Corvinus University of Budapest

Doctoral School of Business Informatics

Use of Ontologies and Business Process Management Systems to Measure the "Knowledge Fit" of an Organisation

Doctoral Thesis

Arru Matteo

Supervisor: Dr. Gábor András CSc.

Department of Information Systems

Budapest, 2018

Arru Matteo

Use of Ontologies and Business Process Management Systems to Measure the "Knowledge Fit" of an Organisation

Department of Information Systems

Supervisor: Dr. Gábor András CSc.

Corvinus University of Budapest

Doctoral School of Business Informatics

Use of Ontologies and Business Process Management Systems to Measure the "Knowledge Fit" of an Organisation

Doctoral Thesis

Matteo Arru M.Eng, MBA

Supervisor: Dr. András Gábor CSc.

Department of Information Systems

Budapest, 2018

Table of Contents

Index of Figures

“To my Dad that encouraged me to start this journey: I wish you could be here to celebrate with me the conclusion “

1. Introduction

1.1. Motivation

We have been working on Business Process Improvement since 2005 when we were working in Toshiba in the “Management Improvement 21” program.

We enjoyed the systematic and quantitative approach to organisational change that this produced in the Italian subsidiary I was employed by. We learned the basics of Six sigma up to obtain a Six Sigma Blackbelt certification.

Our interest in this discipline develop after our experience in the Japanese company, and we wanted to understand its applicability in more varied settings. We joined, therefore, a Management Consultancy firm (Galgano & Associati Consulting) that is very famous for driving Lean transformations in the primary Italian industries. We learn that Improving is much more than a technical matter of moving activities or enforcing procedures; it was in fact about managing people, their expectations, their knowledge and their relationship with the management and the other colleagues.

When we were then working at the European Institute of Technology in Budapest, I got to know the importance of technology to support a business transformation. It was during our years working for the European Commission’s institute that promotes innovation that we decided we want to contribute to the development of the knowledge on how information systems can support a business transformation; we started, therefore, our research around Knowledge Management that drew us to draft this thesis.

In the meanwhile, we developed our professional career joining University College Dublin where we were lecturing principles of Lean Six Sigma in the School of Nursing and Health Systems. In healthcare, the value of the human component is predominant, and we learnt that there no business transformation can happen if there is no transformation of people attitude and professional development.

When we joined the MOL Group, we realised that large organisations are very schizophrenic in their tentative of pursuing business improvement. Nowadays everyone recognises the need of change and want to contribute. However alignment of initiatives and efforts is an essential driver toward a real value creation from those programs.

However, that was all about can coordinate the human value that is available and capitalise on the improvement exercise but also for the business execution.

1.2. Thesis outline

This thesis has 8 chapters. Chapter 1 deals with the overall context of this research. In particular, is explained the motivation to investigate this area of knowledge, the research methodology applied and the overall technical context in which we elaborate the research questions.

Chapter 2 gives the theoretical context by presenting how our study is completing the research in the area of intellectual capital measures.

Chapter 3 introduces a broad literature review of Business Process Improvement practices. This chapter shows the relevance of this research in supporting the strategic decision of reorganisation of enterprises.

The theoretical innovation of this thesis is described in the Chapter 4. This chapter introduces the concept and the measure of the "Knowledge Fit" while Chapter 5 explains the PROKEX system that is the operating environment in which this research was conducted and how the notion of "Knowledge Fit" can support decision of process improvement or company reorganisation.

In Chapter 6 we describe initial experiments precursor to the business case in which we prepare the BPM model and the ontology to test the PROKEX iteration and to enrich the model.

In Chapter 7 we describe the actual passages of the experiment and in Chapter 8 we will answer the research questions and draw conclusions.

STUDIO is an ontology-centric knowledge management tool. It has been developed by Corvinno Technology Transfer Ltd for several years. The STUDIO platform consists of three main parts: the domain ontology represents the concept hierarchy and relations among the concepts of different domains and subdomains. The second part is the knowledge base, the knowledge elements are associated with the ontology nodes. The third part contains node specific MC questions, optionally more questions, according to difficulty and/or language mutations. Hence STUDIO can be used for multiple purposes: helping self-learning activities of students, testing requested knowledge of performers in very different kind of organizations to setting up training program or improving performer-job assignment, recruitment and selecting future employees, grabbing and articulating corporate knowledge. During the past decades STUDIO was tested and deployed in several very different types of research projects and it is regularly used in formal training.

PROKEX - Integrated Platform for Process-based Knowledge Extraction (Vállalati tudásmenedzsment támogatása szemantikus folyamatmenedzsment technológiával) had been developed under a EUREKA project (EUREKA_HU_12-1-2012-0039) within the consortium of Netpositive Ltd, Corvinno Ltd and Nissatech Ltd. The main goal of the project and the development is creating an environment where from BPM models the verbose description of processes and tasks can be extracted for further processing. The combination of process knowledge and domain knowledge opened a promising corridor to grab the corporate knowledge, the identified knowledge gaps served as a driver obtaining the missing pieces of knowledge and/or articulating tacit knowledge. It was not part of the project, but it paved the way to design reorganization actions, feeding back to the initial BPM.

1.3. Why the "Knowledge Fit"?

When Facebook went public in 2012 it was quoted at 104 billion dollars, however, at that time, it did not have any revenue. (Olney, 2012) In a famous conference, Bill Gates CEO of Microsoft said: "Our primary assets, which are our software and our software-development skills, do not show up on the balance sheet at all; this is probably not very enlightening from a pure accounting point of view." (The Economist and Economist, 1999) At the end of the last century, the economic society realised that the value of a company is not related only to its physical assets but in particular in the so-called "intangible assets." The protection of such valuable assets is vital for the resilience of the knowledge-intensive companies.

This research aims to develop an approach to support organisations measuring their capacity to optimise the intellectual capital that they hold in their organisation and in particular the human capital. We call this measure "Knowledge Fit". Through this approach, we would like to provide a framework that can help the organisations to understand to what extent the available knowledge in an organisation is sufficient to operate. Specifically, the organisation can take advantage of its human capital if there is a sufficient alignment between the process improvement practice and the human resources.

1.4. Purpose of the research

The purpose of this research is to validate that the framework can produce a measure that can identify gaps and provide valuable elements to improve processes, organisation and the measuring system itself.

Finally, we will draw conclusions that will reflect upon the benefit or defects of this approach in comparison with different methods available in the literature and/or practice.

1.5. Problem statement and research questions

Practices of process improvement stress the concept that good business performance is mainly connected with the optimal process execution.

Taiichi Ohno (Jones, 2003), father of the Toyota Production System was used to say: “Brilliant process management is our strategy. We get brilliant results from average people managing brilliant processes. We observe that our competitors often get average (or worse) results from brilliant people managing broken processes.”

The general approach of the modern practices for Business Process Improvement does not put the organisational issues as a priority in the activities. The value for the customers is the first element of a re-engineering, followed by the efficient process definition, and only after that technology and organisation enter in the picture. However, technology and human resources complete the picture but are not in the foreground.

Nevertheless, in all re-engineering action, there is a moment of the capacity check where a foreseen process future state should be dimensioned per a future capacity.

In this research, we are exactly focusing on this capacity that must be able to support the process reorganisation. We will develop an approach to the evaluation of the required organisational capacity with a focus on the capacity regarding knowledge.

In fact, it is the common practice to evaluate the capacity regarding FTE allocated to the individual activities as any person is equivalent in the execution.

In the literature research, we will support the idea that optimal processes require correct knowledge. This is a general truth, but the importance of having skilled resources is even more critical in those processes at high complexity.

With the new technological advancements, technology is rapidly replacing people in low knowledge intense jobs; therefore the human resources need to be always more specialised. Specialised knowledge becomes scarce; this is when having knowledge optimisation techniques may play a crucial competitive advantage.

Research Question 1: How can we determine the knowledge capability required by an organisation to run its processes?

To address this problem, we will propose a theoretical measurement framework that will provide an analytical and synthetic measurement of a "de facto" situation of a "Knowledge Fit" given a formal definition of the business processes, skill test results and formal organisational deployment[1]. In this thesis, we will emphasize determining what the level of analysis for which we should perform knowledge measures are.

Research Question 2: What are the possible approaches to validate a reorganisation[2] with a knowledge capability perspective?

Answering this question requires to identify an operating system that supports the formalisation of the reorganisation and, at the same time support a systematic measure of the knowledge capability for the system. To develop this, we will show how semantic enabled BPMS used in conjunction with the PROKEX system and the STUDIO semantic testing platform can provide a sound environment to support the organisational simulation. With the term reorganisation, we mean any change that impacts either people, processes and/or the organisation of systems.

Research Question 3: Is there any possibility for a semi-automatic or automatic solution to optimise the allocation of people to perform business activities?

This third question is very connected to research question 2. In fact the framework that we are going to define on one side will provide knowledge indicators to support decisions at the topological level; at the same time may provide scenarios (using those indicators) that maximise the "Knowledge Fit" while variating the elements of the organisation.

---

[1] In Chapter 4.1 we will give a more exhaustive explanation of the organisation deployment that in brief is the process of connecting individual job holder with the activities through a chain of organisation entities (individuals, positions, roles, activities).

[2] In our context a reorganisation can involve a change in any of the dimensions: People, Processes and Organisation. We must also pay attention to the connection between those three elements of a change: the impact that any individual change has on the other.

By testing in a real case, we would like to highlight the pros and the limitation of an automatic solution that optimisation of the organisational deployment based on the maximisation of the "Knowledge Fit".

1.6. **Research methodology**

This thesis will use case studies to validate the measure approach while identifying those critical points that can impact the adoption of the conceptual framework in a possible real-life implementation. It is important to mention that this thesis mainly focuses on validating the applicability of the conceptual framework but not the generalization of the approach. According to Harland (Harland, 2014), in a case study, the unexpected should emerge, and when it does, there is potential to make a useful contribution to knowledge, theory and practice. The objective of the study will, therefore, explain what the reader or listener needs to consider before they contemplate change and it will be seen as critical in the sense that it avoids being dogmatic in its examination of the case and theory.

The thesis will follow a methodology that was already adopted for several theses (Török, 2014) in this doctoral school and whose steps are the following :

- To research reference paradigms in literature
- To develop a theoretical framework
- To develop an operating environment to work with the theoretical framework
- To identify the requirements against the case study and perform the analysis of the case
- Validate the theoretical framework through the case study

This thesis develops and follows a methodology, which is known in the social sciences investigating the value of intellectual capital in the context of business reorganisation. The methodology incorporates some elements of computer science architecture that in this context can lead to different approaches by the approach that in this school already Klimkó (Klimkó, 2001) followed.

As long as the methodology that we used is based on the adoption of specific computer infrastructure, including Business Process Modelling (BPM) and semantic web technologies, the computer science approach is the prevalent similar to what Weber (Weber, 2017) concluded in his doctoral thesis.

According to Amaral et al. (Amaral *et al.*, 2011), research methodologies in the field of computer science may be of five type:

- Formal
- Experimental
- Build
- Process
- Model

Based on this overview the next sections will shed more detailed light on the collected methodologies, based on the summary by Amaral et al. (Amaral *et al.*, 2011).

1.6.1. **Formal methodology**

In computing science, formal methodologies are mostly used to prove facts about algorithms and system. Researchers may be interested in the formal specification of a software component to allow the automatic verification of an implementation of that component.

Alternatively, researchers may be interested in the time or space complexity of an algorithm, or on the correctness and the quality of the solutions generated by the algorithm.

1.6.2. **Experimental methodology**

Experimental methodologies are broadly used in CS to evaluate new solutions for problems.

Experimental evaluation is often divided into two phases. In an exploratory phase, the researcher is taking measurements that will help identify what the questions that should be asked about the system under evaluation are. Then an evaluation phase will attempt to answer these questions.

A well-designed experiment will start with a list of the questions that the experiment is expected to answer.

1.6.3. **Build methodology**

A build research methodology consists of building an artefact, either a physical artefact or a software system, to demonstrate that it is possible.

To be considered research, the construction of the artefact must be new, or it must include new features that have not been demonstrated before in other artefacts.

1.6.4. Process methodology

A process methodology is used to understand the processes used to accomplish tasks in Computing Science.

This methodology is mostly used in the areas of software engineering and man-machine interface which deal with the way humans build and use computer systems.

The study of processes may also be used to understand cognition in the field of artificial intelligence.

1.6.5. Model methodology

The model methodology is centred on defining an abstract model for a real system.

This model will be much less complicated than the system that it models, and therefore will allow the researcher to understand the system better and to use the model to perform experiments that could not be performed in the system because of the cost or the accessibility.

The model methodology is often used in combination with the other four methodologies. Experiments are based on simulation models. When a formal description of the model is created to verify the functionality or correctness of a system, the task is called model checking.

1.7. **Fundamentals of social science research**

The research methodology provides the rationale for the application of specific procedures or techniques used to identify, select, and analyse information applied to understanding the research problem. (Kallet, 2004)

The fundamental approach in the research tradition are those of deduction and induction (Kirkeby, 1990).

Every research work has the goal either to explore new theories by searching for unknown relations, or to prove discovered but still unproven theories, thus adding to the general knowledge of the given field. These two aims necessitate a different logical approach: while a research based on validation requires deductive logic, an exploratory research follows the inductive logic. (Török, 2014).

1.7.1. **Exploratory research and research based on validation– inductive or deductive logic**

When a research aims to test assumptions or hypothesis that are derived from theory in the field of research, is opportune to use a validation approach because it uses a deductive research approach.

According to Kovács & Spens (Kovács and Spens, 2005) deductive research follows, in fact, a conscious direction from a general law to a specific case. Contrary to this procedure, the inductive research approach reasons through moving from a specific case or a collection of observations to general law, i.e. from facts to theory (Alvesson and Sköldberg, 1994; Danermark, Berth; Ekstrom, Mats; Jakobsen, Liselotte; Karlsson, 2002). For that reason a deductive research approach is most suitable for testing existing theories, not creating new ideas (Stentoft Arlbjørn and Halldorsson, 2002).

It uses deductive logic which is applied to test research theories based on hypotheses. Thus, it is visible that making hypotheses is inevitable in research based on validation. Only after having the hypotheses put down in black and white can the researcher proceed to the observatory part of the research and the evaluation of the hypotheses.

The exploratory approach is an excellent choice in cases when the field of research is entirely or mostly unexplored. Exploratory researches are carried out typically with three primary goals (Szabó, 2000):

- ensure a better understanding of the topic,

- serve as testing the feasibility of future, more thorough researches,
- develop applicable methods for further researches.

In fields where this approach is appropriate, making testable hypotheses would often be too early and untimely. Moreover, the process through which theory development takes place is less strict by its nature (Benbasat, Goldstein and Mead, 1987). Exploratory research is based on inductive logic which says that theories can be developed by analysing research data and generalisation.

When examining PhD theses of our faculty, it must be noted that Klimkó does not make any hypotheses in his PhD thesis (Klimkó, 2001), but instead he draws up his research-related expectations. He, however, emphasises that it is the inductive approach that makes this possible because his thesis is not of research based on validation nature. "Amongst the questions, there are no deductive ones that could be aimed at validating hypotheses. All questions are of inductive nature. That is why our research questions are about "expectations" instead of "hypotheses" (Klimkó, 2001).

Our present research is of exploratory nature and follows the inductive logic. In our thesis, we are going to identify research questions and tasks along with hypotheses and will explain the importance of the questions. Also, by reaching the goals set in the questions, we are also going to explain the importance of the chosen topic itself.

1.7.2. Qualitative and quantitative research

From a methodological point of view, we can take the qualitative and quantitative approaches commonly used in organisation evaluation methods as a basis (Balaton and Dobák, 1982). Quantitative methods include the application of mathematical and statistical means for data processing, so these methods can be used in research where a lot of measurable data is available.

If we want to explore and understand the deeper relations within a discipline without trying to analyse numerical data sets, it is reasonable to use qualitative methods. These are suitable for research fields where a well-founded knowledge base has not been established yet or when the aim is to solve a problem and theory is built based on this solution. To avoid the drawbacks of the methods, it is recommended to use methodological triangulation (the application of different research methods and perspectives for analysing the same question) (Balaton and Dobák, 1982). Types of triangulation are:

- simultaneous application of various quantitative procedures
- simultaneous application of various qualitative procedures
- the combination of quantitative and qualitative methods

Our present research is based on qualitative methods because it follows an exploratory, deductive logic without having access to large, measurable data sets.

1.7.3. **Research based on case studies**

Learning from a particular instance (conditioned by the environmental context) should be considered a strength rather than a weakness. The interaction between a phenomenon and its context is best understood through in-depth case studies. To an increasing extent, the case study approach has become a conventional method in many scientific disciplines (Dubois and Gadde, 2002).

Per Yin (Yin, 1994) basic research strategies can be based on

- experiments,
- questionnaire surveys,
- secondary analyses,
- historical analyses, and
- procession of a case study

Yin asserts that it is expedient to use case studies when "…questions of 'how' and 'why' are asked about current events over which the researcher has little control". Case studies examine phenomena in their natural environment and apply several different data acquisition methods with a small number of examination subjects (Benbasat, Goldstein and Mead, 1987).

The application of case studies is preferred to other methods when researched concepts and relations cannot be examined in an isolated manner. In such situations, it is only the method of case studying that can guarantee the necessary depth for a theory's evolution. This approach has a long tradition in IT literature (Lee, 1989).

The case study approach has many strengths: it provides an overall perspective and enables a more thorough, in-depth understanding. It also helps to reveal such relationships that would remain hidden if a different method was applied (Galliers, 1992; Babbie, 2015). Bensabat et al. (Benbasat, Goldstein and Mead, 1987) make strong statements with respect to case study based research that, as being idiographic, tries to understand problems in their context.

Bensabat et al. summarises main features of the case study-based research strategy as follows:

- examines a phenomenon in its natural setting,
- employs multiple methods of data acquisition,
- gathers information from one or a few entities,
- is of exploratory nature,
- no experimental control or manipulation is used,
- neither dependent nor independent variables are predefined,
- results are highly dependent on the researcher's ability to integrate,
- data acquisition methods can change during the research,
- the nature of the phenomenon and the reason for it is the question, not the frequency of its occurrence.

Case studies may relate to single or multiple events, and there are countless possible levels of analysis in the research. Case studies are usually based on combined data acquisition methods (archives, interviews, questionnaires, observations), in which results can be both qualitative and quantitative.

The case study approach can be applied to reach at least three goals (Eisenhardt, 1989; Steenhuis and De Bruijn, 2006; Ravenswood, 2011):

- with the intention to illustrate (to explain a theory),
- create an applicable theory,
- test a previously worked out theory.

Case studies can also be used to evaluate whether practice corroborates main theoretical concepts. Eisenhardt and Bensabat et al. provide detailed guide to planning a theory development research based on case studies.

To avoid any threats while applying this method, five criteria have to be met (Babbie, 2015):

- a relatively neutral aim should be defined,
- known data sources should be used,
- an adequate time frame should be examined,

- known data acquisition methods should be applied,
- consistency with the currently accepted knowledge base should be ensured.

The main advantage of a case study-based research is its flexibility. It enables the interaction between data acquisition and data analysis. This approach has an outstanding validity: instead of defining concepts, case studies provide a detailed illustration.

However, the case study approach may come with quite a few drawbacks: it rarely provides an accurate description of the state of a large population, and the deductions are rather to be considered as suggestions than definitive conclusions. Reliability may also be an issue in a case study-based research, just like its inadequacy to generalise the findings. The personal nature of observations and measurements can lead to results that can't be reproduced by others. Secondly, it is harder to generalise the in-depth, overall understanding than those results that are based on a strict model and standardised measurements. Thirdly there is a big chance to distort the model (Babbie, 2015). As it is of exploratory nature, our present research uses a case study-based approach to validating hypotheses.

1.8. The scope of the research

The "Knowledge Fit" measure is using two reference formalisms: business process models (BPM) (Gábor and Szabó, 2013) to describe the processes and ontologies (Jurisica, Mylopoulos and Yu, 1999) to represent knowledge. Those models include a representation of knowledge in two different context process/organisation and knowledge domain. They are both formal models to represent codified information. In analysing and the problem, therefore, we must consider that we will address only the explicit knowledge of the individuals. We will not consider a critical area that is related to experience, attitudes that are important but cannot be captured by our framework (Warier, 2014a).

However, the approach proposed have the potential to support the elicitation of tacit knowledge and its codification through the application of an enrichment and refining process of the representation models: BPM and ontologies. (Gábor and Arru, 2014)

This solution integrates the BPM life cycle with the Evans and Ali's (Evans and Ali, 2013) model of the knowledge management cycle (KMC) represented in Figure 1-1.

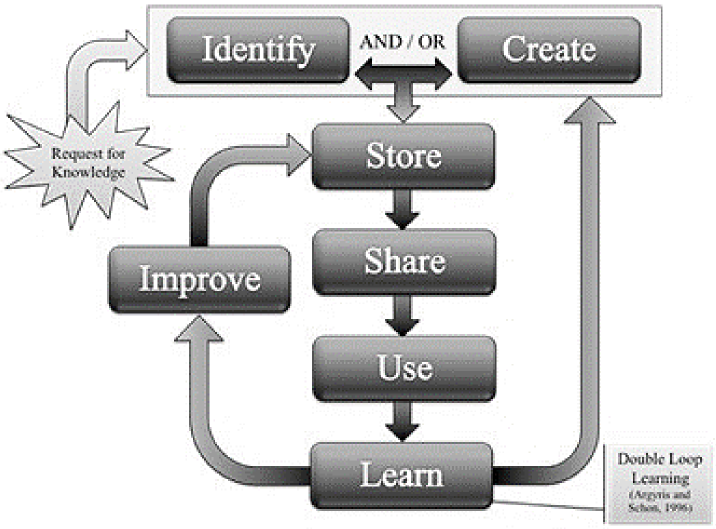

Figure 1-1 The Knowledge Management Cycle (KMC) Model.

1.9. The novelty of the research

The literature has reference to measure model of intellectual capital that is mainly indirect (for instance the contribution to the equity (Sveiby, 1997) of the company). Some approaches are focusing on measuring the knowledge in comparison with a predefined domain (Jing, Liu and Zhan, 2013). However, the only tool used traditionally employed to map the fit of the knowledge in an organisation with the required are the so-called competency matrices (Smith and Smarkusky, 2005). Recently semantic technologies (based on ontology) has been employed to test the knowledge in association with computer-aided testing systems (CAT) (Gaeta *et al.*, 2012)

The “Knowledge Fit” concept has been developed using PROKEX technology as reference technology and introduces a systematic translation between the process and knowledge domain.

The novelty of the approach includes the increased level of granularity and an integrated knowledge management approach.

Regarding granularity, this approach scales up the number of details that are typical semantic testing tools to organisational tools such as the competency matrices.

The solution proposed for measuring the “Knowledge Fit”, further, is integrated into an overall approach for developing and maintaining the knowledge base of a modern organisation that can be reused in different contexts. This allows to reuse documentation and ontology available in the organisation and provide feedback to their further development.

2. Managing the intellectual capital

In this chapter, we will develop the contents of the article that introduced the concept of "Knowledge Fit" (Arru, 2016) that references to the consideration of Jashapara in the definition of the Intellectual Capital (Jashapara, 2010) and the Oxford Handbook of Human Capital (Burton-Jones J.C., 2011).

Human capital is considered a crucial input for the development of new technologies and a necessary factor for their adoption and efficient use, but also a prerequisite for employability (Gábor and Arru, 2014).

The literature around the intellectual capital is dated back to the 90s when IT was not so developed to be taken into consideration its capacity of actually represent and measure it as an operational asset. Since then IT become a pervasive phenomenon and nowadays is a common practice when we would like to access knowledge we do not yet master to say that we are "googling" it (Cimiano and Staab, 2004). At that time where the focus was to understand the concept and its effects to better support the financial evaluation of the companies, now we are in the position of operationally managing it through for instance ontologies (Brewster and O'Hara, 2004). The new technology provides therefore us an analytical tool that can help us unbox the black or grey box and managing it.

In this thesis, we will, in particular, develop the possibility of using ontology as a representation of the knowledge, and we will explore the possibilities offered by this technology to represent and measure the knowledge as crucial element of the Intellectual capital

2.1. **Intellectual capital**

A simple definition of intellectual capital (IC) is the difference between the market value of a company and its net book value (Sveiby, 1997). We choose this definition that shows an accounting origin because the discussion on this theme got maturity together with its incorporation of the international accounting standards (IASC, 1998) and by the Financial Accounting Standard Board (FASB, 1999). This discussion highlights the necessity of justifying the value of a company that was not resulting from the ledger of the physical assets. From that definition, we can identify this difference all that intellectual material such as knowledge, information, intellectual property, which can create wealth(Stewart, 1998). It is clear that the concept is complex and may not be characterised univocally. Different models explain different connotation and phenomenology.

A typical general description of the IC is the one expressed by the Danish Confederation of Trade Unions (Unions, 1999) or the one voiced by Petrash. This approach links the intellectual capital to the creation of value. That can be conducted to the maximisation of three dimensions: Customers, Human Resources and Organisations (Petrash, 1996).

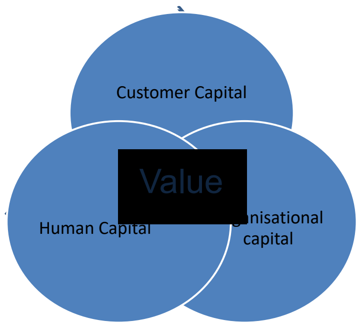

Figure 2-1 Intellectual Capital

In this classification of the various theories, We will refer to the general model by Gőran and Johan Roos that extend Petrash’s approach (Roos and Roos, 1997). Please note that some theories do not follow the same classification, but we will refer to it for easy reading.

