss, bad reporting, and chaos and confusion.

From means to ends: The transformation of ERP in a manufacturing company

Bad performance → Tension / Resistance → Even worse performance → Chaos and confusion

Accounting logics, reconfiguration of ERP system and the emergence of new accounting practices

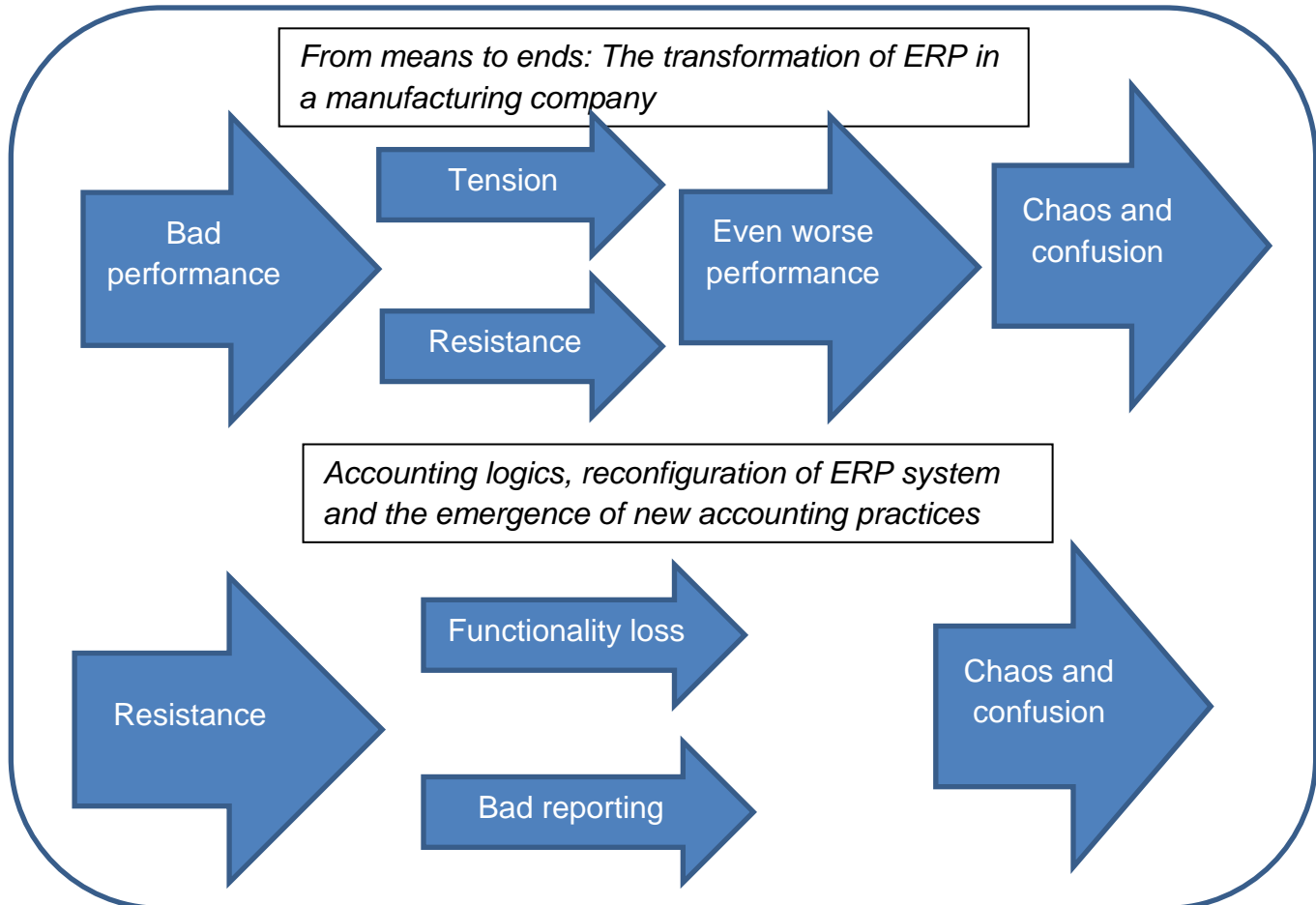Resistance → Functionality loss / Bad reporting → Chaos and confusion

Table 16 – Sequence of negative organizational impacts of two selected changeability projects

Thus, we may conclude, that possible negative impacts of an ERP changeability project are dependent on the organizational environment and cannot be classified into primary and secondary, but they are based on each case separately, depending on the case specifications.