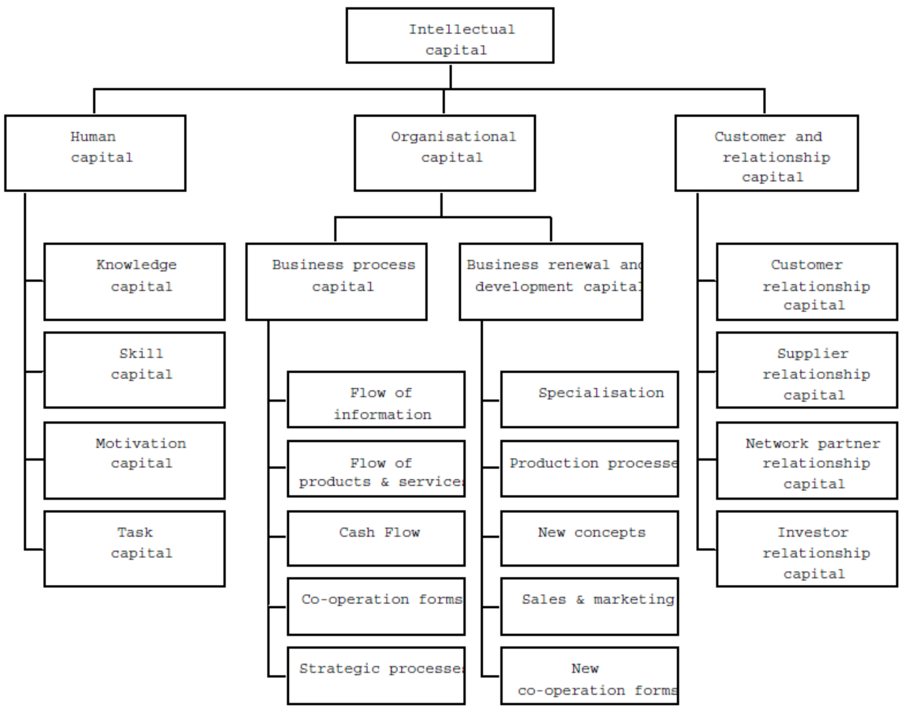

Figure 2-2 Limited distinctions of intellectual capital

According to the definition given by OECD[3], IC is the economic value of two categories of intangible assets of a company: organisational («structural») capital and human capital (Moe, 1999). This definition helps to understand that intellectual capital is not equivalent to intangible assets but is a subset of those. An intangible asset can qualify as IC only when to create value for the organisation. This definition also clarifies that in a company, the IC is partially a structural and tangible asset of the organisation (such as software, codified knowledge, patents, databases). Those are partially embedded in the human resources as professional competence.

2.2. **Human capital**

Schultz and Becker give the earlier definition of human capital as the activities that influence monetary and psychic income by increasing the resources in people (Schultz, 1961; Becker, 1993). This definition highlights the importance of increasing the resources related to humans in the organisation as an enabler for the creation of value for the organisation. The success of any company lies in the optimal utilisation and development of its core competencies indeed. Core competencies consist of a combination of intangible assets that flourish in a given culture (Hamel and Prahalad, 1994).

We shall clarify that when we refer to intellectual capital in the domain of human resources, we should distinguish between competence and competency. Competencies can be defined as knowledge, skills, mindsets, and thought patterns resulting in substantial performance (Dubois, 1998).

Those are the overall competence present in the company and not necessarily represent an asset for the enterprise. On the other hand, competence refers to the critical skills, knowledge, and associated best practices specific to individual tasks leading to optimal accomplishment of organisational goals or enhanced organisational performance (Gilbert, 1996).

[3] The Organisation for Economic Co-operation and Development (OECD) is an international organisation that has as mission to promote policies that will improve the economic and social well-being of people around the world. - http://www.oecd.org/

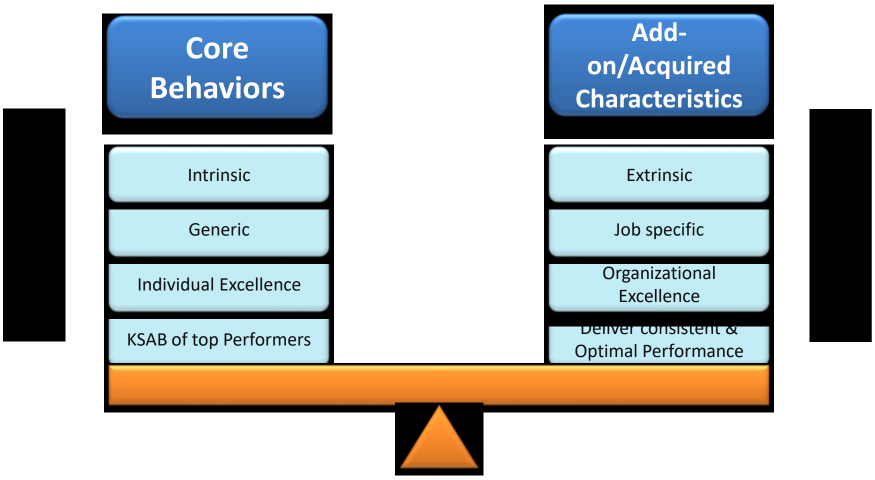

Figure 2-3 Competency vs Competence (Warier, 2014b)

It is clear that a company more than developing the competencies in the company need to maximise the competence. The possibility, to measure the IC, is strictly connected to the problem of improving the internal competence. Unfortunately, the economic theory does not reflect the knowledge creation theory; in fact, human capital is more discussed from organisational learning only (Reinhardt *et al.*, 2002).

In general, the evaluation of competencies and competence is very sophisticated and include analysing the human resources from several points of view. An attractive model is the one designed by Lowendahl. This model focus on the different nature of the intangible assets (in particular those that we define here human capital). It distinguishes the hard (competence) from the soft (relational) nature and the individual from the collective (Lowendahl, 2000).

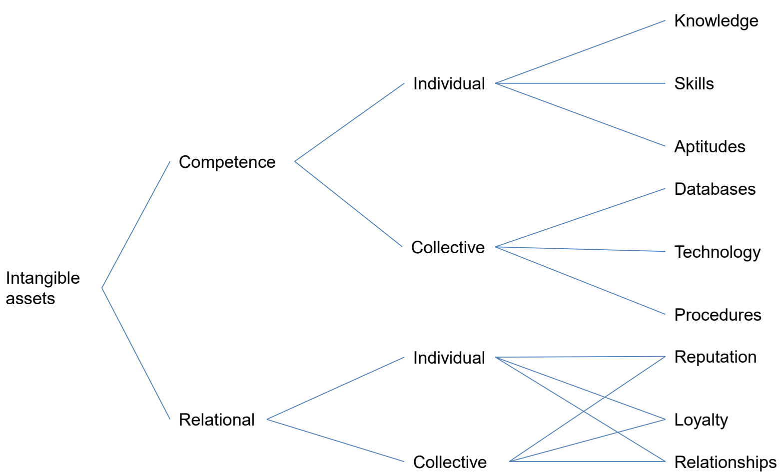

Figure 2-4 Lowendahl's approach

According to Warier, the core competencies are the most essential constituent of the "competency quotient". However, it contributes to 14% of the overall score (Warier, 2014b).

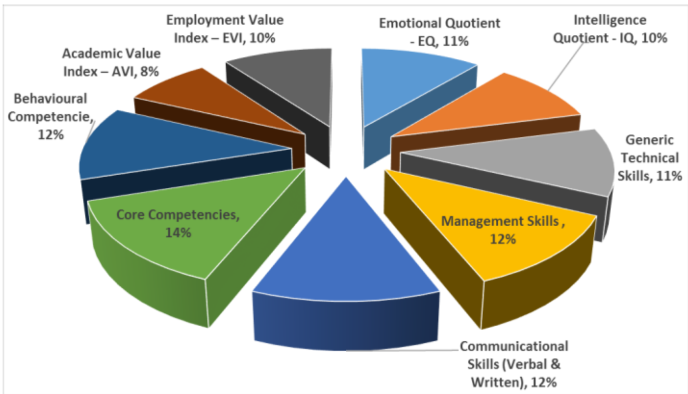

Figure 2-5 Primary constituents of the competency quotient

Even if their contribution is limited, core competencies are the straighter forward to measure. At the Corvinus University of Budapest, we are developing an approach and a methodology to identify those knowledge elements that are assets for the organisation. The underlying concept is that each person in the company plays one or more roles. That role is attributed to a process but needs competence to be performed. The competence is, therefore, the element of the knowledge that fit the role. In fact, it is necessary to implement an activity of the process. The PROKEX system map competencies stored in the domain ontology with the representation in business processes. In that way, identify for each role the required competence and provide an approach to measuring it (Arru, 2014).

2.3. Organisational capital

According to the OECD model, the organisational capital is part of the structural capital.

With the organisational capital, we are referring to the optimisation capability of the organisation where there is suboptimal human capital. Tomer distinguishes two organisational capitals:

- Pure form (organisational structure)
- Hybrid form (embodied in individuals' through investment in socialisation)

According to Tomer, the investment in organisational capital is finalised to increase the productivity of the firm (Tomer, 1987). The concept of the organisational capital as an enabler for creating value is present in other models. For instance, the Balanced Scorecard (BSC), which is the most prominent model for performance management in business, put the innovation and learning perspective as the foundation layer of each company strategy. In this framework, the business results are connected to core measurements of the organisational capital that are enabled by the staff competencies, infrastructure, and climate (Kaplan and Norton, 1996).

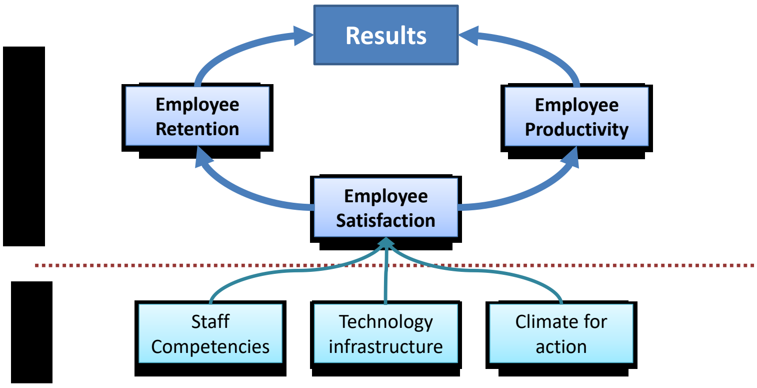

Figure 2-6 The Learning and Growth Measurement Framework of the Balanced Scorecard

The European Foundation for Quality Management (EFQM), in its excellence model, describe the innovation and learning the process. It involves a certain number of enabler to produce results (Eccles, Nohria and Berkley, 1992).

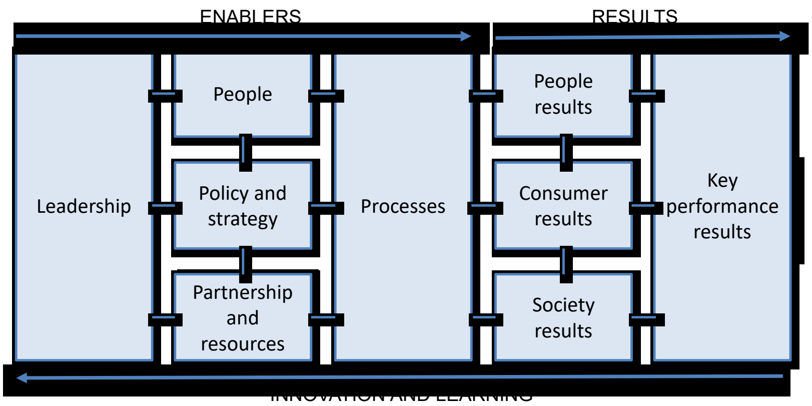

Figure 2-7 EFQM Excellence Model

Edvison and Malone locate organisational capital within the structural capital. In their approach, an intellectual capital is related to the processes and their optimisation. A different capital is the one able to generate innovation.

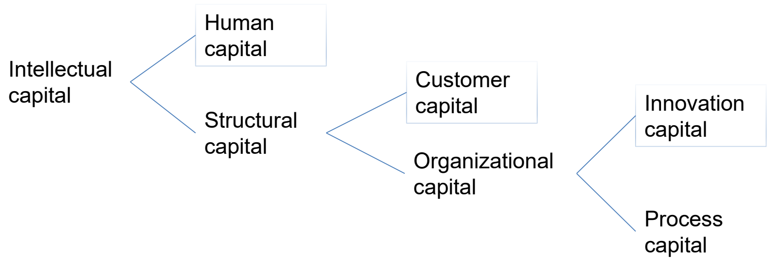

Figure 2-8 IC structure (Edvinsson and Malone, 1997)

The concept of innovation is crucial: in the next chapter, we will discuss the strategic role of innovation for the smart companies. In the literature, in the area of the structural and organisational capital, several experts discuss the level of codification of those capital assets by the theory of knowledge creation theory (Nonaka and Takeuchi, 1995). This is the case of Brooking that focus on the asset nature of the IC. According to Brooking market assets, human-centered assets, infrastructure assets and intellectual property assets constitute the IC (Brooking, 1996). Furthermore, Sullivan explains that the mentioned ones can be found in different stages of the knowledge creation. The tacit knowledge of human capital generates intellectual assets that may become intellectual property (Sullivan, 2001).

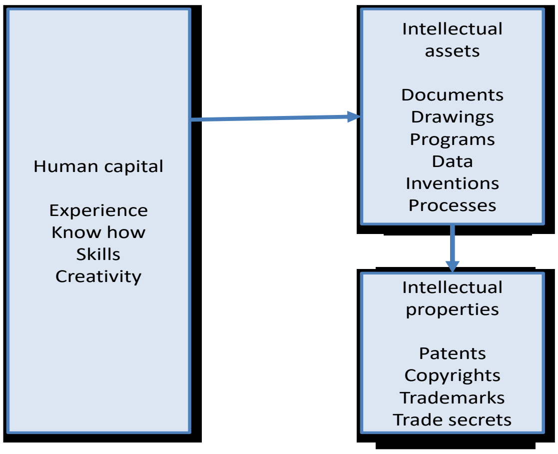

Figure 2-9 Sullivan's model

The intellectual property is, therefore, a form of intellectual capital that is more resilient in an organisation. The higher level of protection of the value embedded in the intellectual property is the patent. The company, to preserve its value, should promote the transformation of human capital in intellectual property.

2.4. Customer and relationship capital

Among the structural capital great emphasis has been given by financial and marketing experts to evaluate the value of the relations that a company has with stakeholders and in particular with its customers.

The customer and relationship capital are very often present in a tacit form of the human resources (including sales, people, service people, customer service). However, this is considered among the different categories of intellectual capital the one more connected to the value. In fact, the IC can exist only when it produces value for the organisation, as previously stated. It is clear that the reason for the value creation exists if there is a customer to grant it. Companies introduce "customer relationship management" (CRM) practices to maximise the customer equity. In this approach, the client is a financial asset that firms and organisations should measure, manage, and optimise, just like any other asset (Blattberg, Getz and Thomas, 2001). Addressing the customers' needs is the prominent business strategy that showed to be more successful.

Methodologies such as quality function deployment (QFD) has been adopted by several organisations to develop products in line with the customer demand (Akao, 2004). Other companies have evolved the CRM to become reactive to the shopping clients and customise the value proposition in real-time. This is the case in particular of the internet-based companies such eBay or Amazon that have a strategy based on event-driven marketing (EDM) (Bel, Sander and Weber, no date)

2.5. Competence Management Systems

When we started working in the MOL group we needed to perform a competency assessment using Petroskills Compass (*PetroSkills Compass - Competency Management solution*, no date), the purpose of this software platform for Competence Management that has similarities with the PROKEX (Gábor *et al.*, 2016) approach used in this research: the knowledge required for a job role is broke down in knowledge elements that include some assessment criteria. Differently from PROKEX, the definition of the skills related to a job role is defined "ad priori", whereas PROKEX introduces a system for knowledge discovery based on process descriptions in BPM. This approach allows a dynamic evolution of the skillset with the changes of the Organisation whereas in Petroskills the knowledge map is standardised and made standard to all companies in the Oil and Gas Industry. Another main difference is the assessment modalities: Petroskills bases its assessment on a 360 evaluation (self-assessment and supervisor assessment) (Darnton, 2002). This approach allows an evaluation of the competencies beyond the knowledge of the subject as in the evaluation can be addressed the capacity of using the skill. However, it introduces an evaluation bias so that a different supervisor will evaluate their subordinates differently on the same skills. PROKEX, on the other hand, tests the employees using online testing. This approach has its significant limitation on the fact that only knowledge is tested and not the ability of the test taker to use it in the work context, however, has the advantage that provides a system to identify knowledge elements based on the contents of the processes without merely rely on the Experts specific sensibility.

2.5.1. **Knowledge Systems and competencies**

In their survey of Industry 4.0 technologies (Oztemel and Gursev, 2018) include Profile and Competency management as one of the beneficial areas by emerging Cyber-physical Systems. They cite the experience of Ermilova and Afsarmanesh's experience (Ermilova and Afsarmanesh, 2007) as evidence that those can simplify the design an adaptable, replicable and sustainable Profile and Competency Management System (PCMS) for virtual organisations.

Among the projects that aim to cover the gap between business and IT domain it worth recall plugIT(Woitsch, 2009). This project develops to use modelling languages that both it and business experts can use to address their concrete needs and summarised within the "Next Generation Modelling Framework" (Woitsch, 2011)

The IVI (Industrial Value Chain Initiative) platform (Nishioka, 2016) aims are to generate a robotics line building for SMEs using cloud knowledge database. This effort focusses on the standardisation of the working styles in "Man–Machine collaborative factories" with the objective of complementing the human knowledge with specific knowledge.

The *4C4Learn* project (*4C4Learn*, no date) aims to provide SMEs with occupational competence models to moderate the strategic deficit that is generating the demographic challenge. The "Modelling and Measuring Competencies in Higher Education (KoKoHs)" is a funding initiative (*Kompetenzen im Hochschulsektor*, no date) whose projects focus on assessment and modelling of teaching competencies in different academic domains (Bohlouli *et al.*, 2017). Also Rogushina and Pryima develop a system for matching learning outcomes in different frameworks (in particular Ukrainian and EU) of qualifications based on ontologies. (Rogushina and Pryima, 2017)

Ontologies are a trending technology that is broadly used in Knowledge systems (Cobo *et al.*, 2015) and often adopted to represent knowledge elements. The STUDIO system bases its engine on Ontologies that describe domain knowledge.

Naykhanova and Naykhanova (Naykhanova and Naykhanova, 2018) claim that knowledge-based systems that use ontologies to build knowledge-based systems offer more natural adaptation in production systems that are rigidly connected with legislation. The adaptation to the regulatory changes can be implemented by changing the rulesets.

Fazel-Zarandi and Fox (Fazel-Zarandi and Fox, 2012) reinforce the understanding that a framework for the continuous evaluation of the knowledge that is associated with the role is a crucial element in frameworks that aim to evaluate the knowledge in an organisation evaluation. They work out an extension of Grüninger and Menzel's Process Specification Language (PSL): a formalism designed to facilitate the exchange of process information among manufacturing systems, such as scheduling, process modelling, process planning, production planning, simulation, project management, workflow, and business process re-engineering. (Grüninger and Menzel, 2003) The Ontology proposed by Fazel-Zarandi and Fox is an extension of the PSL which provides predicates and axioms that enable representation of and reasoning about fluent, activities, activity- occurrences, and values of fluent before and after activity-occurrences; the proposed formal ontology was developed for representing and reasoning about skills and competencies in a dynamic environment.

Proficiency levels relate to the span of activities that an individual can perform in addition to measurable attributes related to skills. This specifies what can be expected of someone who possesses a skill. The final goal is reducing fluctuations in competency measurement and evaluation by ensuring a consistent interpretation of the meaning of proficiency. The approach further identifies different sources of skills and competency information to provide an element for evaluating how information from a source can change the belief about the skills of an individual. The primary objective is to evaluate whether one satisfies a set of requirements, or to conduct a gap analysis in order to determine whom to train and how. (Fazel-Zarandi and Fox, 2012)

2.5.2. **Competence Management Systems in literature**

Stepanenko and Kashevnik (Stepanenko and Kashevnik, 2017) *investigate the* term competence in the literature and conclude that has different meanings. They also identify that there are few standards designed for competence modelling including IEEE RCD (Cetis, 2007) and HR-XML Consortium Competencies Schema (Fazel-Zarandi and Fox, 2013). However, several studies (Harzallah and Vernadat, 2002; Tinelli *et al.*, 2009; Gordeev, Baraniuc and Kashevnik, 2016; Miranda *et al.*, 2017) highlight that these standards fail to consider proficiency level and context as essential elements. They identify the following most common use cases in the competence management and conclude that those are the most critical driver to design Competence Management Systems:

- search for an appropriate employee;
- core competence revealing;
- assessment of the acquired individual competencies;
- acquired competence identification;
- competence gap identification;
- creation of a personal development plan;
- required competence identification;
- storage of descriptions of employees and tasks in the same ontology.

There are competence management systems that aim the management of individual competencies, assess it and create a personal development plan (DeCom (Barbosa *et al.*, 2015), KnoMe (Niemi and Laine, 2016), TENCompetence (Kew, 2007)). Other systems, according to Stepanenko and Kashevnik, are targeting Organisations, which help to compose a team for tasks or projects and reveal the competences (IMPAKT (Carrillo *et al.*, 2003), Technopark ITMO (Gordeev, Baraniuc and Kashevnik, 2016)).

Da Sa Sousa and Leite (Da Sa Sousa and Leite, 2017), propose the GPI (Goal, Process, Indicators) language designed to fill the gap between goal and process layers and overcoming limitations of the business process languages. They introduce the competency concept with the goal to add HR concerns to organisational layers (operational, tactic and strategic) and explicitly model the impacts of misalignments on strategic business goals.

Brandmeier *et al.* (Brandmeier *et al.*, 2017) present a generic framework of an intelligent information system for competence management based on ontologies that offer the possibility of the identification of new relations among concepts based on inferences starting from the existing knowledge.

Emami (Emami, 2017) developed a dynamic system approach based on causal relationships between competency management process and safety performance to understand the impact of competency management system on the incident rate over time.

In their study on Domain driven data mining in human resource management, Strohmeier and Piazza (Strohmeier and Piazza, 2013) identify a whole area of literature that refers to planning and prediction in staffing. According to this study, a topic of relevant interest is the selection of employees both during pre-selection (Tai and Hsu, 2006; Lakshmipathi *et al.*, 2010) and final-selection (Kroll, 2000; Chen and Chien, 2011). Another relevant domain is the prediction of employee turnover and retention to provide prognosis (Quinn, Rycraft and Schoech, 2002; Tzeng, HSier and Lin, 2004), always addressing retention, the study identifies specific literature related to its measurement (Chien and Chen, 2008). Other applications aim to address employee absence due to sickness (Sugimori *et al.*, 2003) or the prediction of workforce requirements (Yang *et al.*, 2009).

In 2016 Google filed a patent (Zhang *et al.*, 2018) for a technology to identify skills from the text that works very similar to PROKEX and Studio's ontology matching described in this paper.

Computerised Adaptive Tests (CAT) are broadly used for testing competences on the job. The selection of the items that relevant in a particular context and that best contributes to student assessment. Badaracco and Martínez (Badaracco and Martínez, 2013) introduce a new item selection algorithm for the selection of the knowledge elements to be tested by Computerized Adaptive Tests (CAT). This approach employs a multicriteria decision model that integrates experts' knowledge modelled by fuzzy linguistic information increasing CATs adaptation to the student profiles. This is the same issue that brought the development of the ProkEx (Gábor *et al.*, 2016) approach that we used for this thesis. The ProkEx approach enhances the STUDIO platform(Weber, Neusch and Vas, 2016) for a knowledge management system with a process perspective and uses natural language processing to identify the knowledge required for each activity, role or position in an organisation. The Studio platform is, therefore, able to test individuals based on the specific business application required.

2.5.3. **Resource Allocation in Competence Management Systems**

The application of Competence Management Systems to support Resource allocation and Organisation optimisation is particularly relevant. Arias et al. (Arias *et al.*, 2018) published a state of the art in the research area of Human Resource Allocation in BPM and Process Mining. According to this research, Human resource allocation is an emerging research area that has been generating new proposals applied to real case studies. Most of those studies were published from 2011 to 2016 on scientific Journals and conference proceedings. The majority of those paper were validation research and evaluation research using either simulation or case studies.

Arena et al. introduce a Human Resource Optimization (HRO) engine which employs semantically-enhanced information and Conditional Random Field (CRFs) probabilistic models with knowledge elicited from workers in an industrial context. The system recommends the right person for the right job in real-time for optimising decisions on how to implement and schedule either repeatedly or non-occurring tasks. (Arena *et al.*, 2017)

Masum et al. propose an intelligence-based Human Resource Information System with some essential features such as Intelligent Decision Support System for decision making and a Knowledge Discovery in Database for knowledge extraction, and others model using knowledge base and model base. The model has reasoning capability using experience in solving complex, HR problems including staffing. (Masum *et al.*, 2018)

Xerox Corporation filed a patent application for a method for role-based auto-selection of employees for training associated with skills required in a project.(Singh *et al.*, 2018)

Whereas in a traditional organisation people are concerns to identify the best tool to perform a specific task, Smirnov et al. (Smirnov *et al.*, 2017) highlight that in the 4.0 paradigm also the opposite is relevant because of one of the limitations in the design of applications the unpredictability of availability and nature of human resources abilities. They propose a Platform as a Service to enable applications to identify and provide them with the human resource. The system represents competencies using ontologies and allows flexible discovery of such resources based on availability and knowledge.

The ComProFITS project uses a web-based platform for the evaluation of existing employees and the recruitment of new employees in organisations. (Mittas *et al.*, 2016) This application supports multiple roles, each role can perform several activities, and some activities are provided in more than one role. (Bohlouli *et al.*, 2015) Similarly to PetroSkills the application supports the assessment of the employees based on a 360-degree assessment where a team evaluates the competence of the individuals based on the opinion of a group of a co-worker, including subordinates, managers and same level colleagues. (Mittas *et al.*, 2016)

Bohlouli et al. developed an approach that analyses ComProFit results using statistical analysis of the competences to find the best fitting candidates for specific job positions in companies. Using the Scott-Knott clustering algorithm, it classifies job seekers such as under or over-qualified or best-fit candidates concerning the specific job definition. (Bohlouli *et al.*, 2017) In this thesis we are developing a similar approach that is not aiming to identify statistical significance of a specific job fit but rather to provide management with a tool to diagnostic the broader scenario in the absence of the relevant test power. The finding of Bohlouli et al., however, demonstrate the significance of such organisational measurement.

Lili (Lili, 2017) summarises the most common approaches in the area of human resources optimisation methods. He includes top-down and bottom-up approach(Li *et al.*, 2011), 0-1 assignment model (Xian-ying, 2012), multi-project human resource allocation based on the negotiation mechanism with consideration of total cost constraint and individual disciplines (Chien, Lin and Tien, 2013), M / M / N + M queuing model for call centres (Miao *et al.*, 2013), " four-in-one " personnel matching method (Zhang, Zhao and Zang, 2013), fuzzy input-output optimization model (Aviso *et al.*, 2018), total utility level or cost input condition (Li and Wang, 2016) and proposes an Inverse Optimization Model considering competency disadvantage structure.

3. Business Process Improvement

In this chapter, we will discuss the importance of business process improvement and business process improvement practices within the organisations to maximise the business performance.

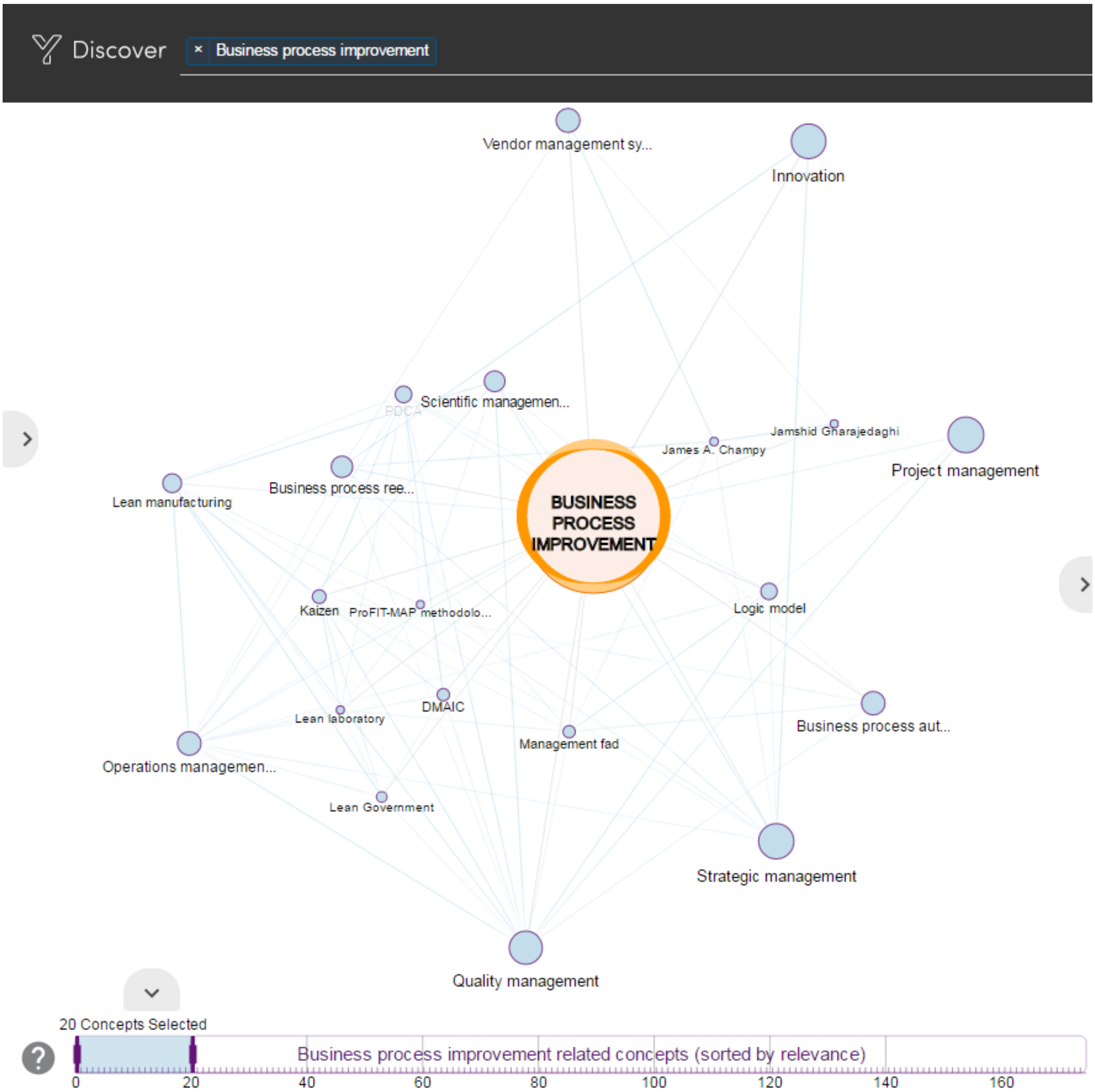

Figure 3-1 Yewno map for Business Process Improvement

According to the Yewno Concept database (Yewno.com, no date), the concept of "Business Process Improvement" is connected to different concepts in several business-related domain including strategic, operation, project and quality management.

In the literature Forster (2006) describes “Business Process Improvement” as a systematic approach to help organisations to archive significant changes in the way they do business. In his, paper Forster recalls that Rosemann (2001) describes Business Process Improvement as the evaluation of alternative ideas and the movement of the organisation. According to Harrington (1998), the Business Process Improvement is the product of Business Process Re-engineering, Redesign, and Benchmarking, depending on the degree of change necessity (Forster, 2006). A significant contribution came from Davenport (1993b) who describes Business Process Improvement as an incremental, bottom-up enhancement of existing processes within functional borders. He further states that the scope is narrower than Business Process Re-engineering, and it works on short-term. One single process change activity with the intention to enhance the process is called process modification step.

Boutros and Purdie summarise a very comprehensive overview of the Business Process Improvement practices. (Boutros and Purdie, 2014) In this analysis, we will develop a literature review, based on their synoptic view of the subject by reflecting on the historical development of this discipline and incorporating the latest trends.

In Chapter 3.8 we will see that different methodologies have their own set of tools and phases, but most improvement projects share the same general outline (Boutros and Cardella, 2016).

All those methodologies have a collective legacy from the scientific management movement that started at the end of the nineteenth century with Taylor (1911) and further developed with the theories of Deming in the first half of the twentieth century (1950).

The mission of Business Process Improvement methodologies is to focus the process on the creation of value for the customer and to eliminate all that is creating costs without adding value.

3.1. The process

The term process derives from the Latin term “processus” that is the past participle of the verb “pro-cedere”: going on, progress. In fact, it is embedded in the term the idea of a sequence. According to the Oxford Dictionaries, a process is a series of actions or steps taken to achieve a particular end. (Dictionaries and Oxford Dictionaries, 2010)

In the book “Competitive Advantage: Creating and sustaining superior performance” Porter introduces the value chain approach. The value chain is a method for decomposing the firm into strategic activities (Stabell and Fjeldstad, 1998), and the overall value-creating logic of the value chain with its generic categories of activities is valid in all industries (Porter, 1985). This approach gives organisations a reading framework of their operations to identify areas of improvement but also to highlight the different level of innovation (Koc and Bozdag, 2017).

The Porter’s approach is one of the most known frameworks in Business Organisation and represents a starting point of the Value Stream analysis developed by some Business Process Improvement analysis methodologies.

In our approach (Roscioli, Arru and Castellucci, 2012; Arru, Teeling and Igoe, 2016c) we refer to the following macro-classification of the processes in an organisation as shown in Figure 3-2:

Core Processes

Core processes are those that are directly adding value to the customers. In the Lean Management view, those are delivering and have the pace in line with the client's demand. Those include sales, production lines, logistics, customer support.

Support Processes

Support processes are functional to the operability of the organisation. Those processes are synchronised with the operability of the core processes. Those include product development procurement, maintenance, production planning.

Functional processes

Functional processes are necessary to run the organisation but not adding value to the customer. Those are not synchronised with the client's demand but rather with administrative cycles. Those include strategic management, HR, financial reporting.

The same process in different organisations may be positioned in a different category.

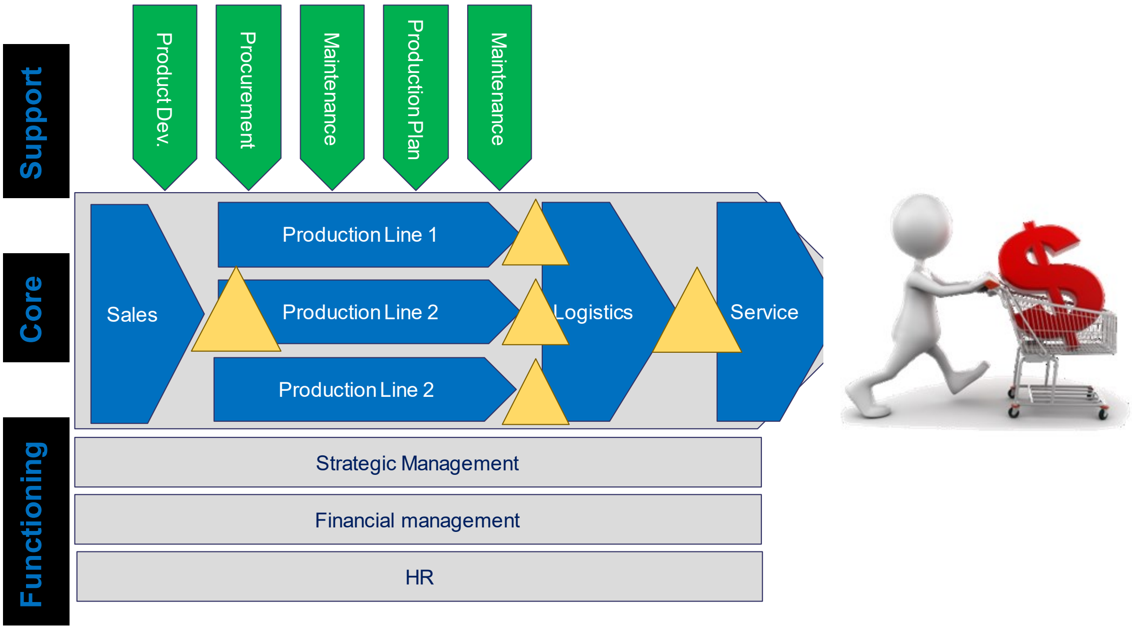

Figure 3-2 Big picture of an organisation's processes (Arru, Teeling and Igoe, 2016c)

3.2. **Four perspectives on business processes**

Melao & Pidd (Melão *et al.*, 2000) propose a conceptual framework to organise different views of business processes under four headings, that aims at providing an integrated discussion of the different streams of thought, their strengths and limitations, within business process modelling. It argues that the multi-faceted nature of business processes calls for pluralistic and multi-disciplinary modelling approaches.

3.2.1. **Business processes as deterministic machines**

The prevailing view sees a business procedure as a settled succession of very well-characterised activities performed by "human machines" that transform input into outputs to achieve clear goals (Figure 3-3). As anyone might expect, this viewpoint is near Pooler and Morgan's bureaucratic machine metaphor (Pooler and Morgan, 1989), what's more, it expects that the way of a business process is unchallenged and its plan is comparable to a specialised engineering movement.

This accords well with many structured processes found in stable manufacturing-type environments, and many bureaucratic paper-based transactional processes found in service environments.

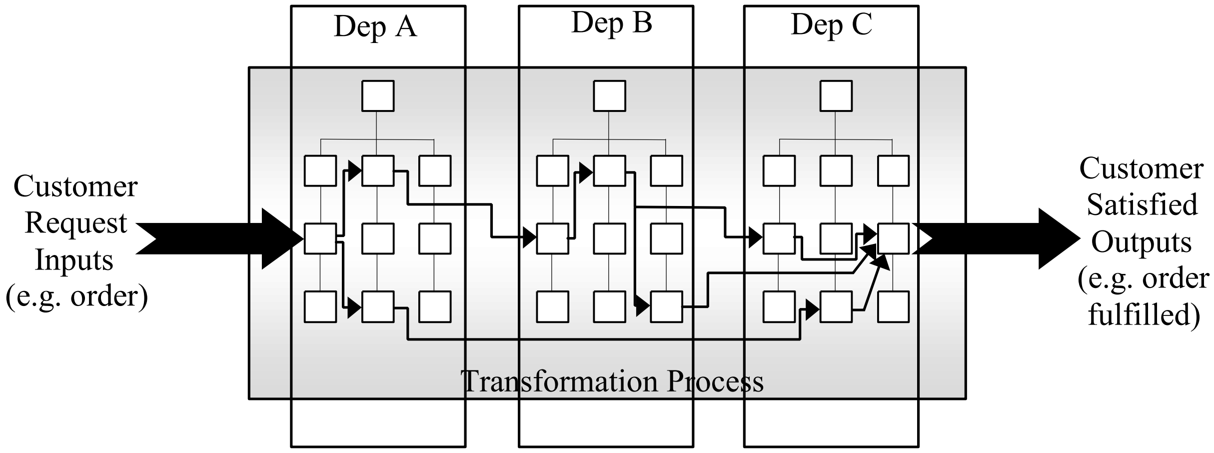

Figure 3-3 Business processes as deterministic machines

The idea that a business process is a deterministic machine can be followed back to Taylor's Scientific Management (Taylor, 1911). According to this approach, the manufacturing processes were made more efficient by an analytical approach.

From this viewpoint, a process may be decomposed into well-defined tasks to be performed by interchangeable people. Managers train individuals to the job in a deterministic way that would lead to an efficient overall manufacturing process.

On the same line Davenport & Short (Davenport and Short, 1990), defined a business process as "a set of logically related tasks performed to achieve a defined business outcome". This idea as expressed with the "new industrial engineering" metaphor, is symptomatic of a mechanistic view, too. Hammer & Champy (Hammer and Champy, 1993) gave a similar definition, but they highlight the customer orientation as an endeavour and cross-functional activity. Also, Armistead & Rowland (Armistead and Rowland, 1996) and Kock & McQueen (Kock Jr and McQueen, 1996) have similar lines where the focus is on the structural and operational features of business processes. It is inevitable therefore arguing that BPR refers to the use of industrial engineering techniques applied to office and service environments (King, 1991).

3.2.2. Business processes as complex dynamic systems

Opposite to consider a business process as a sequence of parts, this second perspective concentrates on the intricate, dynamic and intuitive components of business processes. The fundamental thought is that an open framework adjusts to a changing domain with a specific end goal to survive (Pooler and Morgan, 1989). While the mechanistic view concentrates only on structure and static protests, this view stresses connection and dynamic conducts.

Considered in view of these open systems, a business process can have inputs, transformation, outputs and boundaries (Figure 3-4) (Melão *et al.*, 2000). Any business process can in this context be defined as a set of subsystems (including people, tasks, structure and technology) which interact with each other (internal relationships) and with their environment (external relationships) to achieve some objectives. Each subsystem can, therefore, be seen as a system, that can be hierarchically decomposed into different levels of detail. The most important implication is that there are interfaces between subsystems so that they can communicate with each other. Earl & Khan (Earl and Khan, 1994), who say that the "interdependent, interactive, boundary-crossing, super-ordinate goal conceptualisation of the process is essentially a systems view".

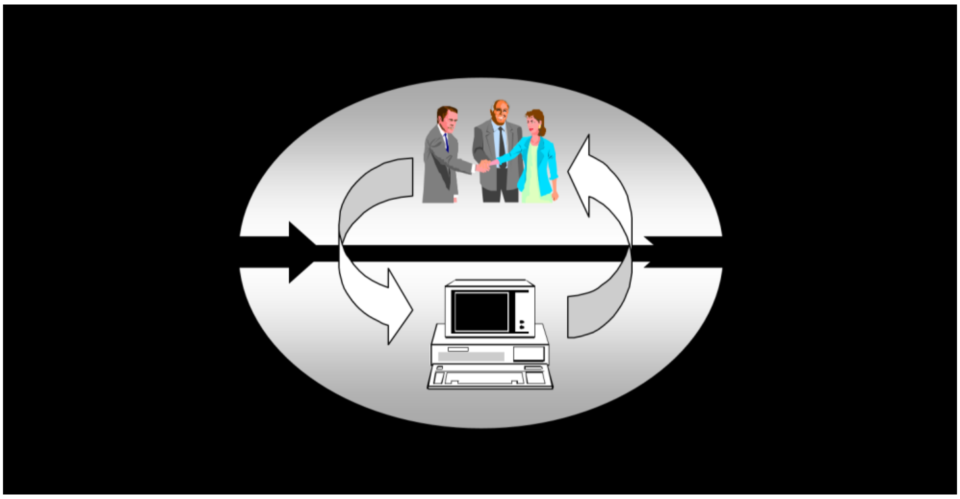

Figure 3-4 Business processes as complex dynamic systems

While the mechanistic perspective ignores issues like the interaction with the external world, this viewpoint highlights its importance. In this context, more attention is given to effectiveness than to efficiency. Hammer (Hammer, 1996) argues that a sensible view of a business process "sees not individual tasks in isolation, but the entire collection of tasks that contribute to the desired outcome". The use of multi-skilled and autonomous workers/teams to deal with a business process holistically illustrate particularly well how this holistic thinking can be put in practice. Zairi & Sinclair (Zairi and Sinclair, 1995), on the other hand, shows that in practical terms it is not always possible to approach business processes holistically because it may be riskier and require more resources than simply analysing a single or a set of components.

3.2.3. Business processes as interacting feedback loops

This third perspective described by Melao & Pidd (Melão *et al.*, 2000) extends the viewpoint by incorporating the interaction between processes and organisation.

The concept of a business process as a network of interacting feedback loops is shown in Figure 3-5. This depicts a business process as flows (rates) of resources (physical or nonphysical) from outside its boundaries through a sequence of stocks (levels) representing accumulations (e.g. materials) or transformations (e.g. raw material to finished product). The flows are regulated by policies (decisions) which represent explicit statements of actions to be taken to achieve the desired result (Pidd, 1997). These actions are taken based on information, and this is where the notion of information feedback loop comes into play (Vennix, 1996).

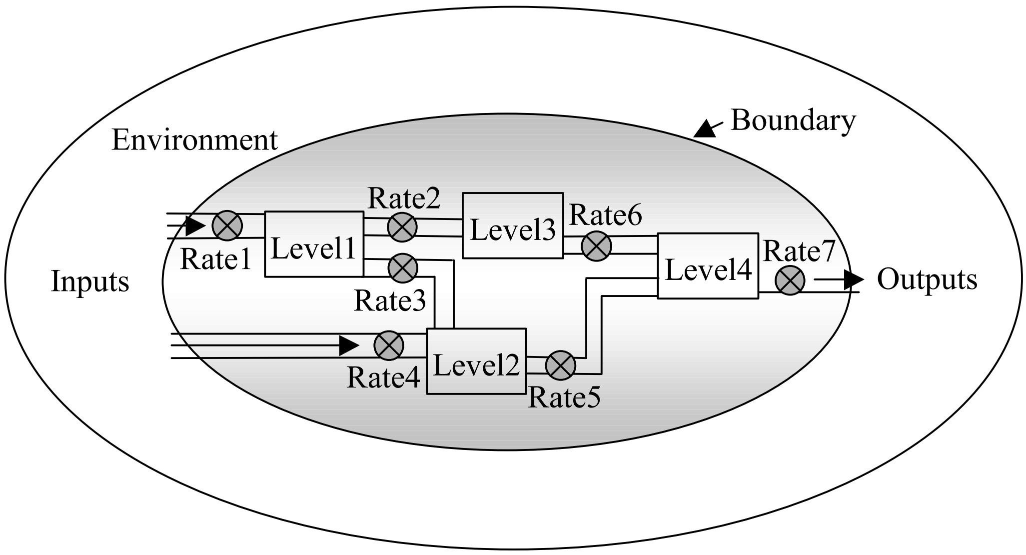

Figure 3-5 Business processes as interacting feedback loops

3.2.4. Soft business processes

Opposite to the deterministic approach is the thesis of Tinaikar al. (Tinaikar, Hartman and Nath, 1995) that sees the processes as a dynamic organism pursuing clear objectives. This fourth perspective emphasises business processes as made and enacted by people with different values, expectations and (possibly hidden) agendas. This view extends the subjective and human aspects of the business process implies that business processes are abstractions, meanings and judgements that people put in the real world, which results from a process of subjective construction of the minds of individuals.

Similarly to this approach, several authors indicate the application of Checkland’s Soft Systems Methodology (SSM) as a balanced approach to modelling business processes.

Chan & Choi (Chan and Choi, 1997) show that SSM can be used to provide methodological support and an analytical framework as well as to deal with ill-defined situations in a business process setting where the purposeful activity of the business process can be seen from different angles (Figure 3-6).

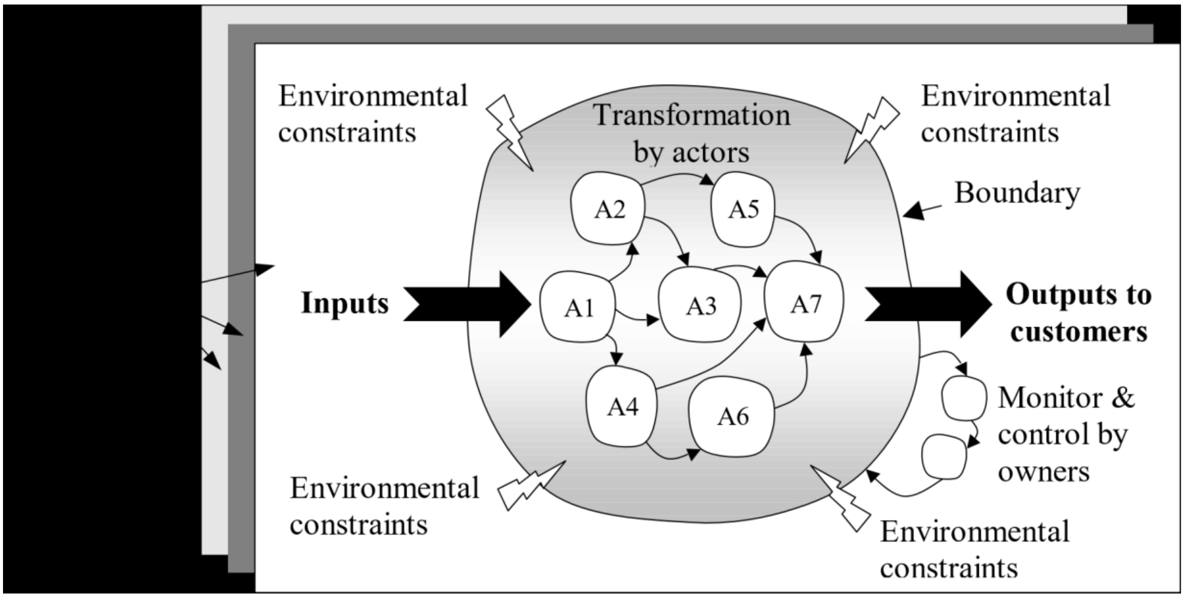

Figure 3-6 Business processes as social constructs

3.3. Why are enterprises embracing business process improvement actions?

In the literature we do not find a specific explanation behind embracing a culture of Business Process Improvement; however, all effective Business Process Improvement programs have corresponding points and give comparable advantages paying little respect to the issues that get the program underway. There are various purposes behind choosing to execute a Business Process Improvement program, for example, administrative matters, presenting industry best works on, correcting consumer loyalty issues, weak or undeveloped quality and finding unnecessary expenses. Hammer and Champy (1993) identify three kinds of companies that undertake re-engineering:

- Companies that find themselves in deep trouble. They have no choice. If a company's costs are an order of magnitude higher than the competitors', or that its business model will allow, if its customer service is so abysmal that customers openly rail against it, if its product failure rate is higher than the competitors', if in other words, it needs order-of-magnitude improvement, that company clearly needs business re-engineering,

- companies that are not in trouble but whose management can see trouble coming,
- companies that are in peak condition and see an opportunity to develop a lead over their competitors.

Boutros & Cardella (2016) classify the factors in 3 categories:

- organisational factors,
- customer, supplier, and partner factors, and
- technology factors

3.3.1. **Organisational factors**

The organisational factors that may trigger Business Process Improvement efforts include

- Difficulty adapting to high development or proactively getting ready for high development
- Inheriting additional complexity through mergers and acquisitions
- The need to rationalise processes and systems
- Internal reorganisation that brings forth changing roles and responsibilities
- Deciding to change corporate direction to operational excellence, product leadership, or customer intimacy
- Organisational goals and objectives not being met
- Compliance or regulatory requirements
- Management Factors that may trigger Business Process Improvement efforts include
- Lack of reliable or conflicting management information
- The need to outfit managers with more control over their methodology
- The need to create a culture of high performance
- The need to gain return on investment from the existing legacy investments
- Budget cuts
- A desire to obtain more capacity from existing staff for expansion Employee Factors Employee factors that may trigger Business Process Improvement efforts include
- High turnover of employees
- Training issues with new employees

- Low employee satisfaction
- A substantial increment of staff
- A desire to increase employee empowerment
- Difficulties with continuous change and growing complexity

3.3.2. Customer, supplier, and partner factors

There are not only factors internal to the organisation. In fact, very often clients, providers and partners may be the reason for a company to start a Business Process Improvement initiative. Efforts include (Boutros and Cardella, 2016; Ueki, 2016)

- Little satisfaction with service
- An increase in the number of customers, suppliers, or partners
- Long lead times to meet requests
- Customer segmentation or tiered service requirements
- The introduction and strict enforcement of service levels
- Major customers, suppliers, or partners requiring a unique process product and service factors product and service factors that may trigger Business Process Improvement efforts include
- Long lead times or lack of business agility
- Poor stakeholder engagement or service levels
- Several goods and/or services having their processes where most activities are common or similar
- New products and/or services compromising existing product and service elements
- Process factors that may trigger Business Process Improvement efforts include
- Need for visibility of operations from an end-to-end perspective
- Significant handoffs or gaps in processes
- No documented processes or procedures
- Unclear roles and responsibilities across the organisation
- Product or service quality is poor
- The amount of rework is substantial
- Processes change too often or not at all
- Methods are not standardised
- Lack of clear process goals or objectives

- Lack of communication and understanding by workers involved in executing processes

3.3.2.1. Technology factors

Technology factors that may trigger Business Process Improvement efforts include

- The introduction of new systems
- The purchase of business process management automation tools
- Retirement of ageing applications and systems
- Existing application systems overlap
- Introduction of a new IT architectures or technologies
- A view that IT is not delivering to business expectations
- A view that IT costs are out of control or too expensive
- The need to retire duplicate systems

3.4. The re-engineering challenges

Champy (Champy and Cohen, 1995) conducted a study of “The State of Re-engineering” including 621 companies, which represent a sample of 6000 of the largest corporations in North America and Europe. The study showed that 69% of the 497 American companies and 75% of the 124 European companies responding were already engaged in one or more re-engineering projects, and that half of the remaining companies were thinking about such projects.