Chapter 6 – Conclusion

Knowing that an average ERP upgrade carries a price tag of $1.5 million (Bonasera – 2002), the impact of an ERP changeability project is extremely interesting for any company stakeholder. Furthermore, when a company starts an ERP changeability project and decides to abandon it in the middle of the project, the financial loss can be really significant, as the case for the second largest retail chain in Canada, which has decided to abandon ERP system initiative and take a resulting $49.9 million charge in its quarterly report (Financial Post, Jan 25, 2001).

With the current paper we have moved one step closer towards the challenge to create, summarize and test knowledge concerning ERP changeability projects. We have set three research questions at the beginning of the paper, concerning ERP changeability:

1. What is ERP changeability? How is it defined in the literature?
2. What framework for ERP changeability can be used in order to analyze ERP changeability results?
3. What recommendations and applications for ERP practitioners can be derived from the analysis of the results?

In order to define ERP changeability, we have made use of the core concept of "Changeability", defined by Ross et al. (2008), which is described with three main aspects: *change agents* as forces instigating the change to occur, *change mechanisms* as particular path a system must take in order to transition from one state to another and *change effect*, as the difference in state before and after the change takes place. The concept of Ross et al. (2008) possesses five system parameters,

describing changeability - Flexibility, Adaptability, Scalability, Modifiability and Robustness. These five parameters were embedded in a changeability framework from Wortmann and Maruster (2013), predicting their change after a specific type of ERP changeability project is carried out. With the current paper we have looked into 18 case studies, with ERP changeability, found in 10 articles. For each of these case studies we have collected information regarding their **change effect** after the project and the **mechanism of change**. Then, we have compared the real change, reported in the case studies to the change expected by the changeability framework, in order to prove that the framework is a trustworthy one and may predict the effects of change in an ERP changeability project.

The third research question, concerning recommendations and applications for ERP practitioners was answered with analysis of the results. We have collected 12 organizational impacts of the changeability projects from the selected 18 case studies through content analysis. Then they were divided into three groups - positive, negative and neutral. Each impact is explained and a possible reason for its appearance was provided. It is interesting to see, that in 44% of the researched cases, unpleasant organizational impacts related to tension were found. In some cases, the tension escalated to chaos and production stops, which is definitely an unwanted result from an ERP changeability project. Thus, the third question, concerning recommendations and applications for ERP practitioners is answered with a list of organizational impacts, following an ERP changeability project. Furthermore, a flag is raised, considering the high risk of tension related organizational impacts, coming from an ERP changeability project.

This paper has two main deliverables - it presents and tests an ERP changeability framework and it collects and summarizes organizational impacts from ERP changeability projects. Regarding the first deliverable - the test of the ERP changeability framework, the results concerning the change in the five system parameters, describing changeability were expected. However, in order to validate the framework completely, further research with more samples is needed. Concerning the second deliverable - the summary of the organizational impacts - to the author's knowledge this is the first time organizational impacts of ERP changeability project are summarized. Although, until now in the literature similar impacts were reported in separate studies (Candra – 2012; Ehie and Madsen - 2005), this is the first literature research to take a look at them as a whole and to summarize them together.

The paper has its strengths in the well-developed ERP changeability framework, which it is testing and the high quality of selected articles for ERP changeability. With this qualitative input, the paper results can be considered good as well. A weakness of the paper is probably based on the small sample of researched cases. As a suggestion for further research, it would be interesting to carry out a research in a number of companies, undergoing ERP changeability project and to test the change of the five system parameters, describing changeability.

To facilitate an ERP changeability project, the project team should be aware of the possible negative organizational impacts from ERP changeability projects, provided in the current paper. The results from these impacts should not be underestimated, as far as in some of the case studies they have brought to production halt, costing millions of EUR. In order to answer the question how to avoid these negative impacts, we should

research each case separately, as far as the grounds for these impacts may vary - in the paper we have evidence of different conditions, leading to the same negative organizational impact.