However, they (Champy and Cohen, 1995) found that substantial re-engineering payoffs appear to have fallen well short of the potential goals Re-engineering the Corporation had set:

- 70 per cent decreases in cycle time,
- 40 per cent decreases in costs,
- 40 per cent increases in customer satisfaction, quality, and revenue, and
- 25 per cent growth in market share.

Although little information is available on the 71 per cent of the ongoing North American re-engineering efforts in the sample, overall, the study showed that participants had failed to attain these benchmarks by as much as 30 per cent. This leads to the conclusion that the thoroughly re-engineered corporation is yet a rarity. The problem, it would seem, is that re-engineering of the organisation is not extending to actual management practice. Three vice presidents typify this (for sales, service, and order fulfilment) at a major US computer company, who were thrilled that re-engineered work processes promised to cut product introduction time in half, raise customer retention rates by 20 per cent, and slice 30 per cent from administrative costs in their areas. They were not thrilled enough, however, to willingly give up control of their functional areas and collaborate. Thus, the reengineering effort died a year after its inception. In this case, senior management's leadership was not strong enough to implement a change in the pattern of shared values, beliefs and rules for behaviour—their culture (Davis, 1984).

Re-engineering horizontal processes such as order fulfilment, new product development, and service delivery, so they become distinctive competencies that competitors cannot readily match is quite different from managing a vertical function in a traditional hierarchical organisation.

Day (Day, 1994) notes three distinctive tenets that must be understood by senior management before re-engineering is undertaken:

- The change to process management emphasises external objectives. These goals may involve customers' satisfaction with the outcome of the process,
- coordinating the activities of a complicated horizontal process, will require boundaries and horizontal connections to be made—culture change, and
- unfiltered information that is readily available to all team members, to facilitate the learning process (Senge, 2010).

The loan approval process within IBM Credit illustrates both the problems and benefits of managing a process, so it becomes a unique capability rather than merely a consecutive series of necessary activities. Often this process is obscured from top management view because it links activities that take place routinely as sales forecasts are made, orders are received and scheduled, products are shipped, and services are provided (Shapiro, Rangan and Sviokla, 1992). In another example, Marriott Hotels can consistently receive the best ratings from business travellers and meeting planners for high-quality service. They are indeed as capable as Hyatt, Hilton, and others at selecting good sites, opening new hotels smoothly, and marketing them well (Irvin, Michaels Iii and Walker, 1989). What consistently sets them apart and reveals a distinctive service core competency is a "fanatical eye for detail". This begins with a hiring process that systematically recruits, screens, and selects from as many as 40 applicants for each position and continues through every hotel operation; for example, maids follow a 66-point guide to making up bedrooms. The effective management of these linked processes, in an organisational culture that values thoroughness and customer responsiveness, creates a distinctive capability that gives Marriott employees clear guidance on how to take the initiative to provide excellent customer service.

3.5. **Risks connected to Business Process Improvement initiatives**

Carr and Johansson (Carr and Johansson, 1995) identified two types of risk in the implementation of BPR and Business Process Improvement initiatives:

- technical risk, which is a fear that the process changes will not work, and
- organisational risk, by far the most significant risk, which is the possibility of corporate culture reaction against the changes.

It is also noteworthy that only 44 per cent of respondents to the Carr and Johansson survey cited that they would accept more than a modest amount of risk during implementation. Thirty-seven per cent of respondents cited multiple communications with employees as a critical must do to minimise the risks in a re-engineering effort. The message should be simple, involve top management, and must be communicated as early as possible so that understanding and buy-in is created at the start of the project. Another methodology cited by Carr and Johansson in the reduction of risk is to demonstrate the success of re-engineering through the implementation of precisely targeted pilot programmes. They help communicate strategy, and can also reinforce management commitment and create user buy-in.

3.6. **Business Process Improvement in Business Process Re-engineering**

This chapter introduces a review of the existing literature on Business Process Improvement and based on the literature review with the aim is to provide a framework for a more conscious adoption of process improvement practices amongst businesses.

Given the definition that we adopted in the beginning of this chapter we use the framework illustrated in Figure 3-7 to describe the relationship between Business Processes Improvement Practices (BPIP) and the other disciplines related to the management of processes.

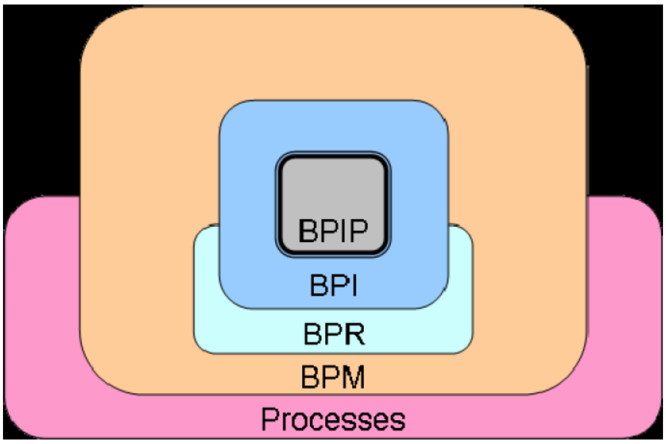

Figure 3-7 Hierarchy among Business Process related frameworks (Forster, 2006)

According to Foster (Forster, 2006), Business Process Improvement is one of the elements of Business Process Re-engineering (BPR). To understand Business Process Improvement is therefore critical to comprehend BPR; in this context, it is relevant to note that according to O'Neill & Sohal (O'Neill and Sohal, 1999), that analyse over 100 bibliographic references between 1980 and 1998 the following major topics are essential to understanding Business Process Re-engineering:

- The definition of BPR
- BPR tools and techniques
- BPR and TQM co-existence
- Understanding organisational processes
- The re-engineering challenge
- Organisational design using BPR

3.6.1. **Defining BPR**

O'Neill & Sohal noticed that in literature, there are different definitions of BPR and that often the same concept is recalled with different names. For example, Davenport & Short (Davenport and Short, 1990) described BPR as the analysis and design of workflows and processes within and between organisations. Hammer and Champy (1993) use the term to refer to a more fundamental rethinking and radical redesign of business processes to achieve dramatic improvements in critical, contemporary measures of performance, such as cost, quality, service, and speed. Talwar (1993) put the focus on the restructuring and streamlining of the business structure, processes, methods of working, management systems and external relationships through which value is created and delivered. Watkins et al. (1993) describe the discipline as the conscious reshaping of an organisation behind a new corporate vision, the marketplace and the customer.

According to White (White, 2014), different approaches correspond to a different level in the change spectrum that is influenced by the different focus of the change (Figure 3-8).

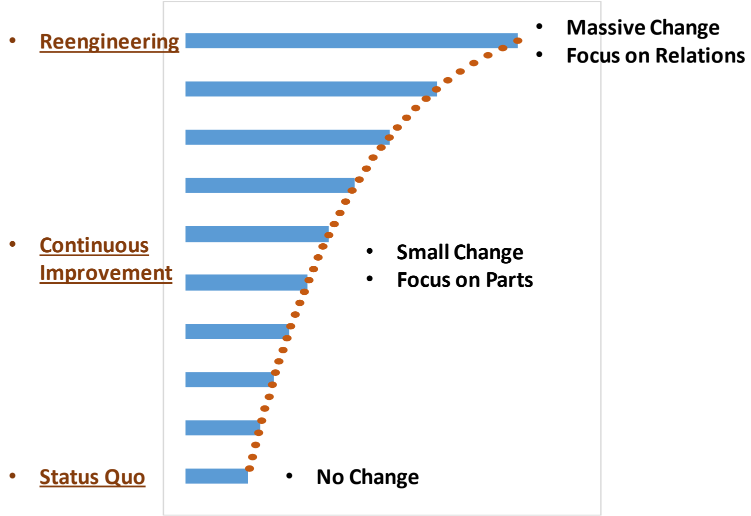

Figure 3-8 Rate of change spectrum

In his model he further determines three different dimensions that characterise a different approach to change:

- the desired level of change
- the system complexity
- moreover, the system focus

According to White when addressing business process changes we must choose either to go for a Continuous Process Improvement (CPI) methodology, and a Business Process Re-engineering when those three dimensions are in harmony. Otherwise, we have ineffective changes (represented by X) as described in Figure 3-9.

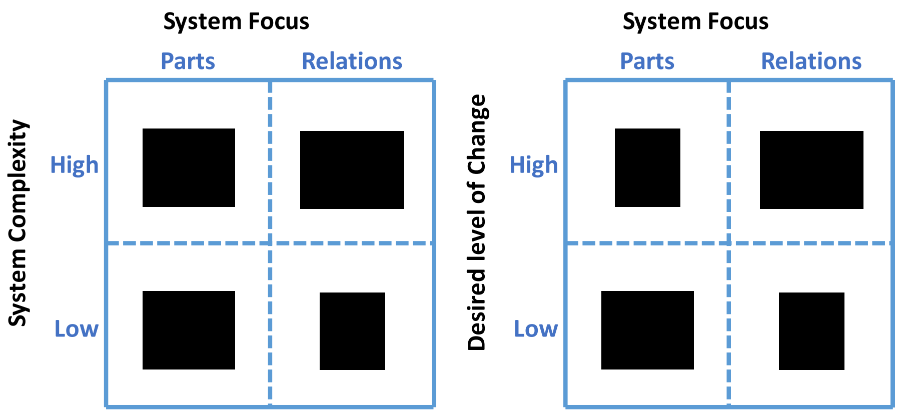

Figure 3-9 When CPI or BPR

According to Petrozzo and Stepper (Petrozzo and Stepper, 1994), BPR involves the concurrent redesign of processes, organisations, and their supporting information systems to achieve a radical improvement in time, cost, quality, and customers' regard for the company's products and services. While Lowenthal (Lowenthal, 1994) stresses that the redesign strongly involves the development of the organisation's core competencies, to achieve dramatic improvements in organisational performance.

O'Neill & Sohal (O'Neill and Sohal, 1999) reflect that is a common denominator that BPR has focused on the definition and operation of business processes to produce products and services within a defined business scope. However, BPR did not focus on strategic business direction setting or planning, but of course, these may be necessary components in achieving the goals envisaged in this vision. They also point out that each methodology, in its own right, does not have the intention or the capability of reinventing business or industry.

Interestingly they conclude that BPR is not necessarily dependent on IT solutions as only one of these definitions refers to information systems. There is general agreement that IT can be a powerful enabler, with the *radical improvements sought more a function of organisational process redesign, rather than IT implementation*. While IT specialists insist that new systems be central to BPR, the challenge is increasingly one of the implementations of organisational change and the visioning involved in that change, rather than the technology itself (Wastell, White and Kawalek, 1994). This conclusion reflects to the evolution of the discipline in the period when this very comprehensive review was developed. On the other hand, the literature shows a change of interest in process improvement practices toward the automatization of the processes and the trend of the last few years is to re-evaluate the technological push as a driver of process improvement.

As we were anticipating before, in the literature O'Neill & Sohal (O'Neill and Sohal, 1999) discover a general confusion in the terminology. Hammer (Hammer, 1990) referred to business process re-engineering, while Davenport and Short (Davenport and Short, 1990) to business process redesign. They identify several terminologies that were adopted to explain concepts similar to BPR with a small variation in the scope of the improvement actions. For example:

- Business process improvement (Harrington, 1991)
- Core process redesign (Kaplan and Murdock, 1991),
- Process innovation (Davenport and Short, 1990),
- Business process transformation (Burke and Peppard, 1995),
- Breakpoint business process redesign (Johansson *et al.*, 1993),
- Organisational re-engineering (Lowenthal, 1994),
- Business process management (Duffy, 1994),
- Business scope redefinition (Venkatraman, 1994),
- Organisational change ecology (Earl and Khan, 1994), and
- Structured analysis and improvement (Zairi, 1997).

While some of these terms are clearly referring to a generic business process improvement model on a large scale, other authors (Watkins, Skinner and Pearson, 1993; Earl and Khan, 1994) point out that re-engineering can be performed at a variety of different levels within the organisation. This is exemplified in IBM's re-engineered finance process, which yielded substantial percentage improvements in costs, time, and quality, but had little effect on overall performance because it was not a core process central to the strategy of the company (Currid, 1996). Put into strategic context, BPR becomes a means of aligning work processes with customer requirements in an interactive way, to achieve long-term corporate objectives. To achieve this, Senge (Senge, 2010) and Deming (2000) advocate a systems outlook involving customers, suppliers, and the future. Gulden and Reck (1992) support this view by showing that the secrets to designing a process lie not so much in intimately understanding the way it is performed today, but rather in thinking about how to reshape it for tomorrow.

Venkatraman (Venkatraman, 1994) provides, however, a framework that we often use to clarify the different type of transformation we are.

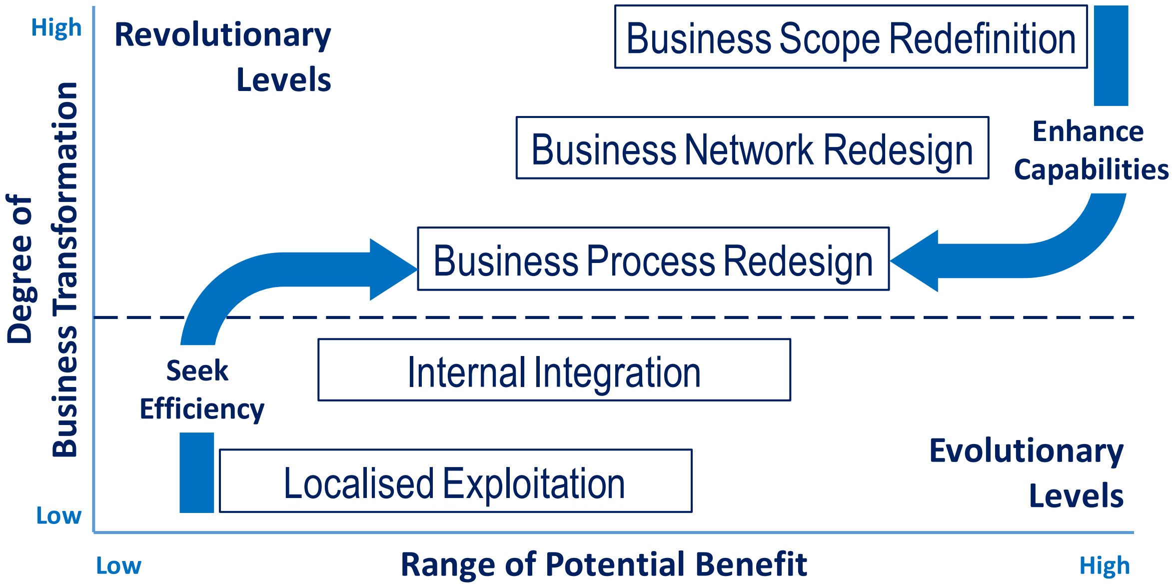

Figure 3-10 Levels of business transformation

In this approach (Figure 3-10) Venkatraman position BPR at the crossroad between approaches that seek efficiency and those that aim for a capability change. It, in fact, requires a drastic change of the internal processes, while the focus is still on the Enterprise's Business Processes.

3.6.2. BPR and TQM coexistence

Among the Continuous Improvement practices, TQM was among the originals and more discussed in the literature.

TQM is "an approach to improving the competitiveness, effectiveness and flexibility of a whole organisation. It is essentially a way of planning, organising and understanding each activity, and depends on each at each level" (Oackland, 1995).

TQM involves placing the customer as the focal point of operations. It aims to continuously improve process performance to satisfy customer requirements (Bennis, 1992). It involves the bottom-down communication and deployment of objectives and the bottom-up implementation of continuous improvement activities. At the centre of TQM is the concept of the management of processes, and the existence of internal suppliers and customers within organisations. Organisations which have adopted TQM are likely to have developed an understanding of the processes which are operated, an attempt to make the client the target of improvement activities (Oackland, 1995).

BPR also emphasises focus on the process. However, authors such as Klein (1993) suggest that BPR is much more radical than TQM, while others, notably Davenport (Davenport, 1993a); Harrison and Pratt (Brian Harrison and Pratt, 1993) suggest that TQM and BPR can and should form an integrated strategic management system within organisations. Davenport (Davenport, 1993b) suggests there is a need to undertake process analysis to identify which processes should be re-engineered, and which should be managed by continuous improvement. The situation is, in reality, less clear-cut than re-engineering versus continuous improvement since improvement activities form a continuum from small incremental improvements to the radical wholesale restructuring of an operation (Gadd and Oakland, 1996). All those definitions suggest that a BPR is relevant when a change of capacity is necessary usually when the organisation faces drastic capacity changes.

There has been an increasing number of articles calling for the need for both continuous and discontinuous improvement. For example, Hammer (Hammer, 1990) suggested that they should both fit under the umbrella of process management, while authors such as Chang (Chang, 1994); Furey (1993); Taylor (Taylor, 1993) described programmes that integrate TQM and BPR as management tools. Hammer (Hammer, 1991) described sequential performance improvements using the two techniques and warned against using the two approaches concurrently.

Several authors of papers on BPR appear to consider the continuous improvement of processes to be the only link to TQM. However, other aspects of the management of processes are considered equally important in both TQM and BPR, including:

- benchmarking (Brian Harrison and Pratt, 1993; D'Aveni and Gunther, 2007),
- culture change (Bartlett and Ghoshal, 1995) and
- performance measurement (Guha, Kettinger and Teng, 1993; Hagel, 1993).

While improvements usually happen through small steps, Kano (Kano, 1993) contends that the continuous accumulation of these can lead to radical breakthroughs. Juran (Juran, 1964) goes even further to state that quality improvement teams can move directly to significant innovations of a "breakthrough" kind. Hill and Wilkinson (Hill and Wilkinson, 1995) have also made clear that, while the BPR critique misunderstands the nature of TQM, it is possible that the practice of TQM in many organisations may have contributed to the misperception. Some TQM implementations are used to generate only incremental improvements and thus are a partial form of TQM that operates primarily among low-level employees, where small-scale incrementalism is likely. In this case, BPR proponents have criticised the practice of organisations with partial quality management, rather than TQM itself. This may render more acceptable the failure of Hammer and Champy (Hammer and Champy, 1993) and others to come to grips with TQM. However, Hall et al. (Hall, Wade and Rosenthal, 1993) have argued that BPR initiatives have also tended to be too narrow or partial because they take place within functions and departments rather than across the organisation. That is, they lack sufficient managerial stewardship, and they are not integrated with the holism of organisational change (Hill and Wilkinson, 1995).

According to (O'Neill and Sohal, 1999) BPR might be less likely to succeed outside TQM since it uses the methods, process, and customer orientations of TQM to deliver step changes. If it does so on an ad hoc basis, without the training, experience, and organisational infrastructure that TQM takes for granted, it might be anticipated that corporate resistance would be higher than in a culture where planned quality change is taken for granted. Could this help explain the high failure rate among first time BPR projects? No, as argued by Zairi and Sinclair in their 1995 study of UK organisations (Zairi and Sinclair, 1995), a tiny distinction exists between TQ and not TQ organisations, and the successful integration with BPR.

Cole (Cole, 1994) concludes that an extraordinary amount of overlap exists between the quality and re-engineering movements and that the two initiatives complement each other. He believes that each component of the "quality house" is a building block onto which subsequent change programmes should build. Similarly, Thomas (Thomas, 1994) writes about the "aesthetic of manufacturing", that simultaneously achieves mastery over current processes, promotes continuous improvement in those processes, and prepares for transformational change. Most authors would seem to agree that if BPR helps focus attention on transformational change, without damaging core competencies and continuous improvement, it could effectively contribute to a whole quality framework that will benefit the whole organisation. Looked at in this way, Gadd and Oakland (Gadd and Oakland, 1996) argue further that TQM and BPR can be considered as two distinct and different approaches capable of coexisting in the same organisation but used at different times to achieve varying levels of performance improvement.

To conclude TQM practice in the Venkatraman approach shown in Figure 3-10 can be collocated in the lower two blocks where the company seeks efficiently toward. In our experience, companies are looking to continuous improvement methodologies like TQM to obtain improvement without CapEx[4]. In a more holistic view of Business Process Improvement practices, however, we have to consider that there may be the necessity to overcome technical constraints or cover technological gaps to provide the enterprise with new capacity.

3.6.3. BPR and BPI tools and techniques

The various definitions of BPR described in Chapter 3.6.1 suggests that the radical improvement of processes is the goal of BPR. They do not, however, refer specifically to the tools and techniques used in re-engineering business processes. To drive a BPR transformation is, in fact, more the strategic fit than a particular tool. The result of this void is that authors and consultants alike have pursued the use of many different tools in the search for the best re-engineering application. These tools and techniques employed by BPR are therefore not notably different from those adopted in any other Business Process Improvement initiatives and include the following.

Process visualisation

While many authors refer to the need to develop an ideal "end state" for processes to be re-engineered, Barrett (1994) suggests that the key to successful re-engineering lies in the development of a vision of the process.

Process study by mean of BPA/M tools

Cypress (1994) and Venkataiah & Sag (2013) suggest that the tools of operational method studies are ideally suited to the re-engineering task, but that they are often neglected. O'Neill & Sohal (2016) recent evidence suggests that these concepts have been incorporated into tools for business process analysis and modelling (BPA/M) such as IDEF0 (Integrated Definition Method), SSADM (Structured System Analysis and Design Methodology), DFD (Data Flow Diagrams), OOA (Object Oriented Analysis)

---

[4] CAPEX: Capital expenditure, or CapEx, are funds used by a company to acquire or upgrade physical assets such as property, industrial buildings or equipment. It is often used to undertake new projects or investments by the firm. This type of outlay is also made by companies to maintain or increase the scope of their operations. These expenditures can include everything from repairing a roof to building, to purchasing a piece of equipment, or building a brand new factory. (http://www.investopedia.com/terms/c/capitalexpenditure.asp)

(Yu and Wright, 1997), and Prince2 project management processes guidelines (Department for Business Enterprise and Regulatory Reform, 2007).

Change management

Several authors concentrate on the need to take into account of the human side of re-engineering, the management of organisational change. Some authors (Bruss and Roos, 1993; Mumford and Beekman, 1994) suggest that the management of change is the most significant task in re-engineering. Kennedy (1995) on the other hand, incorporate the human element of re-engineering due to the perceived threat it has on work methods and jobs.

Benchmarking

Several authors suggest that benchmarking forms an integral part of re-engineering since it allows the visualisation and development of processes which are known to be in operation in other organisations (Brian Harrison and Pratt, 1993; Furey, 1993; Chang, 1994)

Process and customer focus

The primary aim of BPR, according to some authors, is to redesign processes about improving performance from the client's perspective (Vantrappen, 1992; Chang, 1994). This provides a strong link with the process improvement methodologies suggested by authors from the quality field, such as Harrington (1991). In some cases, notably Chang (1994), the terminology is almost identical to that used by quality practitioners in the improvement of processes. The significant difference, as outlined earlier, appears to be one of scale.

It should be noted that few authors refer to any single technique when discussing BPR. Most incorporate a mixture of tools, although the nature of the mix depends on the application, whether it be hard (technological) such as proposed by Teng et al. (1994) or soft (management of people), as seen from Mumford and Beekma (1994). While the exact methodologies to be used are the source of some discussion, it can be seen that BPR, as a strategic, cross-functional activity, must be integrated with other aspects of management if it is to succeed. This is especially true, since it is not the methodologies themselves, but rather the way that they are used which is unique in BPR. Of particular interest are the links between BPR and TQM.

In summary, therefore, BPR can be seen to represent a range of activities concerned with the improvement of processes. While some authors appear to suggest that tools and techniques are the keys, most authors suggest that a strategic approach to BPR and the development of a BPR strategy is the key to success (Bruss and Roos, 1993; Guha, Kettinger and Teng, 1993). There seems little doubt in either the literature or in practice that efforts on the scale of BPR must be strategically driven and supported by senior management if they are to succeed (Barrett, 1994; Gadd and Oakland, 1996; O'Neill and Sohal, 1998).

3.7. **Business Process Improvement principles**

For the particular interest of our thesis, we will focus on all Business Process improvement (BPI) initiatives with no relevance if this is a radical change or an incremental adaptation necessary to cope with a change of the external or internal conditions or in seek of efficiency or effectiveness.

In a more recent publication Boutros & Cardella (2016) recall a set of principles of Business Process Improvement (10 tenants):

Agility

Business Process Improvement values agile and iterative improvement. Since change is inevitable, companies that desire to enhance ceaselessly must have the capacity to acclimate to and exploit rising open doors agilely. This includes concentrating on adaptable work and arranging ones custom-made toward incremental change.

Quality

Business Process Improvement values quality in all aspects, from process creation to its termination, including process, people, and technology changes. As Aristoteles was used to say: "the quality is not an act but a habit". Organisations that understand and focus their attention on all elements of quality, from the beginning of transformation initiatives to the end, are more successful.

Leadership

Business Process Improvement values leadership for a proactive and open ideas creation for improving the company's organisation. In many continuous improvement practices, solely methods and tools are in focus of the implementation. However, they merely represent the superficial elements of continuous improvement practices. The real key success factor is the involvement of employees in improvement on daily basis. This can be achieved through a different way of leadership (Dombrowski and Mielke, 2013). Leaders communicate and inspire a clear and compelling vision for the future while teams become more engaged and open to improvement opportunities (Taylor, Aken and Tech, no date).

Communication

Business Process Improvement values open communication and participative decision making. In every organisation, individual members have the potential to speak up about important issues, but a growing body of research suggests that they often remain silent instead, out of fear of negative personal and professional consequences (Kish-Gephart et al., 2009). When an organisation recognises that everyone has a contribution, and should have the opportunity to voice opinions, ideas, and experiences, is becoming more innovative in its improvement conceptions.

Respect

Business Process Improvement values group-working relationships when improving the organisation. The literature has emphasised the importance of the human dimensions of motivation, empowerment, and respect for people. Alongside this, commitment is needed from the management as continuous improvement practice is not just a tool, but rather a strategic move towards cultural transformation. (Gupta, Sharma and Sunder M., 2016) The company's success depends on every time more on having safe and trusts on people capacity of innovating for good.

Discipline

Business Process Improvement values organisational discipline and maturity. Structured companies with high regulatory control and therefore performing business processes in a standard, repetitive fashion are more competitive and usually they are leaders in their markets. Further, integration of Business Process Improvement with other management disciplines could unlock the potential of a stable structure to measure and gradually improve knowledge transfer processes. (Jochem, Geers and Heinze, 2011) Ensuring a disciplined approach to all Business Process Improvement activities helps ensure accurate and robust solutions are implemented.

Enterprise perspective

Business Process Improvement values the consideration of what is best for the organisation rather than specific departments, focus areas, geographies, or individuals when making decisions and conducting day-to-day work. An important aspect of enterprise integration is the ability to look at the process from different views. The information view, behavioural view, organisational view, decisional view, etc. (Bal, 1998). Ensuring Business Process Improvements meet not only the needs of those involved with the activities in question but also the larger enterprise provides time and money are not wasted deploying and redeploying solutions.

Service orientation

Business Process Improvement values the notion that process improvement activities provide a service to companies, departments, sponsors, individuals, the community, the consumers, and the profession. Service orientation presents some massive cultural and technical challenges that cross three areas that have traditionally worked mostly in isolation from one another: Business Process Improvement, application development and software operations. This introduces the central idea of service-oriented architecture (SOA) (Allen et al., 2006). This involves doing what is right for the customer in question and endlessly providing expertise for their benefit.

Continuous learning

The Business Process Improvement values training and educating those involved in Business Process Improvement efforts. The primary objective of training is to provide all personnel, suppliers, and customers with the skills to effectively perform quality process activities, and to build this concept directly into an organisation's operations. This practice enables continuous learning within the organisation and promotes improvement and process-oriented thinking. Further according to several authors it is an essential driver for competitive advantage (Nonaka and Takeuchi, 1995; Wick and León, 1995; Watkins, 1996; Yolles, 2009; Evers et al., 2011; Van Breda-Verduijn and Heijboer, 2016)

Human-centred design

Business Process Improvement values the consideration of what is best for customers of a process (operators and end consumers) when developing and implementing process solutions and enhancements. The customer of a process is the only one who can decree the achieving of its goal and the level of quality (Watson, 2002; Arru, Teeling and Igoe, 2016b) when improving products or services; the user-friendliness is an essential attribute to consider (Goodwin, 2009).

Among the advantages that an organisation can pursue, we can list the following: (Boutros and Purdie, 2014)

- Quickly adapting to changing requirements or market factors
- Significantly reducing the risk associated with continuous improvements
- Accelerating the delivery of business value to customers
- Ensuring that value is continually being maximised throughout the continuous improvement process
- Meeting customer requirements faster and more efficiently
- Building innovation and best practices that help reach new maturity levels
- Discovering hidden knowledge and expertise within their workforce
- Improving performance and motivation across all areas of the business

3.8. The phases of Business Process Improvement

All Business Process Improvement framework has a disciplined approach to innovation (Jochem, Geers and Heinze, 2011). A methodical approach is necessary to obtain consistency in the results.

In the beginning of this chapter we mentioned a common root in the development of Business Process Improvement practices. The same source strongly influences the phases of those disciplines that are derivate from the Deming's plan–do–study–act (PDSA) (Deming, 1950), and Shewhart's Plan-Do-Check-Act (PDCA) (1917).

The plan–do–check–act cycle is a four-step model for carrying out change. Similarly, as a circle has no end, the PDCA cycle ought to be rehashed and for constant change (Tague, 2005).

Per the American Society for Quality (ASQ) the PDCA may be used for the following purposes

- as a model for continuous improvement,
- when starting a new improvement project,
- when developing a new or improved design of a process, product or service,
- when defining a repetitive work process,

- when planning data collection and analysis to verify and prioritise problems or root causes, and
- when implementing any change.

The phases of the PDCA are the following:

- **Plan.** Recognise an opportunity and plan change.
- **Do.** Test the change. Carry out a small-scale study.
- **Check.** Review the test, analyse the results and identify what one has learned.
- **Act.** Take action based on what one learned in the study step: If the change did not work, go through the cycle again with a different plan (Tague, 2005).

If one were successful, incorporate what one learned from the test of more extensive changes. Use what one learned to plan new improvements, beginning the cycle again.

Based on the PDCA Burke & Peppard (1995) determine that fundamental phases in BPR, and therefore in Business Process Improvement are to establish a vision, identify and understand the current business processes, redesign the processes, and finally to implement redesigned processes

Lewin (Lewin, 1947) describes the change as the passage from a stationary phase to another through a sequence of unfreezing, motion and re-freezing

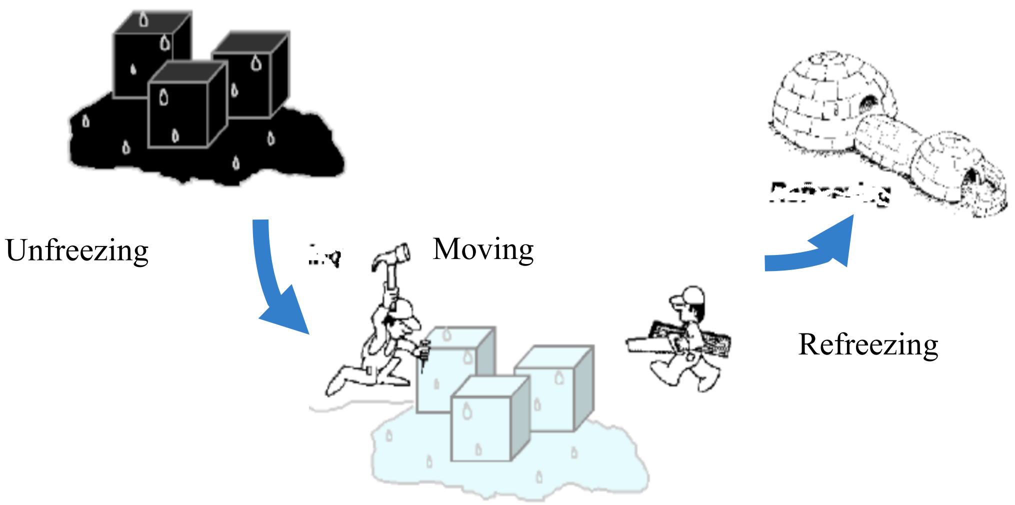

Figure 3-11 Change Process (Arru, Teeling and Igoe, 2016a) *in an operational Business Process Improvement context according to Lewin*

Archer et al. (2006), on the other hand, after analysing a large number of approaches from consultancy firm conclude that continuous improvement is another crucial phase

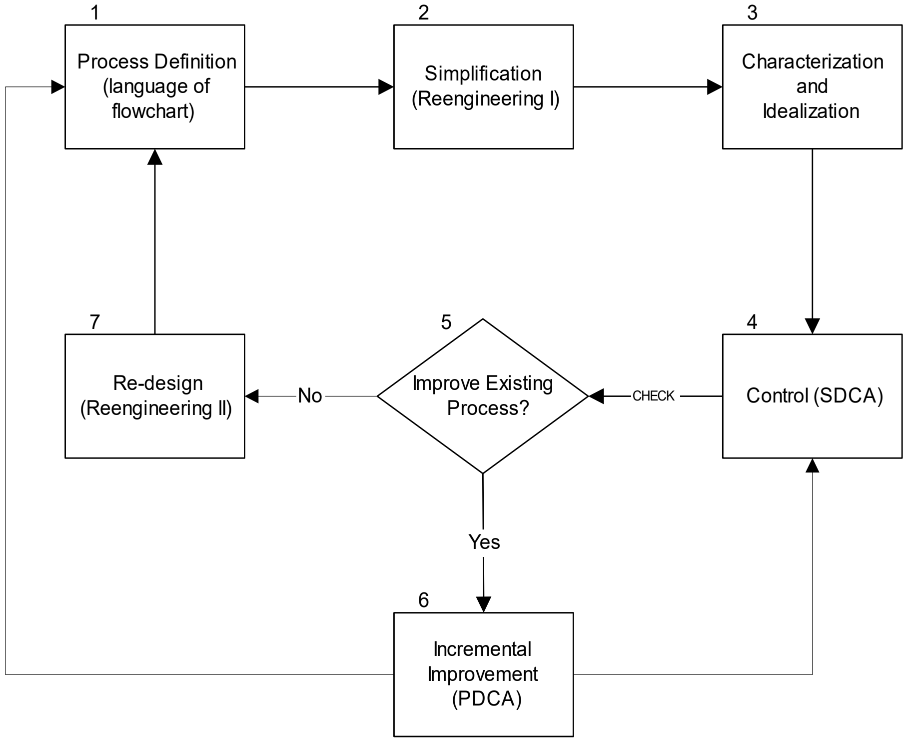

Figure 3-12 The 7-steps of process management.

that Business Process Improvement practices often propose. This is in line with Schneiderman's approach (2000) as illustrated in Figure 3-12 that one of the most cited reference model.

Boutros & Cardella (2016), in fact, explain the phases of any Business Process Improvement as follow:

Planning

During the planning phase, most methodologies suggest identifying and clarifying the issue or challenge clearly and succinctly. During the planning phase, activities might include chartering a team to work on the project, identifying the problem, and presenting the project to a sponsor or executive team for approval or endorsement. Teams will also have to begin measuring relevant metrics, and come up with a definition of what success is going to look like. Factors to be considered in this phase include the following.

Analysing

Investigating the current state by documenting the as-is process, deciding on the appropriate metrics and goals, and taking baseline measurements occurs in the analysis phase. Teams continue to gather information during the analyse phase, which might include one or more process maps. They also interpret data, coming up with possible root causes for the problem, and validate those causes. Toward the end of the analyse phase, teams brainstorm solutions and decide which solutions they will move forward with.

Designing

During the design phase, the team focuses on identifying as many countermeasures as possible to reach the intended goals of the improvement project. They prioritise the countermeasures based on perceived impact and design a to-be process that they believe will help meet the aims of the organisation. During design phases, teams develop new processes or products that will solve the problem or improve the situation. In many projects, this might mean developing new technical solutions.

Implementing

At this point, the change is documented, and the organisation begins using the new process. The team measures the results and compares them to baseline results or other benchmarks. Changes are often tested to ensure that processes react as expected to change, and new problems and risks are not created. After teams confirm that implemented solutions are working as planned, they put controls in place to ensure ongoing performance and quality. Processes are then transitioned back to the needed owners and participants.

Continuously improving

The job of Business Process Improvement does not stop after one first improvement effort. It is the ongoing responsibility of teams and process operators to ensure that processes are continually improved. Business processes must be monitored and continuously analysed to discover any opportunities for improvement. It is a journey toward excellence, and all of those involved in ongoing operations should continuously be looking for new and better ways of working.

Liesener (Liesener, 2015) compares different methodologies of Business Process Improvement and shows the similarities between all those methods. In particular Figure 3-13 shows how can the various phases in PDCA (Shewhart, 1917), Lean's A3 thinking (Shook, 2009), Six Sigma's DMAIC (Tennant, 2000) and Ford's 8D PSP (Snyder and Jowa, 2004), can be assimilated.

PDCA	DMAIC	A3	8D/PSP
Plan	Define	Clarify the Problem	1. Create Team & collect Information 2. Describe the Problem
	Measure	Break down the Problem	
		Set a Target	3. Define Contain-ment Actions
	Analyse	Analyze the Root Cause	4. Analyze the Root Cause
		Develope Countermeasures	5. Define possible corrective Actions
Do	Improve	See Countermeasures	6. Implement corrective Actions
Check	Control	Evaluate Results & Processes	7. Define Actions to avoid Recurrence 8. Congratulate your Team
Act		Standardize Success	

Figure 3-13 Phases of the most popular Business Process Improvement methodologies (Liesener, 2015)

3.9. **Process maturity**

Process maturity is an indication of how close a process or organisation is to be complete and capable of continual improvement through qualitative measures and feedback (Srinivasan and Murthy, 2012; Boutros and Cardella, 2016).

Development models are a thriving way to deal with enhancing an organisation's procedures and business process management (BPM) abilities. The quantity of relating development models is high to the point that specialists and researchers risk losing track (Röglinger et al., 2012).

In a mature organisation processes, must be complete and useful, automated where applicable, reliable in information, and continuously improved. In any case, most organisations have a constrained comprehension of end-to-end business processes, and if any understanding exists, it is regularly in different gatherings over the enterprise. It is uncommon to discover a firm that has connected its scattered procedure skills to bolster a far-reaching process operational excellence. Companies that need to accomplish operational excellence consistently assess their processes and functional parts, including information quality, strength in their culture, advancements, and policies and controls, while searching for approaches to expand proficiency, enhance profitability, and wipe out waste.

A popular model maps the maturity to 5 levels (Srinivasan and Murthy, 2012):

Level 0 – Person-Dependent Practices

This level is for cases where the activity being performed is not documented. In other words, it is not recorded either in outline or detail. The activity is entirely person dependent and the sequence, timing and result may vary during the repetition. This requires much supervision. There is no guarantee of either achieving the desired result or adhering to timelines. The activity is entirely ad hoc, with little communication between functions. The effectiveness of the operation is entirely dependent on individuals. Knowledge transfer could conceivably happen when handover activities in the occasion of a change in the ownership.

Level 1 – Documented process

At this maturity level, there is a document that has been reviewed and approved by the supervisor or the approving authority as the standard process. However, it might be far-fetched that the action being performed is according to the report. This might be a direct result of a procedure float or some radical change since the archive was drafted.

Level 2 – Partial deployment

Here, the activity that is documented is being deployed, but there is inconsistency in the implementation. The procedure may not be conveyed in totality. That is, it may not be implemented in all the expected areas, or however, all capacities, or by all the planned owner or every one of the exercises characterised in the process may not be performed. This would imply that the report has not been intended to take into account this level of varieties. There are irregularities in aftereffects of various process owners.

Level 3 – Full deployment

At this level, there is no inconsistency between the documented process and the deployed process. The procedure reported and conveyed considers all the expected areas, owner and every one of the activities that should be performed. The process also shows the same connection between the functions and the other processes wherever there is a need for any interaction. This means that the process shows a higher consistency of actions and communication between functions.

Level 4 – Measured and automated

The process has set itself goals such as adherence to timelines, customer satisfaction, cost. The process also is being measured against its objectives. The process is system-driven by enablers such as using enterprise resource planning or customer resource management or any other custom-made software (Al Hanaei and Rashid, 2014).

Level 5 – Continuously improving

The goals set for the process are being audited for achievements and developed with regularity. The timelines, cost targets, satisfaction levels are being regularly achieved; the objectives likewise are being fixed by utilising nonstop quality change strategies, including Six Sigma and Kaizen. The enabling system is an object of the improvement too and being made error-free by strategies such as poka-yoke (mistake proofing).

However, Röglinger et al. (Röglinger et al., 2012) conducted a broad literature review on the status of art of BPMN and concluded that the analysed maturity models sufficiently address basic design principles, as well as principles for a descriptive purpose of use. The outline standards for a prescriptive utilisation, however, are barely met. Those maturity models provide limited guidance for identifying desirable maturity levels and for implementing improvement measures. The same conclusions are reported in a more recent review (Tarhan, Turetken and Reijers, 2016) showing that despite that many BPM methods were proposed in the last decade, the level of empirical evidence that reveals the validity and usefulness of these models is scarce.

Given this limitation, the Shingo Institute (Robert D., 2016) identifies the maturity level for a company on a different behavioural level. Per this model, in fact, a company should have embedded the principle in every associate behaviour to be able to sustain continuous Business Process Improvement.

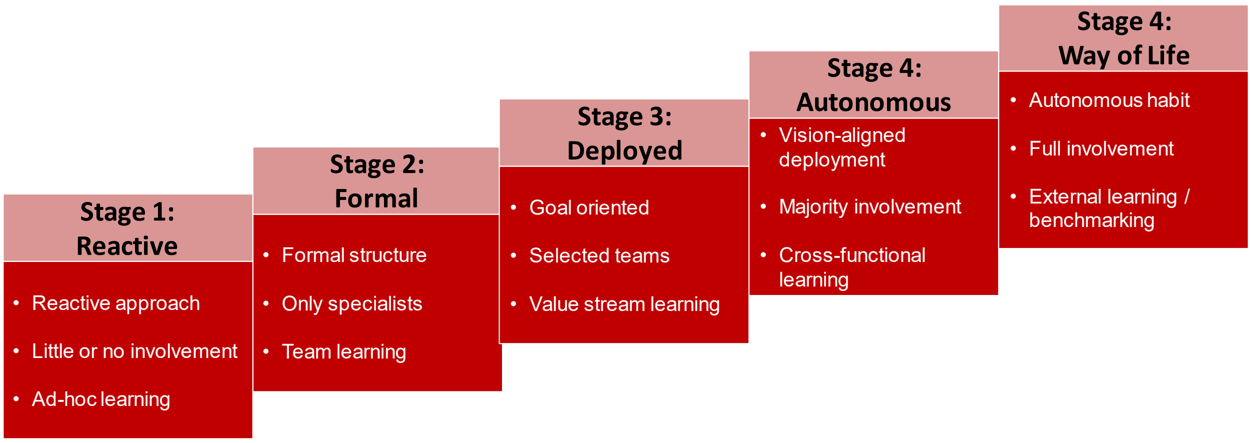

Figure 3-14 The Shingo Maturity Model

The Shingo Institute identifies the five stages (Figure 3-14) in a journey of a company to excellence each one characterised by the following three key characteristics:

- ways of working,
- employee engagement, and
- learning best practices.

3.10. Business and process architecture

Business architecture is defined as a blueprint of the enterprise that provides a shared understanding of the organisation and is used to align strategic objectives and tactical demands. (Ulric and McWorther, 2010)

Boutros & Cardella (2016) distinguish process architecture from the system, business, or data architecture, that contribute to the broader enterprise architecture discipline. Systems architecture applies the same concepts of integration and communication but is usually limited to the world of technology. Data architecture is, on the other hand, concerned with how data are stored, managed, secured, integrated, archived, accessed, and used. Business architecture is usually concerned with connecting strategy and tactical business functions.

In practical terms, a process architecture is the design and organisation of business processes and related components into a unified structure and hierarchy. This structure provides an overview of the various process systems, interfaces, interdependencies, rules, and other relationships within and between processes across a company, and helps align functional business objectives and strategies to process execution. (Boutros and Cardella, 2016)

The Zachman Framework for Enterprise Architecture (Zachman, 2003) is a normalised schema, one (meta) fact in one place.

The framework is a semantic structure. It implies nothing about implementation processes (methodologies) or tools whether they are top-down, bottom-up, left-to-right, right-to-left, or where to start.

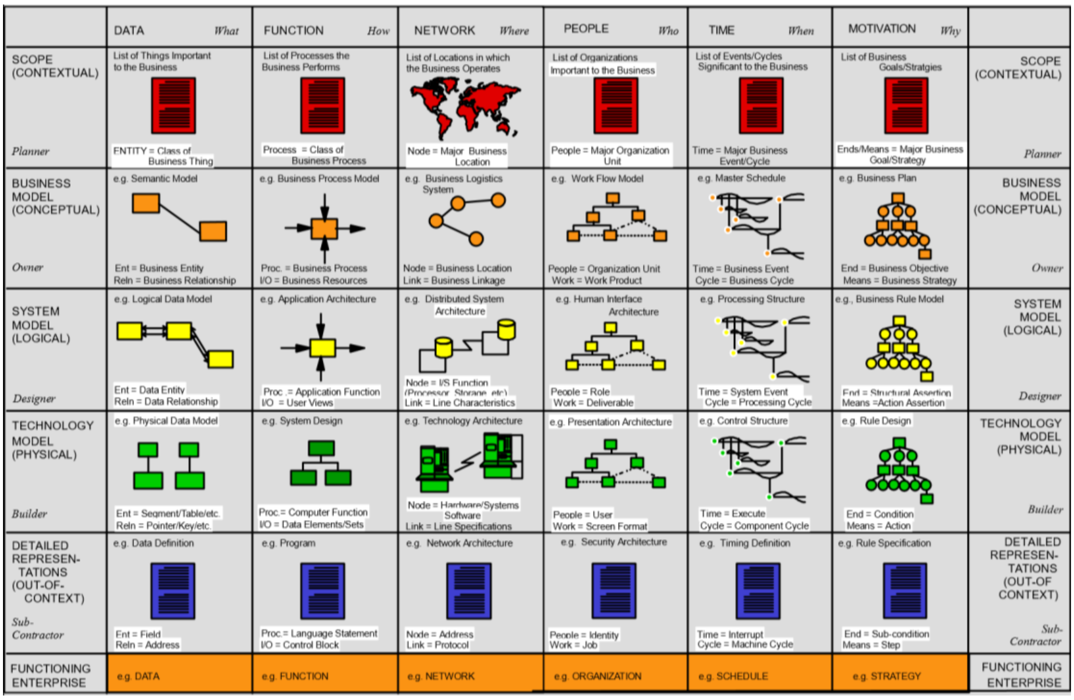

Figure 3-15 Enterprise Architecture - a framework

The abstractions, the other dimension of the classification system, depict the independent variables that constitute a comprehensive depiction of the subject or object being described, including:

- *What* it is made of - the material composition of the object, the bill-of-materials - for enterprises, the Thing (Data) models.
- *How* it works - the functional specification, the transformations - for enterprises, the Process (or Function) models.
- *Where* the components are located relative to one another - the geometry, the connectivity - for enterprises, the Logistics (or Network) models.
- *Who* does what work - the manuals, the operating instructions - for enterprises, the People (or, Work Flow) models.
- *When* do things happen relative to one another - the life cycles, the timing diagrams - for enterprises, the Time (or Dynamics) models.
- *Why* do things happen - the ends/means - for enterprises, the Motivation models.

The most relevant aspect of business architecture is that it represents a business that is not necessarily bounded within an enterprise. Business architecture must, therefore, represent portions of a business that have been outsourced as well as stakeholder interests (Business Architecture Guild, 2013).

Figure 3-16 describes the high-level domains of abstractions within a business represented by the business architecture.

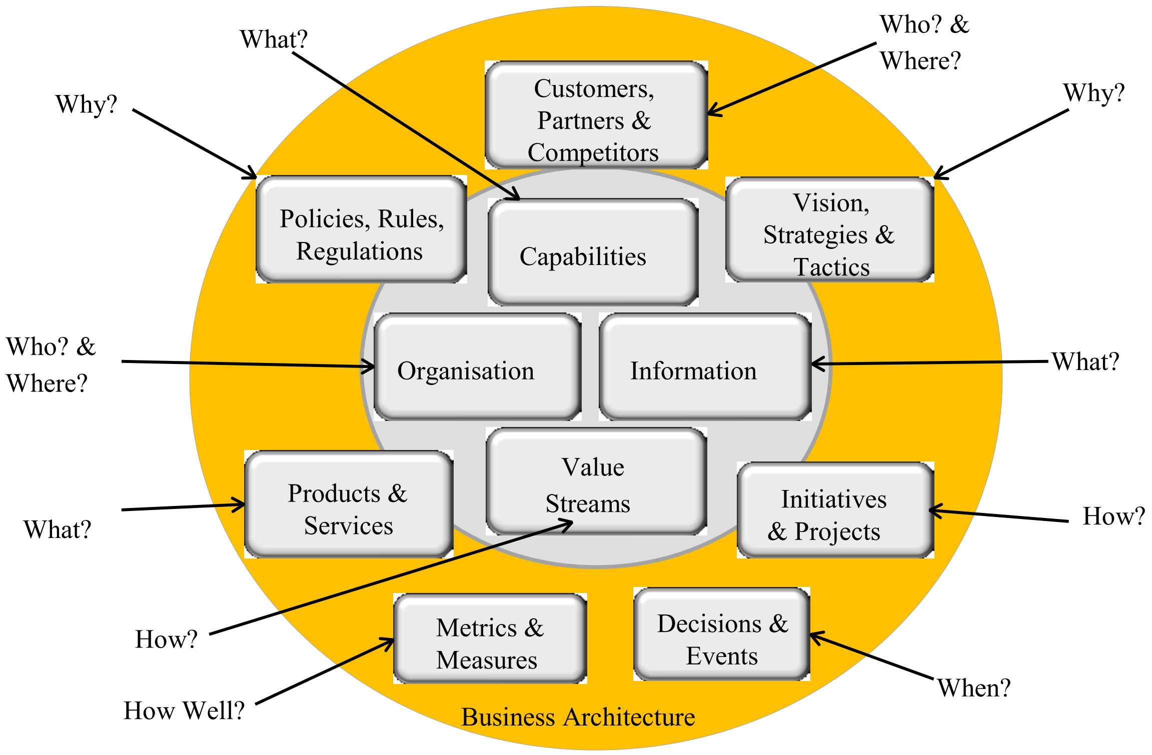

Figure 3-16 Aspects of the Business Represented by Business Architecture (Business Architecture Guild, 2013)

The fundamental principles that apply to business architecture imply that it:

- is about the business
- has scope aligned with the business
- is not prescriptive
- is iterative
- is reusable
- is not about the deliverables (Business Architecture Guild, 2013)
- is information rich
- is relationally rich
- is analytically rich
- is presentation rich. (Boutros and Purdie, 2014)

Process architecture provides some benefits to organisations and people by helping them achieve (Ulric and McWorther, 2010):

- Consistent representation of the business architecture environment that empowers many hardware sellers to convey more valuable institutionalised business and IT arrangements.
- Automation of the creation, joining and redesigning of a wide assortment of administration investigation and reporting.
- Alignment of business and IT transformation efforts.
- Automated reproductions of different arranging situations that permit management to envision and plan for the effect of changes in business as well as IT architectures.
- Improved planning, analysis, design and development of tools capacity that translates between business and IT ecosystems.
- Agility to extend and act based on the information coming from many different sources.

The formalisation of business architecture, along with the subsequent alignment between business architecture and IT architecture, provides a robust foundation for enabling a variety of business scenarios, vendor solutions and new and improved technologies (Ulric and McWorther, 2010).

3.11. **Strategic implications**

The problem of strategic alignment is an essential element in any Business Process Improvement framework. Although the alignment with the value provided to the customer is the first driver for a Business Process Improvement transformation, earlier or later coordination of all the organisation change activities deems to be necessary. Moreover, this includes Business Process Improvement initiatives.

Top management is therefore actively involved in shaping the value proposition of the companies and defining the strategic roadmap toward its implementation (Iaea, 2006).

Organisations understand that a policy deployment is not the only approach and is not only value of the highest hierarchies to provide directions for improvement, on the contrary, it is vital to incorporate the technical expertise and the particular viewpoint of those operating in the process. The role of the management is therefore to facilitate the emerging of opportunities and to appropriately steer them.