Attachment 1: List with words, related to ERP changeability

Category	Term
Changeability related terms from literature	Configuration, modification, customization, adaptation, tailoring, flexibility, personalization, modeling, hard-coded logic
ERP related keywords	implementation, adoption, parameter setting
Merriam dictionary	adaptable, adjustable, alterable, flexible, elastic, fluid, malleable, modifiable, pliable, variable
Others	Maintainability, agility, patches, service packs, release –new versions, malleability, robustness, scalability, modifiability

Attachment 2: Other organizational impacts (open coding)

Chaos or Confusion

Title	What is IT? SAP, accounting and visibility in a multinational	From means to ends: The transformation of ERP in a manufacturing	Accounting logics, reconfiguration of ERP system and the emergence of new
Open coding	Chaos in the accounting system due to different accounting practises around the world	Complete loss of control and production stop	Main users are puzzled

Bad Reporting

Title	What is IT? SAP, accounting and visibility in a multinational	Accounting logics, reconfiguration of ERP system and the emergence of new	ERP evaluation during the shakedown phase: lessons from an
Open coding	Users felt "blind" because they could not see events in remote subdirectories	Reduced ability to control and manage spendings by Project Managers	Unreliable information, concerning product availability

Functionality Loss

Title	Accounting logics, reconfiguration of ERP system and the emergence of new	What is IT? SAP, accounting and visibility in a multinational
Open coding	Loss of reports the personel and other useful functions	Lack of quick reporting through the system

IT Issues

Title	Strategies for the adaptation of ERP systems	An exploratory study of the impacts of upgrading packaged software: a stakeholder perspective
Open coding	Difficulties data transfer from previous system hanging of organizational structure	Printers & faxes became unoperate for some time during the implementation

Bad Performance

Title	ERP evaluation during the shakedown phase: lessons from an after-sales division	From means to ends: The transformation of ERP in a manufacturing company
Open coding	Slowing down of business processes due to double check, thus increasing workload	Financial loss of millions of EUR

Attachment 3: Brief explanation of the mechanisms of change, provided in the ERP Changeability framework of Wortmann and Maruster.

№	Name	Explanation
0	Introduction of Vanilla-ERP	Introducing an EPR without configuration or upgrade. The package, which is installed without changes, is called "vanilla".
1	Change in configuration of vanilla ERP	Change required by the new business reality, which should correspond to the installed system.
2	Upgrade vanilla ERP to new service pack	An upgrade of implemented ERP system, enforced by the ERP vendor in order to fix a number of bugs.
3	Upgrade vanilla ERP to new release	An upgrade of a vanilla package to a new version.
4	Change of vanilla ERP to modified ERP	It means that the software is modified (often extended) in a way which is not foreseen and not supported by the vendor. The consequence of modification is that future upgrades are complicated.
5	Change in configuration of modified ERP	This is the same as №1, but here the change is done in modified ERP.
6	Upgrade modified ERP to new service pack	This is the same as №2, but here the upgrade is done for modified ERP.
7	Upgrade modified ERP to new vanilla release	This is the same as №3, but here the upgrade is done for modified ERP
8	Upgrade modified ERP to new modified release	This is the same as №7, but after the completion of the effort, the process continues – a new modification is carried out, to meet the business needs.
9	Deployment mode from 'On premise' to ASP	ASP stands for "Application Service Provider". In this mechanism of change, the ERP software is substituted by ASP ERP, which provides similar ERP solutions to multiple (similar) customers. E.g. different apparel retail companies. Due to the fact that the customers are more than one, the changeability of the system is restricted.
10	Deployment mode from 'On premise' to SaaS	SaaS stands for Software-As-A Service. In this mechanism of change, the ERP software is substituted by cloud-based software. The initial SaaS is vanilla. However, the SaaS ERP software can be configured per customer.
11	Expansion of scope to multi-site (vanilla)	This mechanism of change implies a change of the business model – the ERP is expanded to multiple sites from a single site. In this case, the increase in scope may pertain to all kinds of functionality, which were initially disabled. A multi-site implementation of ERP requires more configuration choices to be made, than a single site configuration.
12	Expansion of scope to multi-site (modification)	This is the same as № 11, but we have modification of the ERP software during the implementation.

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