In the Lean philosophy, this approach is named Catchball (Tapping and Shuker, 2004): a system to significantly improve bi-directional feedback and ownership — especially for complex decision making and policy deployment. Playing catchball ensures that everyone who should give input does. It also ensures that everyone is committed to doing what everyone agreed to (System2Win, no date).

According to Tapping & Shuker (2004) "Catchball is simple. Regardless of who initiates a project (although it is most commonly a manager), that person articulates the purpose, objectives, and other ideas and concerns and then ‘throws' them to the other stakeholders for feedback, support, and action. In value stream management, the catchball process essentially begins as soon as a manager assembles a core implementation team and identifies an area to improve. Based on the purpose, objectives, and concerns communicated by the manager, the team completes a team charter that defines the project in more detail and then throws it back. Catchball is also used to reach agreement on the future-state map and Kaizen plans."

Many Japanese companies have established an effective strategy deployment process (Harmon and Wolf, 2016), known as Hoshin Kanri, which attempts to integrate top management goals into daily operations. This technique was initially developed in Japan from the concept of Management by Objectives and has been the subject of many English translations, which although similar, can confuse interpretation. The various translations include “policy deployment, policy control and management by policy”. (Tennant and Roberts, 2001)

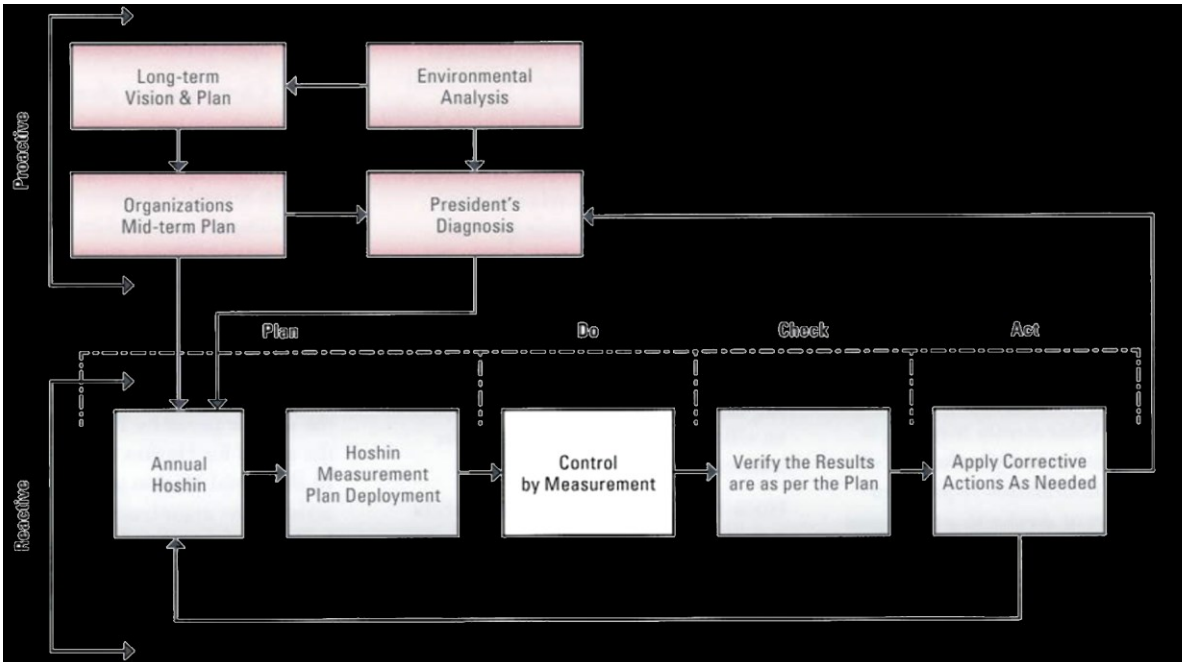

Figure 3-17 The Hoshin Management and PDCA (Meier, Williams and Singley, 2010)

Like the Business Process Improvement practices also Hoshin Karin process is aligned with a PDCA cycle with two different phases as shown in Figure 3-17. In the Proactive phase, a Strategic deployment creates a Diagnosis that results in the Annual Hoshin.

In the Reactive phase the Annual Hoshin, which represent an implementation plan, is implemented and the actions feedback the Hoshin and similarly the planning stage.

The primary management tool in Annual Hoshin is the X-Matrix that links the strategic objectives with the Execution. The X-Matrix (as shown in Figure 3-18) when including risk management within the Hoshin Karin (strategic objectives, projects, risks and quality metrics) is also called PQR (Project Quality Risk) matrix (Costin, 2008).

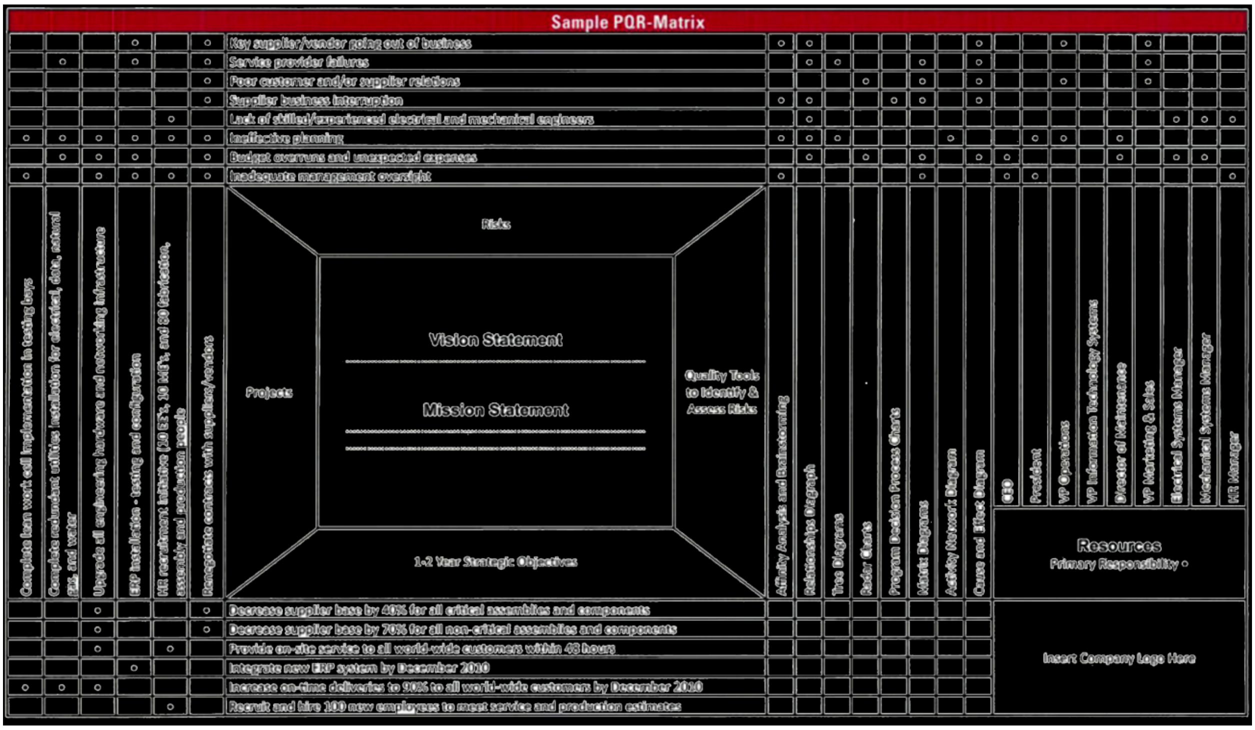

Figure 3-18 The PQR matrix modified from the X-matrix (Meier, Williams and Singley, 2010)

Melander et al. (2016) recognise the vastity of the literature, but also that research on the implementation of an annually based strategic management system is somewhat rare (Li, Guohui and Eppler, 2010). In the earlier literature, the formalisation of the management systems was related to organisational growth, following a deterministic logic (Gluck, Kaufman and Walleck, 1982). In recent publications, this is hierarchically imposed, and the link to a particular development phase is weaker (Atkinson, 2006; Fernandes, Raja and Whalley, 2006).

In a review of the literature on Hoshin Kanri from an application perspective, da Silveira et al. (2013) detect 23 central aspects. Out of those, according to Melander et al. (2016), four are of interest when introducing Hoshin Kanri to management.

- Hoshin Kanri is a management model that is centred on continuous improvement. The learning being that Hoshin Kanri is not a quick fix.
- Hoshin Kanri requires the active involvement of leadership. The learning being that Hoshin Kanri is not a strategic management system that can be delegated to middle managers or consultants.
- Third, Hoshin Kanri is built on the Nemawashi philosophy (Koch et al., 2012). The learning being that Hoshin Kanri is a management system that should be lived and integrated into daily management.

- For Hoshin Kanri to work, there must be an existence of a clear vision that is challenging and relevant to all employees. The learning is that the necessary focus, fundamental in Hoshin Kanri, is the result of alignment with clear objectives.

As illustrated in the overview of the Hoshin Kanri design, and in line with da Silverira et al.'s (2013) arguments, top management's engagement in the process, the long-term approach, and a clear vision are crucial in the introduction phase (Osada, 1998).

It is at this stage that the organisational direction is decided. The primary focus of the literature is, however, on the outlining of a clear vision. Both strategic management systems reviewed emphasise the need for accurate and trustworthy facts in this phase. (Melander et al., 2016)

3.12. Organisation impact

3.12.1. Understanding organisational processes

Both Deming (1993) and Senge (1990) have written about the importance of systems thinking in understanding workflow, business processes, and the impact of feedback. In any system, events will occur that effect elsewhere in the system, and possibly on the event itself. To have a full understanding of the consequences of what is being done, it is necessary to understand the entire process, and how it fits into the organisational system.

IT has the capability of providing the means to achieve breakthrough performances in organisational systems. The vision, however, must come from understanding both the current and potential processes. This reality requires a more holistic view than that taken in traditional TQM programmes (Chang, 1994; Petrozzo and Stepper, 1994). The changes documented by Hammer (1990) at Ford, and by Davenport and Short (1990) at Xerox, involved radical redesign of the processes concerned. Cranswick (1994) reports that many Australian companies have undergone similar radical redesign identifying the problems inherent in this approach are:

- the danger of designing another inefficient system,
- ignoring the embedded system knowledge accumulated over many years, and
- not appreciate the scope of the problem (Petrozzo and Stepper, 1994; O'Neill and Sohal, 1998).

Therefore, many authors (Klein, 1994; Stoddard and Jarvenpaa, 1995; Grover and Malhotra, 1997) recommend a thorough understanding of current processes before embarking on a re-engineering project. Current processes can be understood and documented by flowcharting and process mapping. As processes are documented, their interrelationships become apparent, and a map of the organisation emerges. BPR aims to make discontinuous, significant improvements. This invariably means organisational change, the extent of which depends on the scope of the process re-engineering.

As these cross-functional processes are re-engineered to improve added-value output and efficiency, many organisations are now questioning the need, or even the relevance of traditional functional structures and are beginning to organise around core processes. In essence, these are the processes that control the flow of real and virtual resources within an organisation (Kaplan and Murdock, 1991).

3.12.2. **Organisational redesign using BPR**

BPR is not intended to preserve the status quo, but to change fundamentally and radically what is done; it is dynamic. Therefore, it is essential for a BPR effort to focus on outcomes rather than tasks, and the required outcome will determine the scope of the BPR exercise.

Schaffer and Thomson (Schaffer and Thomson, 1992) highlighted how focusing on results rather than just activities makes the difference between success and failure in change programmes. The measures used, however, are crucial. At every level of re-engineering, a focus on outcome gives direction and measurability; whether it be a cost reduction, headcount reduction, increase in efficiency, customer focus, identification of core processes and non-value-adding components, or strategic alignment of business processes. Benchmarking is a powerful tool for BPR and is the trigger for many BPR projects, as shown in Ford's accounts payable process. The value of benchmarking does not lay in what can be copied, but in its ability to identify goals (Richman and Koontz, 1993; Earl and Khan, 1994). If used well, benchmarking can shape strategy and identify a potential competitive advantage (Zairi and Léonard, 1994).

Hamel and Prahalad (Hamel and Prahalad, 1990) established that strategic direction via intent rather than portfolio analysis, should be the key to an organisation's core competencies and that through expeditionary marketing, this should lead on to developing the skills required to achieve the intent. Establishing its core processes focuses a company on what it does, how it does it, and how it should do it. Core process redesign can thus channel an organisation's competencies into an outcome that gives it a strategic competitive advantage (Kaplan and Murdock, 1991). The critical element is visioning this result (Goss, Pascale and Athos, 1993).

3.12.2.1. The redesign processes

Central to BPR is an objective overview of the processes to be redesigned. Whereas information needs to be obtained from the people directly involved in those processes, it is never initiated by them. Even at its lowest level, BPR has a top-down approach (Hammer and Champy, 1993). Therefore, most BPR efforts take the form of a project (Earl and Khan, 1994). Numerous methodologies are being proposed, but all share common elements. Typically, the project takes the form of several discrete phases (Carr and Johansson, 1995).

People need to be equipped to assess, re-engineer, and support—with the appropriate technology—the fundamental processes that contribute to customer satisfaction and corporate objectives (Coulson-Thomas, 1993). Therefore, BPR efforts can involve substantial investment (Petrozzo and Stepper, 1994), but they also require considerable top management support and commitment. Critical to the success of the redesign is the makeup of the re-engineering team. O'Neill & Sohal (O'Neill and Sohal, 1999) concludes that is a common understanding that the team should comprise the following:

- senior manager as a sponsor,
- a steering committee of senior managers to oversee overall re-engineering strategy,
- process owner,
- team leader, and
- redesign team.

This structure varies depending on the author. For example, Harrington (Harrington, 1991) referred to executive improvement teams and process improvement teams rather than steering committees and re-engineering teams. Champions (team leaders) and czars (sponsors) were also referred to, and depending on the scope of the re-engineering effort, the sponsor, process owner, and leader may be one or more people (Hammer and Champy, 1993). The process owner is someone given the responsibility for the overall re-engineering of a specific process.

The project approach to BPR suggests a one-off approach. When the project is over, the team is disbanded, and business returns to normal, albeit a radically different routine. It is generally recommended that an organisation not attempt to re-engineer more than one primary process at a time, because of the disruption and stress caused. Therefore, in relevant re-engineering efforts of more than one process, as one team is disbanded, another is formed to redesign yet another process. Considering that Ford took five years to redesign its accounts payable process (Davenport, 1993b), BPR on a large scale is a long-term commitment. In a rapidly changing business environment, it is becoming more likely that companies will re-engineer one process after another. *Competitive advantage* is a dynamic goal—one that does not stand still (D'Aveni and Gunther, 2007).

Once a process has been redesigned, most authors call for continuous improvement of the new process by the team of people working in the process. That is, organising work around people which fosters interaction, understanding, and responsibility. The dissemination of information via IT empowers the team to make decisions and inevitably results in a delayering of management structures.

4. “Knowledge Fit”

In this chapter, we will explain what our definition of “Knowledge Fit” and how to measure it in the context of the PROKEX approach is.

4.1. Organisation deployment from process to job-holder

This thesis would like to provide a possible measure of intellectual capital that in particular can measure that set of competencies that can support the operativity of companies processes. In particular, we would like to provide a framework to analyse the fit between the knowledge required and the knowledge available in an organisation.

To be able to understand the “Knowledge Fit” in the context of PROKEX is relevant to know how the knowledge of the people is allocated to the processes through different entities. We call organisation deployment the process of connecting the various organisational layers between activities and job holders (also defined as individuals). A process is a set of interrelated activities sequence of tasks that interact to achieve a result. In our work, we refer therefore to a task as an activity that is performed within a process. According to WorldAtWork, a job is the total collection of tasks, duties, and responsibilities assigned to one or more individuals whose work has the same nature and level of work (World at Work, The WorldatWork and World at Work, 2007). In the context of PROKEX, we will use this definition to refer to a “Job Role”. According to this definition, we can say that a job role is associated with the work to be performed within one or more task. According to the same source, a “Position” is a group of specific duties, tasks, and responsibilities assigned to one employee. We, therefore, consider a position as a set of roles that are identified for a particular job holder. A position exists despite its association to a given job-holder. This is the case when the position is used to advertise job opening or to standardise the management of different individuals (for example when there are a group of people performing the same set of roles in different shifts or different production lines).

To better clarify the difference between those entities let’s consider a nursing context. Examples of task are: *“registering a new patient”* or *“measuring blood pressure”*. All those tasks can be performed by the same job role, for instance, a *“General Ward Nurse”*. In this hospital, for example, the “Nurse” position can be associated with both the “General Ward Nurse” and the “Post-Operative Nurse”.   Finally, in the same hospital can work at the same time filling the "Nurse" position Mrs. Mary Breckinridge and Mr. Walt Whitman.

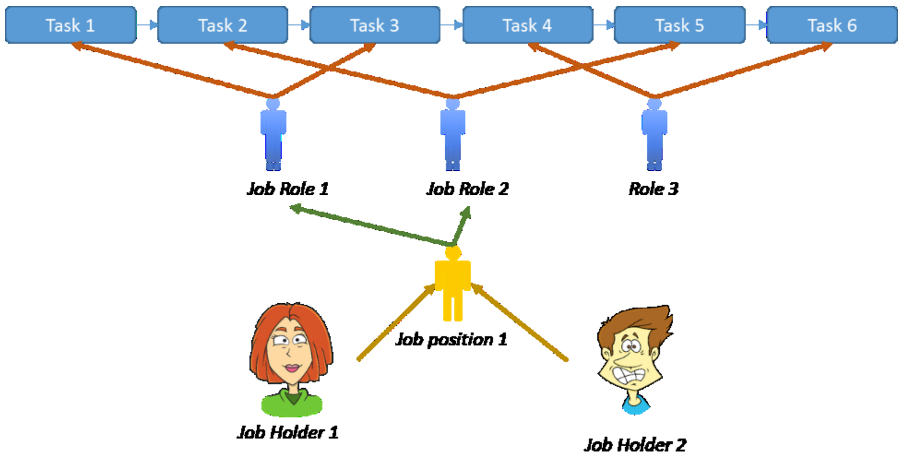

Figure 4-1 Elements of the PROKEX knowledge deployment

When an organisation employs a knowledge worker, it does for their capacity to fulfil specific roles. However, the knowledge of an individual goes beyond the knowledge necessary to fulfil his duties within the position.

4.2. Representation of the knowledge required for a job

Given this preamble, the knowledge(able) worker is hired by a company for his capacity of running its processes.

Opposite to the way computers and machines work, the human needs to learn the knowledge related to a job, and they can also forget it. Furthermore, from humans being it is expected that they can make use of the knowledge and take decisions in the implementation of their actions based on an extended knowledge that is not strictly articulated or formalised within the Business Process Model. Using PROKEX, we provide a tool that can select from a vast domain (represented within an ontology) the knowledge necessary to run a task also considering this knowledge that is not directly derived from the process model. Using PROKEX, we combine the knowledge required to execute the tasks to identify the knowledge that constitutes a role, and a specific positions.

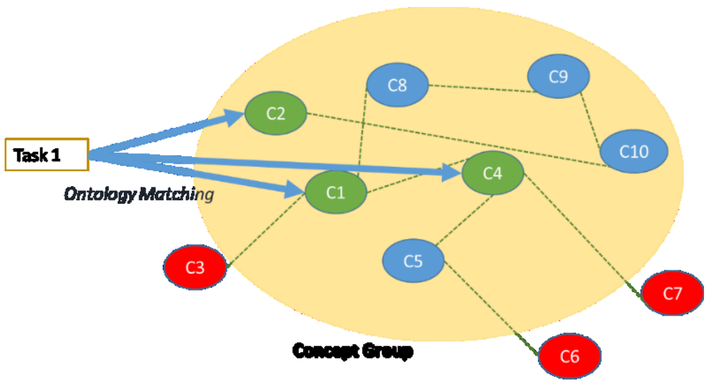

Figure 4-2 Ontology mapping to a Concept Group

In STUDIO, we define a "Concept Group" as the part of the ontology that describes the knowledge necessary to run a particular process, or task associated with a particular job role. The Concept Group represents the ideal map of the required knowledge for a specific task an implicitly for job role. A Concept Group can be used as a formal representation of the knowledge possessed by an individual in a particular domain. In STUDIO, for testing purpose, we can associate questions with each node and to test test-takers (employees, performers, etc.) through a dedicated platform. Within a "Concept Group", we define a set of the ontology nodes that represent the knowledge available or necessary at each level of the PROKEX knowledge deployment from Processes to Organisation.

4.3. Different measures of the "Knowledge Fit".

The Fit is a measure of the overlap between two entities in this PROKEX knowledge deployment.

According to the different problems, we can decide to study the fit close to the domain of the problem or to enlarge the domain to the residual knowledge that is not related to the problem. We can therefore either focus the fit analysis to the problem itself, or the individuals, or on a broad level of analysis (Arru, 2019).

Given R the set of knowledge elements in the Concept Group related to a specific job role; we can decide to test an individual against the knowledge of *R* or to test her or him against the overall knowledge of the Domain *D*. In the most general case we can assume to do this against the most significant knowledge *D* and the *I* represents the result of the test.

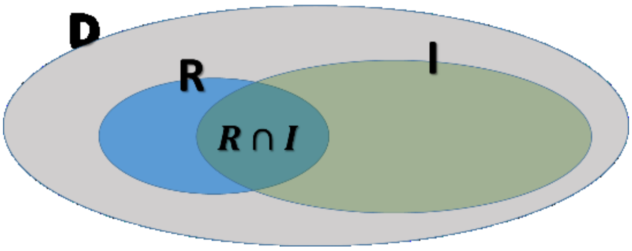

Figure 4-3: "Knowledge Fit"

The "Knowledge Fit" is always a measure that is related to a problem. If in our case the problem is how the knowledge of the individuals fit the knowledge for a role, the "Knowledge Fit" is given as the ratio of the cardinality of the intersection of R and I and the cardinality of R: $f(R,I) = \frac{|R \cap I|}{|R|}$.

Of course, if the domain of the test is broad enough to cover the Concept Group of several roles, for the same individual, I can obtain different "Knowledge Fit" with different roles. Further, the vector containing the fit with all different roles can represent a measure of the "Knowledge Fit" of the individual with the organisation and can be used to derive indicators of the flexibility of the individual within the organisation.

If the concept groups related to an organisation set is $O = \langle R_1, R_2, \dots, R_{n-1}, R_n \rangle$ the organisation fit is the vector $f(O,I) = \langle f(R_1,I), f(R_2,I), \dots, f(R_{n-1},I), f(R_n,I) \rangle$.

What we have discussed so far related to the knowledge tested with individuals can also apply to other entities, for instance, university curricula and we can measure those against the organisation set.

The measure of the "Knowledge Fit", however, represents only one element of the fit analysis. Once identified a gap the fit analysis should bring the attention to the actual elements of distance, and, therefore, it opens to more qualitative investigations.

The "Knowledge Fit" analysis is a framework that can help organisations taking decisions. Using STUDIO, we aim to provide a measure of "Knowledge Fit" to support the analysis of the following problems:

Role	to what extent the availability of roles is sufficient to drive the processes		
Position	to what extent an organisation has the right positions available to run its processes	to what extent the roles are correctly associated with the positions	
Job holder	to what extent the organisation has enough job holder to run the processes	To what extent job holder is flexible to play several roles in the organisation	to what extent a job holder has the knowledge to fit a particular job position
	Activity	Role	Position

4.4. **"Knowledge Fit" formalism**

To elaborate a formalism to analyse the "Knowledge Fit" as may be generated from the PROKEX application, I will use a classic (at least in my country) hypothetical scenario: a Pizzeria.

We will use the support of Octave (MATLAB is also an alternative) to describe the underlying algorithms with a syntax that is broadly used in the academia.

4.4.1. **The basic elements**

4.4.1.1. Individuals

We associate the individuals with the elements of the vector $i \, \epsilon \mathbb{T}^{i \times 1}$. Note that we will use the same letter to indicate the basic vector and the related dimension. This overriding should not represent an issue in reading the formalism, on the contrary simplifies the understanding of the relations between a matrix and the related dimensions.

In our example, in the Pizzeria, we have 8 employees: $i = \begin{vmatrix} \text{Matteo} \\ \text{Dorina} \\ \text{András} \\ \text{Gábor} \\ \text{Gian} \\ \text{Attila} \\ \text{Emanuel} \\ \text{Roberto} \end{vmatrix} \in \mathbb{T}^{8x1}$.

The same example can be defined in Octave with the following expression:

```
i=["Matteo"; "Dorina"; "András"; "Gábor"; "Gian"; "Attila"; "Emanuel";
"Roberto"]
```

4.4.1.2. Positions

The owner of the Pizzeria defined 3 different job positions. The vector of the positions is $p \in \mathbb{T}^{p\times 1}$:

$$p = \begin{vmatrix} waiter \\ cook \\ owner \end{vmatrix} \in \mathbb{T}^{3x1}$$

The same example can be defined in Octave with the following expression:

```
p=["waiter"; "cook"; "owner"]
```

4.4.1.3. Position by individual

The matrix $IP \in \mathbb{B}^{i\times p}$ is a Boolean matrix that represents the association between the individuals and the job position.

From the matrix $IP = \begin{vmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \\ 1 & 0 & 0 \\ 1 & 0 & 0 \\ 0 & 1 & 0 \\ 1 & 0 & 0 \\ 1 & 0 & 0 \end{vmatrix} \in \mathbb{B}^{8x3}$ we can easily infer that Matteo is a waiter like Gábor, Gian, Emanuel and Roberto, that Dorina and Attila are cook and András is the owner of our Pizzeria.

```
IP=[1 0 0; 0 1 0; 0 0 1; 1 0 0; 1 0 0; 0 1 0; 1 0 0; 1 0 0]
```

4.4.1.4. Activities

To run "serve Pizza to its customers" our Pizzeria perform certain activities that we store in the vector $a \in \mathbb{T}^{a\times 1}$:

$$a = \begin{vmatrix} take\ the\ order \\ procure\ the\ material \\ prepare\ the\ dough \\ prepare\ the\ tables \\ serve\ the\ beverages \\ assemble\ the\ pizza \\ bake\ the\ pizza \\ serve\ the\ pizza \\ receive\ the\ payment \end{vmatrix} \in \mathbb{T}^{8x1}$$

The same in Octave is declared as follow:

```
a=["take the order"; "procure the material"; "prepare the dough";
"prepare the tables"; "serve the beverages"; "assemble the pizza";
"bake the pizza"; "serve the pizza"; "receive the payment"]
```

4.4.1.5. Roles

In simple organisations, roles and positions coincide. For better adaptability, we will consider that roles define a subset of activities that one or more positions can perform as described in Chapter 4.1.

For instance, the general position of "cook" can be associated with the "pizzaiolo" role. The "owner", similarly can perform the job of a "waiter" and a "barman" like those with the "waiter" position, but they can be "cashier" also, and do "procurement".

The roles are stored in a vector $r \epsilon \mathbb{T}^{r\times 1}$ that in our example is the vector:

$$r = \begin{vmatrix} \text{waiter} \\ \text{pizzaiolo} \\ \text{cashier} \\ \text{barman} \\ \text{procurement} \end{vmatrix} \in \mathbb{T}^{5x1}$$

The same table can be instantiated in Octave with

```
r=["waiter"; "pizzaiolo"; "cashier"; "barman"; "procurement"]
```

4.4.1.6. Activity by role

The matrix that creates the relationship between the activities and the roles is the table $AR \epsilon \mathbb{B}^{a\times r}$ that in our examples correspond to the matrix

$$AR = \begin{vmatrix} 1 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 1 \\ 0 & 1 & 0 & 0 & 0 \\ 1 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 1 & 0 \\ 0 & 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 & 0 \\ 1 & 0 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 \end{vmatrix} \in \mathbb{B}^{9x5}$$

Defined in Octave by

```
AR=[1 0 0 0 0; 0 0 0 0 1; 0 1 0 0 0; 1 0 0 0 0; 0 0 0 1 0; 0 1 0 0 0;
0 1 0 0 0; 1 0 0 0 0; 0 0 1 0 0 ]
```

The activities and the association activity-role can be extracted from a formal description of a process, for instance from the BPMN.

4.4.1.7. Roles in a position

The roles are associated with a position usually in a job description where is explicitly or implicitly defined into the job description. For example, the job description of a cook that should work in a pizzeria should state that he should be a pizzaiolo.

From this job description, we can derive the matrix $RP \, \epsilon \mathbb{B}^{r \times p}$ that associates roles and positions that in the case of the Pizzeria will be:

$$RP = \begin{vmatrix} 1 & 0 & 1 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \\ 1 & 0 & 1 \\ 0 & 0 & 1 \end{vmatrix} \in \mathbb{B}^{5x3}$$

In Octave this is defined by the instruction

```
RP=[1 0 1; 0 1 0; 0 0 1; 1 0 1; 0 0 1]
```

Given those input matrices we can derive the other relations between those basic elements using linear algebra.

4.4.1.8. Positions working on activities

For instance, the relationship between the activities and the positions can be determined as the vector product between AR and RP: $AP = AR \times RP \, \epsilon \mathbb{B}^{a \times p}$.

This expression corresponds to the Octave's

```
AP=AR*RP
```

In our demo case Octave computed the following matrix:

$$AP = \begin{vmatrix} 1 & 0 & 1 \\ 0 & 0 & 1 \\ 0 & 1 & 0 \\ 1 & 0 & 1 \\ 1 & 0 & 1 \\ 0 & 1 & 0 \\ 0 & 1 & 0 \\ 1 & 0 & 1 \\ 0 & 0 & 1 \end{vmatrix} \in \mathbb{B}^{9x3}$$

Octave is very well performing in linear operation on the matrix and can scale quickly with larger simulation scenarios.

4.4.1.9. Individuals having a role

The relation between the role and the individuals is the matrix $RI = RP \times RI^T \, \epsilon \mathbb{B}^{r \times i}$

That Octave computes with the following instruction:

```
RI= RP*IP'
```

The result is:

$$RI = \begin{vmatrix} 1 & 0 & 1 & 1 & 1 & 0 & 1 & 1 \\ 0 & 1 & 0 & 0 & 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 \\ 1 & 0 & 1 & 1 & 1 & 0 & 1 & 1 \\ 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 \end{vmatrix} \in \mathbb{B}^{5x8}$$

4.4.1.10. ***Individuals participating in activities***

The final relation between the activities and the individuals is provided by the equation $AI = AP \times IP^T \epsilon \mathbb{B}^{a \times i}$

Corresponding to the Octave's expression

```
AI=AP*IP'
```

That generates the matrix:

$$AI = \begin{vmatrix} 1 & 0 & 1 & 1 & 1 & 0 & 1 & 1 \\ 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 & 0 & 1 & 0 & 0 \\ 1 & 0 & 1 & 1 & 1 & 0 & 1 & 1 \\ 1 & 0 & 1 & 1 & 1 & 0 & 1 & 1 \\ 0 & 1 & 0 & 0 & 0 & 1 & 0 & 0 \\ 0 & 1 & 0 & 0 & 0 & 1 & 0 & 0 \\ 1 & 0 & 1 & 1 & 1 & 0 & 1 & 1 \\ 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 \end{vmatrix} \in \mathbb{B}^{9x8}$$

4.4.2. **The knowledge dimension extracted from PROKEX**

The novelty introduced by the PROKEX approach is the extraction of the knowledge elements from the description of the processes. The output of the PROKEX process could be a vector of knowledge elements that are relevant for running activities and finally a process. As explained in Chapter 4.2, the knowledge required is associated with a specific Concept Group that is a subset of the overall domain ontology. This Concept Group can be represented by the vector $k \, \epsilon \mathbb{T}^{k \times 1}$.

In the case of the Pizzeria the knowledge required may be something like:

$$k = \begin{vmatrix} order\ taking \\ recipes \\ allergens \\ calligraphy \\ food\ serving \\ etiquette \\ knead \\ baking \\ bread \\ pizza\ types \\ ingredient \\ topping \\ beverages \\ count \\ money\ management \\ math \\ taxation \\ fire\ prevention \\ vendor\ management \\ folding \\ hygiene \\ food\ preparation \\ drinks \\ gluten - free\ cooking \end{vmatrix} \in \mathbb{T}^{24x1}$$

Equivalent in Octave to

```
k=["order taking"; "recipes"; "allergens"; "calligraphy"; "food
serving"; "etiquette"; "knead"; "baking"; "bread"; "pizza types";
"ingredient"; "topping"; "beverages"; "count"; "money management";
"math"; "taxation"; "fire prevention"; "vendor management"; "folding";
"hygiene"; "food preparation"; "drinks"; "gluten-free cooking"]
```

4.4.2.1. Knowledge necessary for an activity

Further, PROKEX provide us with the association of which knowledge node is associated to which activity. This association is stored in the matrix $AK \epsilon \mathbb{B}^{a \times k}$

$$AK = \begin{vmatrix} 1 & 0 & 1 & 1 & 1 & 1 & 0 & 0 & 1 & 1 & 1 & 0 & 1 & 1 & 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & 1 \\ 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & 1 & 1 & 1 & 0 & 1 & 0 & 1 & 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 \\ 0 & 1 & 1 & 0 & 0 & 0 & 1 & 0 & 1 & 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & 1 & 1 & 0 & 1 \\ 0 & 0 & 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 1 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 & 1 & 0 \\ 0 & 1 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & 1 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & 1 & 0 & 0 \\ 0 & 1 & 0 & 0 & 0 & 0 & 0 & 1 & 1 & 1 & 1 & 1 & 0 & 0 & 0 & 0 & 0 & 1 & 0 & 0 & 1 & 1 & 0 & 1 \\ 0 & 0 & 0 & 0 & 1 & 1 & 0 & 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 1 & 0 & 0 & 0 & 1 & 0 & 0 & 0 & 1 & 1 & 1 & 1 & 0 & 0 & 0 & 0 & 0 & 1 & 0 \end{vmatrix} \in \mathbb{B}^{9x24}$$

With this table, for instance, we state that the knowledge of "money management" is necessary only for the activity "receive the payment" and, on the contrary, the knowledge of "pizza types" is essential for most the activities.

4.4.2.2. Knowledge required in a role

Given the information of the knowledge required for running activities, we can obtain the knowledge necessary for role, position and individuals with simple linear equations.

However, a typical vector product of two matrices would return not a binary matrix because of the multiplicity in the relationship between activities and roles. For this reason, we will use an " " (also called Unit Matrix (Weisstein, no date))

$J_{r,k} = \begin{vmatrix} 1 & 1 & \dots \\ 1 & 1 & \dots \\ \vdots & \vdots & \ddots \end{vmatrix} \epsilon \mathbb{B}^{r \times k}$ to normalise all obtained values to either 1 or 0.

The knowledge required for a role is, in fact, the matrix

$$RK = (AR^T \times AK) \; AND \; J_{r,k} \; \epsilon \mathbb{B}^{r \times k}$$

that in Octave is computed by the following lines:

```
RK=AR'*AK;
RK=RK & ones(rows(RK), columns(RK))
```

In the case of the Pizzeria the matrix will be:

$$RK = \begin{vmatrix} 1 & 0 & 1 & 1 & 1 & 1 & 0 & 0 & 1 & 1 & 1 & 0 & 1 & 1 & 0 & 1 & 0 & 0 & 0 & 1 & 1 & 0 & 1 & 1 \\ 0 & 1 & 1 & 0 & 0 & 0 & 1 & 1 & 1 & 1 & 1 & 1 & 0 & 0 & 0 & 0 & 0 & 1 & 0 & 1 & 1 & 1 & 0 & 1 \\ 0 & 0 & 0 & 0 & 0 & 1 & 0 & 0 & 0 & 1 & 0 & 0 & 0 & 1 & 1 & 1 & 1 & 0 & 0 & 0 & 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 0 & 1 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 & 1 & 0 \\ 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 & 1 & 1 & 1 & 1 & 0 & 1 & 0 & 1 & 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 \end{vmatrix} \in \mathbb{B}^{5x24}$$

4.4.2.3. Knowledge required in a position

Similarly, we can calculate the knowledge necessary for a particular position using the formula

$PK = (AP^T \times AK)\ AND\ J_{p,k} \in \mathbb{B}^{p \times k}$ that correspond to the Octave's expression

```
PK=AP'*AK;
PK=PK & ones(rows(PK),columns(PK))
```

That will generate the matrix

$$PK = \begin{vmatrix} 1 & 0 & 1 & 1 & 1 & 1 & 0 & 0 & 1 & 1 & 1 & 0 & 1 & 1 & 0 & 1 & 0 & 0 & 0 & 1 & 1 & 0 & 1 & 1 \\ 0 & 1 & 1 & 0 & 0 & 0 & 1 & 1 & 1 & 1 & 1 & 1 & 0 & 0 & 0 & 0 & 0 & 1 & 0 & 1 & 1 & 1 & 0 & 1 \\ 1 & 1 & 1 & 1 & 1 & 1 & 0 & 0 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 0 & 1 & 1 & 1 & 0 & 1 & 1 \end{vmatrix} \in \mathbb{B}^{3x24}$$

4.4.2.4. Knowledge required by individuals

Finally, the knowledge requested by each person is formula

$IK = (AI^T \times AK)\ AND\ J_{i,k} \in \mathbb{B}^{i \times k}$

that correspond to the Octave's expression

```
IK=AI'*AK;
IK=IK & ones( rows(IK),columns(IK))
```

This is in the case of our Pizzeria the matrix

$$IK = \begin{vmatrix} 1 & 0 & 1 & 1 & 1 & 1 & 0 & 0 & 1 & 1 & 1 & 0 & 1 & 1 & 0 & 1 & 0 & 0 & 0 & 1 & 1 & 0 & 1 & 1 \\ 0 & 1 & 1 & 0 & 0 & 0 & 1 & 1 & 1 & 1 & 1 & 1 & 0 & 0 & 0 & 0 & 0 & 1 & 0 & 1 & 1 & 1 & 0 & 1 \\ 1 & 1 & 1 & 1 & 1 & 1 & 0 & 0 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 0 & 1 & 1 & 1 & 0 & 1 & 1 \\ 1 & 0 & 1 & 1 & 1 & 1 & 0 & 0 & 1 & 1 & 1 & 0 & 1 & 1 & 0 & 1 & 0 & 0 & 0 & 1 & 1 & 0 & 1 & 1 \\ 1 & 0 & 1 & 1 & 1 & 1 & 0 & 0 & 1 & 1 & 1 & 0 & 1 & 1 & 0 & 1 & 0 & 0 & 0 & 1 & 1 & 0 & 1 & 1 \\ 0 & 1 & 1 & 0 & 0 & 0 & 1 & 1 & 1 & 1 & 1 & 1 & 0 & 0 & 0 & 0 & 0 & 1 & 0 & 1 & 1 & 1 & 0 & 1 \\ 1 & 0 & 1 & 1 & 1 & 1 & 0 & 0 & 1 & 1 & 1 & 0 & 1 & 1 & 0 & 1 & 0 & 0 & 0 & 1 & 1 & 0 & 1 & 1 \\ 1 & 0 & 1 & 1 & 1 & 1 & 0 & 0 & 1 & 1 & 1 & 0 & 1 & 1 & 0 & 1 & 0 & 0 & 0 & 1 & 1 & 0 & 1 & 1 \end{vmatrix} \in \mathbb{B}^{8x24}$$

4.4.3. The "Knowledge Fit"

In the PROKEX framework STUDIO is the component that tests individuals and determines their level of knowledge of a particular subject included in a specific domain.

STUDIO can also test a particular Concept Group. In our case, the Concept Group is related to the subset of knowledge k extracted from the BPM representing the process by PROKEX.

4.4.3.1. *The STUDIO's Score matrix*

The test will populate the Boolean matrix $IT \in \mathbb{B}^{i \times k}$ that contains the information whether the person knows or not the concepts that are part of the Concept Group.

In the case of the Pizzeria the table of the individual tests will be:

$$IT = \begin{vmatrix} 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 0 & 1 & 1 & 1 & 1 \\ 0 & 1 & 0 & 0 & 0 & 1 & 0 & 1 & 0 & 1 & 0 & 1 & 1 & 0 & 1 & 1 & 1 & 1 & 1 & 1 & 0 & 0 & 1 & 0 \\ 1 & 1 & 1 & 1 & 1 & 1 & 0 & 0 & 1 & 1 & 1 & 1 & 1 & 1 & 0 & 0 & 0 & 0 & 0 & 1 & 1 & 0 & 1 & 1 \\ 1 & 1 & 0 & 1 & 1 & 0 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 0 & 0 & 0 & 1 & 0 & 1 & 1 & 0 & 1 & 0 \\ 1 & 0 & 1 & 1 & 1 & 1 & 0 & 0 & 1 & 1 & 1 & 0 & 1 & 1 & 0 & 1 & 0 & 0 & 0 & 1 & 1 & 0 & 1 & 0 \\ 0 & 1 & 1 & 0 & 0 & 0 & 1 & 1 & 1 & 1 & 1 & 1 & 0 & 0 & 0 & 0 & 0 & 1 & 0 & 0 & 1 & 1 & 0 & 0 \\ 1 & 0 & 1 & 0 & 1 & 1 & 0 & 0 & 0 & 1 & 0 & 0 & 1 & 1 & 0 & 1 & 0 & 0 & 0 & 0 & 1 & 0 & 1 & 0 \\ 0 & 0 & 1 & 1 & 1 & 1 & 1 & 0 & 1 & 0 & 1 & 0 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 0 & 1 & 1 & 1 & 1 \end{vmatrix} \in \mathbb{B}^{8x24}$$

In Octave defined with:

```
IT=[1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 0 1 1 1 1; 0 1 0 0 0 1 0 1 0
1 0 1 1 0 1 1 1 1 1 1 0 0 1 0; 1 1 1 1 1 1 0 0 1 1 1 1 1 1 0 0 0 0 0 1
1 0 1 1; 1 1 0 1 1 0 1 1 1 1 1 1 1 1 0 0 0 1 0 1 1 0 1 0; 1 0 1 1 1 1
0 0 1 1 1 0 1 1 0 1 0 0 0 1 1 0 1 0; 0 1 1 0 0 0 1 1 1 1 1 1 0 0 0 0 0
1 0 0 1 1 0 0; 1 0 1 0 1 1 0 0 0 1 0 0 1 1 0 1 0 0 0 0 1 0 1 0; 0 0 1
1 1 1 1 0 1 0 1 0 1 1 1 1 1 1 1 0 1 1 1 1]
```

4.4.3.2. *The individuals "Knowledge Fit"*

The correspondent Fit matrix is computed by

$$IFit = IT \ or\ !\,IK \in \mathbb{B}^{i \times k}$$

In Octave is

```
IFit=or(IT,not(IK))
```

In practice, it means that there is fit when the knowledge is required, and the individual passed the test for this knowledge. It is true also in any case where the knowledge is not required: if the knowledge is not required in having or not the knowledge is invariant for the sake of measuring the fit.

In the Pizza example the "Knowledge Fit" for individuals is:

$$IFit = \begin{vmatrix} 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 0 & 1 & 1 & 1 & 1 \\ 1 & 1 & 0 & 1 & 1 & 1 & 0 & 1 & 0 & 1 & 0 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 0 & 0 & 1 & 0 \\ 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 0 & 0 & 0 & 1 & 0 & 1 & 1 & 1 & 1 & 1 \\ 1 & 1 & 0 & 1 & 1 & 0 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 0 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 0 \\ 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 0 \\ 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 0 & 1 & 1 & 1 & 0 \\ 1 & 1 & 1 & 0 & 1 & 1 & 1 & 1 & 0 & 1 & 0 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 0 & 1 & 1 & 1 & 0 \\ 0 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 0 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 0 & 1 & 1 & 1 & 1 \end{vmatrix} \in \mathbb{B}^{8x24}$$

This works when we are making the Fit between two binary matrices. However, to be more generic (and considering the following measures of fit we introduce a more programmatic fit function that, in the case of the knowledge is required, it returns the value of the test.

In our approach, we assume that individuals cannot hold partial knowledge of a concept: either they know or not. However, talking about the fit, we will soon introduce a new measure of fit where individuals are aggregated because, for instance, we are evaluating the knowledge at the level of the position where more individuals are holding the same position.

This new Fit function is a binary operation that takes a generic Boolean matrix that describes the knowledge required $K \epsilon \mathbb{B}^{x \times k}$ and a generic Real matrix that includes the result of an evaluation of the same knowledge $T \epsilon \mathbb{R}^{x \times k}$ and return a Real matrix: $fit: K \times T \rightarrow Fit$ where $Fit \; \epsilon \mathbb{R}^{x \times k}$.

If $k_{i,j}$is any element of the matrix and $t_{i,j}$ is a generic element of matrix $T \epsilon \mathbb{R}^{x \times k}$, $\forall i, j$ the Fit function is defined as $fit_{i,j} = \begin{cases} 1 & ; k_{i,j} = 0 \\ t_{i,j} & ; k_{i,j} = 1 \end{cases}, \forall i \in [1, x], \forall j \in [1, k]$.

In Octave this is equivalent to the function:

```
function RETURN = Fit( Knowledge, Test )
  output_max_field_width=2
  output_precision=2
  # test that the two matrices have the same size
   if size(Knowledge)==size(Test)
      # if they are the same size continue
  else
      # Otherwise stops
       fprintf('The Knowledge and the Test should have the same
size!\n');
    return
  end
  # Identify the dimensions
  ncols=columns(Knowledge);
  nrows=rows(Knowledge);
  #loop in the dimensions
  for i=1:ncols
    for j=1:nrows
      if cast(Knowledge(j,i), "single")==cast(0, "single")
        RETURN(j,i)=1;
      else
        RETURN(j,i)=Test(j,i);
      end
    end;
  end;
 endfunction
```

By using this function, the individuals fit matrix will be $IFit = fit(IK, IT) \; \epsilon \mathbb{R}^{i \times k}$. In our Pizzeria case, the result will be the same.

Similarly to the “Knowledge Fit”, we define the complement function “Knowledge Spare” that represents all the knowledge that an individual has but it is not required for its current assignment, however may be relevant in another organisational setting.

If $k_{i,j}$is any element of the matrix and $t_{i,j}$ is a generic element of matrix $T\epsilon\mathbb{R}^{x\times k}$, $\forall i,j$ the Spare function is defined as $spare_{i,j} = \begin{cases} 0 & ;\ k_{i,j} = 1 \\ t_{i,j} & ;\ k_{i,j} = 0 \end{cases}, \forall i \in [1,x], \forall j \in [1,k]$.

We will not repeat the calculation for the Spare function, but the reader can assume for any fit measurement or application exists a related spare measurement and application. In Chapter 7.3 we will develop further this concept to draw some conclusion related to the current setting.

4.4.3.3. The position “Knowledge Fit”

As previously indicated the “Knowledge Fit” at the position level introduce an additional layer of complexity: more than one individual may hold each position.

The “Knowledge Fit” at the level of the position describes to what extent the position is covered with adequate knowledge. If more than one person holds the position, this indication should be the ratio of people that have such knowledge among the ones that should have had divided by the overalls number of individuals that should have this knowledge.

Let us for instance consider the knowledge about “calligraphy”. Per the matrix PK, this is the knowledge that is necessary for the “waiter” and the “owner” but not for the “cook”.

This means (according to matrix IK) that everyone, except Dorina and Attila, should have it. By the table IT we understand that Emanuel and Attila are the only ones not having a good “calligraphy”.

According to the IP matrix, we know that we have 5 “waiter”, 2 “cook” and one “owner”.

The “Knowledge Fit” for the position of waiter should, therefore, be four waiters (Emanuel is not compliant) out of 5 that is equal to 0.8. For the “cook” position will be one because even if Attila does not hold the knowledge, for his job is not required. For the owner, there is only 1 individual “András” that holds the knowledge. Therefore, the “Knowledge Fit” result will be 1.

Reflecting on what we just described in the example case, the first step is understanding how many individuals are reflected in the role.

The information can be extracted by counting the non zero elements in the columns of the table IP. Since the matrix IP is Boolean, counting the items is equivalent to sum them.

We define therefore a new function that generically from a matrix $A \epsilon \mathbb{B}^{x \times y}$ return a Real vector $A \rightarrow elementsByColumn \ \epsilon \mathbb{R}^{1 \times x}$ containing the sum of the values in the columns.

If $a_{i,j}$ is any element of the matrix A the function is defined as

$$elementsByColumn_i = \sum_{k=1}^{y} a_{k,i}, \forall i \in [1, x].$$

In Octave this is:

```
function RETURN = ElementsByColumn( A )
  ncols=columns(A);
  for i=1:ncols
    RETURN(i)=sum(A(:,i));
  end;
endfunction
```

After that, we must divide every element of the test matrix by the measure of the cardinality of the tested elements (Position, Roles, Activity).

In our case for the individuals fit we have $IT \ \epsilon \mathbb{B}^{i \times k}$so we have knowledge on the columns and individuals on the rows. The same will happen in the case of the position.

As we do not have a test at the position level (and it is not possible to test an abstract concept like position, role or activity), we derive a measure from the individuals through the joint table IP that puts in relation individuals with the position. This operation takes two binary matrices and returns a real matrix $\mathbb{B} \times \mathbb{B} \rightarrow \mathbb{R}$.

In the case of the "Knowledge Fit" at Position level, the test table can be represented by the matrix $IP^T \times IT \ \epsilon \mathbb{R}^{r \times k}$.

The rows of this new test matrix should then be divided by the elements of the vector including the cardinality of the roles $elementsByColumn(IP) \ \epsilon \mathbb{R}^{r \times 1}$.

To do that we need a new function that given a generic matrix $A \ \epsilon \mathbb{R}^{x \times y}$ and a vector $v \ \epsilon \mathbb{R}^{1 \times x}$ return a matrix

$A \times v \rightarrow DivideBySize$ where $DivideBySize \ \epsilon \mathbb{R}^{x \times y}$.

If $a_{i,j}$ is any element of the matrix A and if $v_{i,j}$ is any element of the vector v the function is defined as $DivideBySize_{\ i,j} = \frac{a_{i,j}}{v_i}, \forall i \in [1, x], \forall j \in [1, y]$.

In Octave this will be:

```
function RETURN = DividePerSize( A, v )
   if rows(A)==columns(v)
      #fprintf('Size correct\n');
  else
       fprintf('The number of rows of the matrix shall be equal to the
columns of the vetor!\n');
    return
  end
   ncols=columns(v);
  for i=1:ncols
1
  end;
endfunction
```

After defining this new last function, we can finally define the "Knowledge Fit" at position level

$$PFit = \ fit(PK, dividePerSize(IP^T \times IT, elementsByColumn(IP))) \ \epsilon \mathbb{R}^{p \times k}.$$

Or in Octave:

```
PFit= Fit(PK,DividePerSize(IP'*IT, ElementsByColumn(IP)))
```

In the case of the Pizzeria we will have the following matrix:

$$PFit = \begin{vmatrix} 0.8 & 1 & 0.8 & 0.8 & 1 & 0.8 & 1 & 1 & 0.8 & 0.8 & 0.8 & 1 & 1 & 1 & 1 & 0.8 & 1 & 1 & 1 & 0.4 & 1 & 1 & 1 & 0.4 \\ 1 & 1 & 0.5 & 1 & 1 & 1 & 0.5 & 1 & 0.5 & 1 & 0.5 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 0.5 & 0.5 & 0.5 & 1 & 0 \\ 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 0 & 0 & 0 & 1 & 0 & 1 & 1 & 1 & 1 & 1 \end{vmatrix} \in \mathbb{R}^{3x24}$$

Please note that the positive values in the PFit are usually smaller than the ones in IFit. This is since we are multiplying numbers that are $\preccurlyeq 1$and will result in a number that is lower than any of the factors. As far as expectation is concerned, we will expect that the scores may be evaluated only within the same Fit table and not between two fit tables, for instance comparing scores in the Individuals Fit table and those in the Positions Fit table.

4.4.3.4. The roles "Knowledge Fit"

Computing the "Knowledge Fit" at the roles level means understanding to what extent we have the knowledge to run our processes with the current allocation of work.

Similarly to "Knowledge Fit" at the position, we define the "Knowledge Fit" at the role level

$$RFit = fit(RK, dividePerSize(RI \times IT, elementsByColumn(RI^T))) \epsilon \mathbb{R}^{r \times k}.$$

Alternatively, in Octave:

```
RFit= Fit(RK,DividePerSize(RI*IT, ElementsByColumn(RI')))
```

In the case of the Pizzeria we will have the following matrix:

$$RFit = \begin{vmatrix} 0.8 & 1 & 0.8 & 0.8 & 1 & 0.8 & 1 & 1 & 0.8 & 0.8 & 0.8 & 1 & 1 & 1 & 1 & 0.7 & 1 & 1 & 1 & 0.5 & 1 & 1 & 1 & 0.5 \\ 1 & 1 & 0.5 & 1 & 1 & 1 & 0.5 & 1 & 0.5 & 1 & 0.5 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 0.5 & 0.5 & 0.5 & 1 & 0 \\ 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 0 & 0 & 0 & 1 & 1 & 1 & 1 & 1 & 1 & 1 \\ 1 & 1 & 1 & 1 & 1 & 0.8 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 \\ 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 0 & 1 & 1 & 0 & 1 & 1 & 1 & 1 & 1 \end{vmatrix} \in \mathbb{R}^{3x24}$$

4.4.3.1. The activity "Knowledge Fit"

Computing the "Knowledge Fit" at the activity level means to understand to what extent we have the knowledge to run our processes at a high level.

Similarly to the position and role "Knowledge Fit" we define the "Knowledge Fit" at the activity level

$$AFit = fit(AK, dividePerSize(AI \times IT, elementsByColumn(AI^T))) \epsilon \mathbb{R}^{a \times k}.$$

Alternatively, in Octave:

```
AFit= Fit(AK,DividePerSize(AI*IT, ElementsByColumn(AI')))
```

In the case of the Pizzeria we will have the following matrix:

$$RFit = \begin{vmatrix} 0.8 & 1 & 0.8 & 0.8 & 1 & 0.8 & 1 & 1 & 0.8 & 0.8 & 0.8 & 1 & 1 & 1 & 1 & 0.7 & 1 & 1 & 1 & 0.5 & 1 & 1 & 1 & 0.5 \\ 1 & 1 & 0.5 & 1 & 1 & 1 & 0.5 & 1 & 0.5 & 1 & 0.5 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 0.5 & 0.5 & 0.5 & 1 & 0 \\ 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 0 & 0 & 0 & 1 & 1 & 1 & 1 & 1 & 1 & 1 \\ 1 & 1 & 1 & 1 & 1 & 0.8 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 \\ 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 1 & 0 & 1 & 1 & 0 & 1 & 1 & 1 & 1 & 1 \end{vmatrix} \in \mathbb{R}^{3x24}$$

4.4.4. **The Fit Score**

One may think that an average of the scores by row in the fit matrix would be a good indicator; however, not all elements should be considered in the computation, because are related to knowledge that is not necessary.

For instance, in the case of the individual knowledge, we can use the matrices $IFit \in \mathbb{R}^{i \times k}$ and $IK \in \mathbb{B}^{i \times k}$ to generate a vector $IFit \times IK \rightarrow iScore \in \mathbb{R}^{i \times 1}$.

In a more generic case, where the Fit can be at any level of the organisational deployment, let say that we have a fit matrix $F \in \mathbb{R}^{x \times k}$ and a knowledge matrix $K \in \mathbb{B}^{x \times k}$ and the function will generate a vector $F \times K \rightarrow score \in \mathbb{R}^{x \times 1}$.

To compute the function score will, therefore, use the Hadamard product (Million, 2007) between the Fit matrix and the knowledge matrix. The Hadamard product is the element-wise product that can be implemented between matrices of the same size: $F \circ K \in \mathbb{R}^{x \times k}$.

The score function will then sum all elements in a row divided by the number of required knowledge items:

$$score_i = \frac{\sum_{j=1}^{k} (F \circ K)_{i,j}}{\sum_{j=1}^{k} K_{i,j}}, \forall i \in [1, x] \in \mathbb{R}^{x \times i}.$$

In Octave this corresponds to the following function:

```
function RETURN = Score( Knowledge, Fit )
  output_precision(5)
  # test that the two matrices have the same size
   if size(Knowledge)==size(Fit)
      # if they are the same size continue
  else
      # Otherwise stops
       fprintf('The Knowledge and the Fit should have the same
size!\n');
    return
  end
  # Sum all elements by row and divide for the number of knowledge
elements
  RETURN= sum(Knowledge .* Fit,2)./sum(Knowledge,2);
endfunction
```

This provides us with a vector with individuals scores.

Please note that given the conclusions of section 4.4.3.3 we should assume that the scores have meaning when compared to the same level of analysis and the comparison may be relative to and not absolute.

To have a synthetic indicator for the overall fit at this level of analysis, we can, therefore, determine a single number $gScore = \frac{\sum_{j=1}^{x} score_j^2}{x} \in \mathbb{R}$.

Please note that instead of calculating the mean, we instead used the mean squared. We do that to emphasise the missing knowledge.

By combining the two algorithms in Octave, we define it as:

```
function RETURN = GScore( Knowledge, Fit )
  output_precision(5)
  # test that the two matrices have the same size
   if size(Knowledge)==size(Fit)
      # if they are the same size continue
  else
      # Otherwise stops
```

```
       fprintf('The Knowledge and the Fit should have the same
size!\n');
    return
  end
  # Sum all elements by row and divide for the number of knowledge
elements
  RETURN= meansq(sum(Knowledge .* Fit,2)./sum(Knowledge,2),1);
Endfunction
```

Obviously, also in this case we can evaluate similarly to the FitScore a SpareScore and their related Global Score.

In Chapter 7.4 we will see that the “Knowledge Fit” is a tool that is very difficult to read and interpret by a human. It is beneficial for an application to process. However, its Score function allows a more synthetic interpretation.

4.5. The benefit of the model

Based on such measures the management may find ground justification to support several organisational decisions such as:

- train the job-holder to improve their fit with the position,
- recruit new employees that have the proper “Knowledge Fit”,
- re-allocate the roles to various positions,
- re-define the Roles to fit better the process and the job holders,
- re-define retention and HR policies, and
- re-engineer the processes or redefine the services that the processes support.

5. The PROKEX framework

5.1. General objectives

According to the Lisbon Strategy, the EU aims to become the most competitive and dynamic knowledge-based economy in the world (European Council Presidency, no date). To achieve this goal the strategy outlines taking advantage of the growth and employment opportunities afforded by new technologies. Development and adoption of new technologies result in increased investment in knowledge, skills and infrastructure. Human capital is considered a crucial input for the development of new technologies and a necessary factor for their adoption and efficient use, but also a prerequisite for employability (De la Fuente and Ciccone, 2003).

Complex organisations use to model and manage their processes using Business Process Management (BPM) tools. These applications help to describe the organisational processes, together with the required information and other resources (amongst other human resources) needed to perform each activity. Business processes are defined as a sequence of activities. From the Human Resource Management view it is required to determine unambiguously, who is responsible for the execution of each activity regarding the RACI matrix (Responsible, Accountable, Consulted, Informed), bridging the organisational model and the process model. Usually, BPM methodologies' requirements are satisfied with the definition of the type of job role, this is emphasized in the RACI matrix. The PROKEX approach explicitly differentiates between the task (as an element of the process) and the job role (associated with or assigned to the task). Job role is interpreted as a bridge between the task (to be executed) and the actor (in case of PROKEX always a human resource). Human resource always has at least two organisational attributes: position and job role, they may relate to each other several ways (1:1, 1:m, n:1, m:n). The knowledge (often cited as competences) relates to the job role, what is considered as content. The knowledge elicitation, extraction refers to the content, while the type of the job role has more organisational aspects than knowledge management. To include the job role knowledge properly into the process model, we use the extended RACI matrix, that is the description of the task from knowledge perspective is added to the RACI, and this extension is treated later in the system. In brief, one of the overall objectives of BPM is the transformation of informal knowledge into formal knowledge and facilitates its externalisation and sharing (Bernus, 2006).

The relevant and internalised knowledge is embedded and strongly related to the roles as building an element of the organisational structure. In dynamic environment both the roles and required competencies are changing, therefore the knowledge elicitation[5], articulation cannot be independent of the permanently updated business process model; hence, the business process model is one of the essential ingredients of the knowledge to be captured.

The proposed solution is to extract the knowledge from information stored in the process model to articulate, externalise, represent and transfer (reuse) it. Since the business process models are often used for the execution of processes in a workflow engine, another significant source for gathering useful knowledge are real-time instantiations of the business processes, that are giving a view of the dynamic knowledge, usually represented in the form of different business rules. The expected impact is the preservation and efficient management of corporate intellectual capital, a better return on investment in human capital that will lead to the more efficient execution of processes and consequently higher profit. The expected impact is the preservation and effective management of corporate intellectual capital, a better return on investment in human capital.

The goal of the proposed framework is to develop a solution to extract, organise and preserve the knowledge embedded in organisational processes to:

— enrich organisational knowledge base in a systematic and controlled way,
— support employees to quickly acquire their job role-specific knowledge,
— help to govern and plan the human capital investment.

To achieve this goal a complex IT solution and method is developed which integrates:

- organisational process management tool,
- learning management tool,
- real-time data monitoring and processing tool,
- data and text mining tools for developing a knowledge base (domain ontology) and

[5] Knowledge elicitation is the process within knowledge capture where hidden or tacit knowledge is being articulated. Frequently but not exclusively selected experts are encouraged to articulate their knowledge

- the interfaces which are responsible for the communication between these components.

On-the-job training is put on the focus, since it increases productivity at the firm level and is a source of innovation and therefore long-term competitiveness of firms, too.

The novelty of this approach is based on the connection between process model and corporate knowledge base, where the process structure will be used for building up the knowledge structure. A common form of the knowledge base is the ontology, which provides the conceptualisation of an individual domain (Gruber, 1993).

The main innovation lies in new algorithms for the extraction and integration of the static and dynamic process knowledge and a novel integration architecture that enables smooth integration of the eLearning methods in the process execution models.

However, the capability of the ontology to describe the process knowledge domain is very much related to the way the model has been generated, therefore in this framework we apply a Semantic Business Process Management approach.

The primary challenge in Business Process Management (BPM) is the continuous translation between the business requirements view and the IT systems and resources. Semantic Business Process Management (SBPM) is a new approach to increasing the level of automation in the translation between these two levels and is currently driven by principal players from the BPM, and Semantic Web Services area. The core paradigm of Semantic Business Process Management is to represent the distinct levels using ontology languages and to employ automated translation (Ternai and Torok, 2011).

The approach of this study will provide a paradigm to evaluate the level of alignment between process requirements and domain requirements and providing input to the domain expert to revise the process critically and to enrich the Business Process Model.

5.2. Technology state of the art

The various Business Process Management solutions offer different modelling approaches, but the underlying logic behind the modelling methods remains the same. The different approaches include the definition of activities, descriptions, and responsible positions or roles for execution. To integrate the different approaches, the primary market leaders agreed to create a standard modelling method, BPMN, which latest version is v2.0.2 (OMG, no date).

Innovative e-learning solutions are combined with semantic technology to have a substantial knowledge base in knowledge elements structuring. The standard form of the knowledge base is the ontology, which provides the conceptualisation of a particular domain. E-learning solutions started to include semantic interpretation of knowledge areas, ontology-based adaptive testing (Kismihók and Vas, 2006).

Real-time data processing has become very important recently since the number of the information that is produced daily (business transactions, process measurements, web activities, to name but a few) is growing steadily and the ability for processing them not only in the batch mode (once per week/day) but rather in the real-time is crucial for the competitive advantage. Currently, the real-time processing tools in the industry (like these from Tibco, IBM, Oracle) are not considering the connection between static and dynamic process data.

Moreover, existing solutions have not been integrated into the learning context yet, which gives us the chance to develop a very competitive and useful solution. In fact, the objective is to describe and manage data in a static context.

However, companies have to manage the vast and growing volume of content. The amount of information that must be retained to comply with rules and regulations is expected to grow from 25% of the digital universe last year to 35% in 2012 (Wray, 2009).

To use the embedded knowledge of the content data, web and text mining solutions are applied, that is one of the reasons for their increasing popularity recently. Free software, like Python and R, are the more popular in data and text mining based on the KDnuggets Poll in 2016 (Piatetsky Gregory, 2016). However due to the introduction of commercial versions of those tools shows an increase of adoption of those software: 29% of the users used only commercial software, 30% only free software, and 41% both. RapidMiner, R, and Excel were again the most popular tools. W. European data miners had the highest percentage of free tool use, 35%, while E. Europe has only 29%. The ratio of the projects, which did not apply text analytics/text mining in the past 12 months is decreasing (33.7% in 2014, 34.7% in 2011 and 45% in 2010)(Piatetsky, 2015).

5.3. The PROKEX framework

With the PROKEX framework, in particular, starting from the representation of the firm processes by mean of BPM models (Gábor et al., 2013). We identify a subdomain of an ontology that is covered with this process domain to provide context-specific tests (Gábor and Arru, 2014). The technology utilises techniques of process modelling, text mining (Gillani and Kő, 2014) and ontology matching. The application of adaptive testing provides an innovative approach to measuring the coverage of the required competence and at the same times results in a powerful tool for self-training (Weber and Vas, 2014). The applications of this approach may go beyond the e-learning but can be applied to a more comprehensive evaluation of the fit of resources to the required domain necessary to run the processes in an organisation. It is common practice in the structured organisations to have a formal model of their processes using Business Process Management (BPM) practices. The formal representation and the documentation of such process is a valuable asset to promote the resilience of the organisation to rotation of staff and to promote quality improvement. The primary challenge in Business Process Management (BPM) is the continuous translation between the business requirements view and the IT systems and resources. The usage of Semantic Business Process Management (SBPM) allow enriching the potentialities of BPM, enabling automated translation between the two perspectives (Ternai and Torok, 2011). The approach adopted by this study will provide a paradigm to evaluate the degree of alignment between process requirements and domain requirements and providing input to the domain expert to revise the process critically and to enrich the Business Process Model. The goal of the proposed framework is to develop a solution to extract, organise and preserve the knowledge embedded in organisational processes to:

- enrich organisational knowledge base in a systematic and controlled way,
- support employees to quickly acquire their job-role-specific knowledge,
- Help to govern and plan the human capital investment.

PROKEX aims to address these issues through an IT solution and method that integrates:

- organisational process management tool,
- learning management tool (Kismihók and Vas, 2006),
- real-time data monitoring and processing tool,

- data and text mining tools for developing domain ontology (Gillani and Kő, 2014) and
- the interfaces that are responsible for the communication between these components.

5.4. Characteristics of the solution

The proposed solution envisages a comprehensive procedure whose unique feature is the integration of different partial technologies, owned by the participants to the project, as business process modelling, semantic technology, real-time data processing, knowledge elicitation, representation and transfer; data and text mining technologies mainly support the knowledge extraction.

The technologies involved are mostly open source elements since the interoperability is a crucial pre-condition of the application. The added value comes from the realisation and integration. While the case studies and scenarios are very different, the architecture is loosely coupled and, depending on the local circumstances, elements can be replaced without radical changes in the structure and usability. The source of knowledge extraction is the business process model, including its instantiation online. The on-time data processing and analysis methods are used for the generation of the dynamic knowledge, e.g. in the form of business rules. The appropriate text mining solution produces the content and the structure that is then uploaded to the ontology-based application. For example, one of the business cases aims to create an e-learning application based on the ontology instantiated, or an application to map knowledge gaps in an organisation.

The proposed complex approach will cope with these challenges, through a semi-automatic solution, which applies the advanced text-mining technology for annotation that helps to identify specific activities and the required competency areas. Text selection (e.g. job role description) is semi-automatic, controlled by the process structure. Text-mining solutions determine the relationship between the specific activities and job role specific competencies. The structure of the job role competencies and the structure of the organisation and business processes should be mapped. The result of the analysis is a domain-specific ontology that will be used as the basis for structuring the content. The domain ontology is always industry specific; therefore, the industrial benchmark will be used to validate the results.

5.5. How does it work?

An explanation of the PROKEX architecture is available in previous publications (Arru, 2014). The PROKEX solution is a composite infrastructure where different technologies are employed in various phases of the process as shown in Fig. 5-1. Despite the specific business application four main elements constitute the technology, and that implement the iterative translation from the process to the ontology domain.

- A process model
- Translation to a domain model
- Content development and exploitation of the ontology
- Feedback to the process model

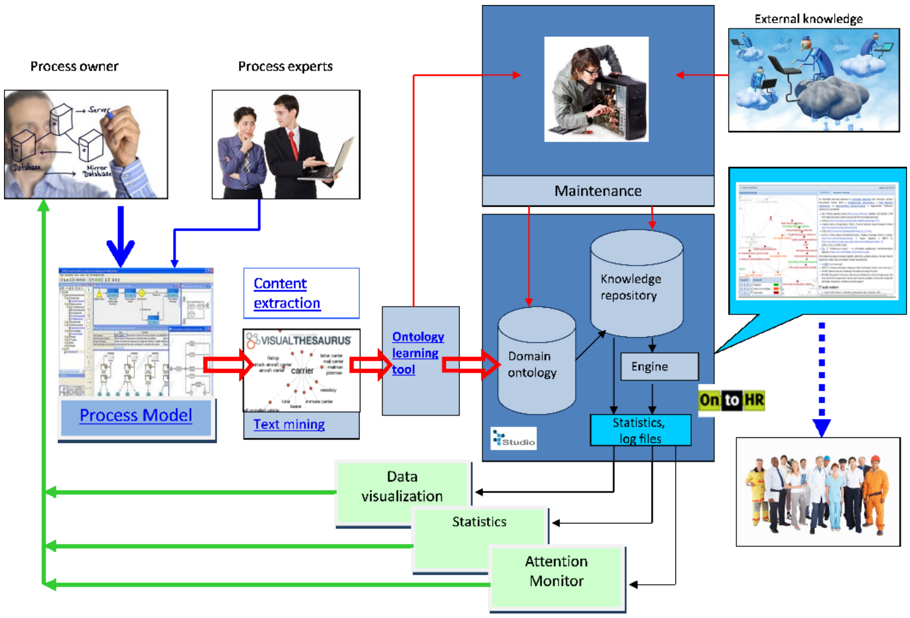

Fig. 5-1. The Big Picture

5.5.1. Business Process Modelling

Business Process Modelling is the graphic representation of an organisation's business processes. In this first phase, the business process is formalized using SBPM tools. Process modelling aims at graphically describing the process flow and providing information to company so that even complex processes remain transparent. Detailed processes are grouped in process groups and sub-groups; event-driven process chains are often used at the lowest level of the process hierarchy. By definition, each elementary task should have an organisational actor to perform it. A well-described process model contains all the relevant tasks and their description (Ternai, Török and Varga, 2014).

In the description of each task is stored the information about the content of the work. Relation with other task, roles, resources, input and output are contextualising the active role in the process. Supporting documents, (e.g. regulations) enrich the description of the activities.

5.5.2. Ontology building

In the second phase, all the relevant information extracted from the process models and related documents will be processed and analysed. Text and data mining techniques are employed for knowledge extraction from the context data. Those knowledge elements will be the basis to create the new specific domain ontology.

The technology behind this phase is described more in details in the article "Process-based Knowledge Extraction in a Public Administrative Authority: A Text Mining Approach" is to create an ontology from the originating SBPM (Gillani and Kő, 2014).

5.5.3. **Content development**

The ontology created in the previous phase will be the basis for the development of the relevant contents. Corvinno's system called STUDIO will be used to store the content in the knowledge repository. The ontology will ensure that content is structured in a way that reflects the unique features of the selected business models.

In particular, the contents created, will be used to feed an e-Learning platform (Kismihók and Vas, 2006) that will support the organisation resilience.

5.6. The PROKEX retroaction

In the previous chapter, we defined “Knowledge Fit” and explained how we could obtain it with the assistance of the PROKEX system. Hereafter we would like to elaborate the concept and evaluate the reasoning that the information of “Knowledge Fit” may trigger for those responsible for an organisation to redesign the processes.

5.6.1. Premise

It is important to clarify that the criteria for the actual feasibility of a process change cannot only rely on the information coming from the “Knowledge Fit”.

A professional analyst when redesign a process must take into consideration several other aspects including

- the possibility of implementing the pull,
- the correct position of the process pace-maker,
- the attitudinal mix of the resources,
- the availability of technology,
- the knowledge required.

In this research, we consider that all the other dimensions have been already addressed and only the resource “Knowledge Fit” need to be analysed. Otherwise, it is possible to use the “Knowledge Fit” to evaluate a scenario designed using the other criteria with the knowledge perspective.

5.6.2. Context

The first straightforward application of “Knowledge Fit” and the “Fit Score” is to perform a gap analysis. The fit is, in fact, a measure of a gap with the relative topologic knowledge matrix (E.g. IFit with IK).

In this chapter, we describe how the measure of such gap can help an organisation derive conclusions that can drive a change.

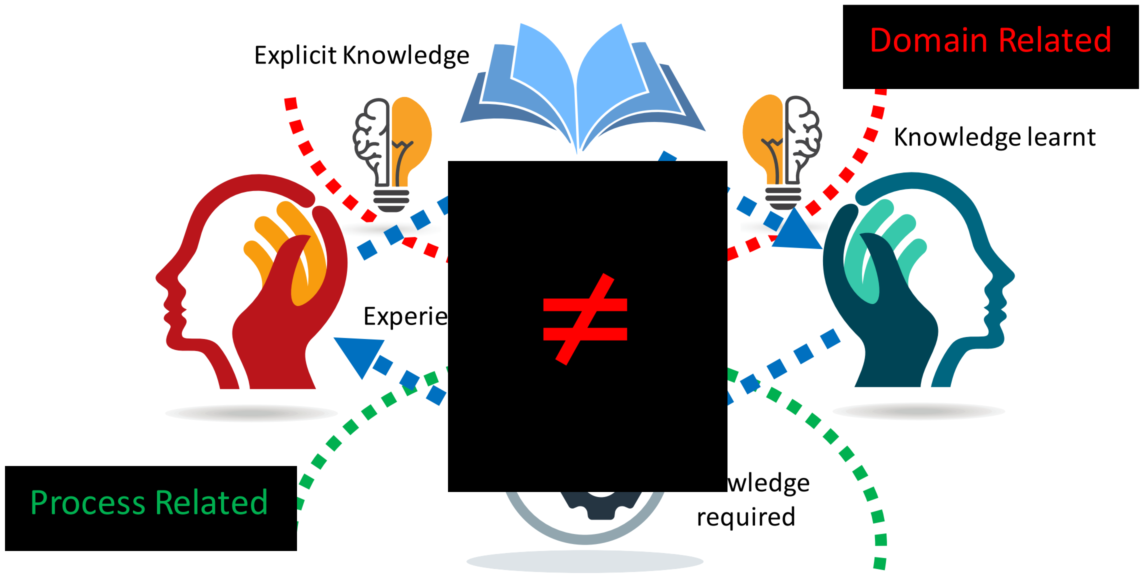

Figure 5-2 Elements measured by the "Knowledge Fit".

In Chapter 4, we have discussed the application of the "Knowledge Fit" to an organisational deployment. However, the organisation is only one part of the picture, and it is the trick enterprises are using to allocate people with their knowledge to the tasks that lay in the processes.

On the other hand, in Chapter 4 when we described the overall approach, we made explicit that the central point of the PROKEX approach is to create a link between the process and the knowledge domain. The final goal of this research is, in fact, to provide companies with a tool to manage the continuous translation of those two domains.

In between those two domains, there are the individuals that elicit the knowledge they create trough experience and eventually, they may explicit in the explicit knowledge that the organisation can capture through its knowledge management systems. Only through its explicit form, the knowledge can be transferred to other individuals that have to operate the same task (Figure 5-2). Humans have therefore two primary roles in this process: to create knowledge, formalise it, then to learn knowledge, and finally to apply it. This ideally should continue in a loop that continuously develops the corporate knowledge and improve the processes.

The measure of the "Knowledge Fit" aims to measure the effect that can show root cause in all the elements represented in Figure 5-2: The people, the organisation, the formalised knowledge, the processes plus the measurement system itself.

5.6.2.1. *The people*

The first direct consequence of a gap in the "Knowledge Fit" may represent a non-optimal background knowledge hold by the job holders. A potential intervention, in this case, may be training or substituting the individuals with those having the required knowledge.

5.6.2.2. *The organisation*

Looking at the "Knowledge Fit" with an organisation perspective means analysing first if the gaps are systematics or individual. A systematic gap may mean that the scare knowledge need to be acquired on the market or, as an alternative can pinpoint opportunities for a process change to mitigate the effect.

If, on the other hand, the gap is not systematic the "Knowledge Fit" provides the management with a tool to identify candidates within the organisation that can better perform the job as described in section 5.6.2.1. However, it may offer measurement to decide if a specific role should be allocated to a different job position or a task to a different role wherever the capacity is sufficient and so the "Knowledge Fit".

5.6.2.3. *The processes*

The "Knowledge Fit" can be a compendium to the BPR practices: the "Knowledge Fit" can be recalculated and provide a simulation of target criticality. For instance, an intervention may require that a particular task should be performed by the same person that is performing the one before creating the material flow. The simulation can highlight the potential training interventions necessary.

The "Knowledge Fit" (and in connection with it the knowledge spare as it was introduced in section 4.4.3.2) can highlight those resources that have the flexibility to operate beyond their job description, and that may be employed in a different setup.

Further, "Knowledge Fit" can support the development of transformation processes like digital transformations. In this context, it is in fact always an issue to identify priorities among the potential interventions that the "Knowledge Fit" can inspire. If knowledge is systematically missing to perform a particular task, this is a good candidate for automatization.

5.6.2.4. *The corporate knowledge*

Not only the "Knowledge Fit" but in general the PROKEX process allows to highlight missing knowledge from the corporate Knowledge Management Systems. In Chapter

6.5 we will show that concepts may be identified within the BPM but are not included into the ontology. Further, in Chapter 7.4, we will show that we can identify activities where only few knowledge elements were identified, and therefore that may require further refinement of the BPM. The same can happen by identifying knowledge required from the semantics of the ontology.

5.6.2.5. The measurement system

Finally, the measurement system may also require a revision: the testing may identify questions that are too easy or too difficult to be answered. A knowledge gap may always be a real gap or may be an error in measurement. This could be a fascinating area of research around testing systems.

5.6.3. Resources optimisation

The third research question is to validate the possibility of using the measures of the "Knowledge Fit" to automatically identify the optimal organisational setup. Once we have information about the "Knowledge Fit", we may want to organise the staff, roles and positions to optimise the knowledge allocation.

Like in every optimisation problem we should define a measure that synthetically defines how far we are from the ideal situation.

The "Knowledge Fit" as we have defined now is not a synthetic indicator but rather an analytical representation of the correspondence between knowledge required and owned at a different level of the organisation deployment.

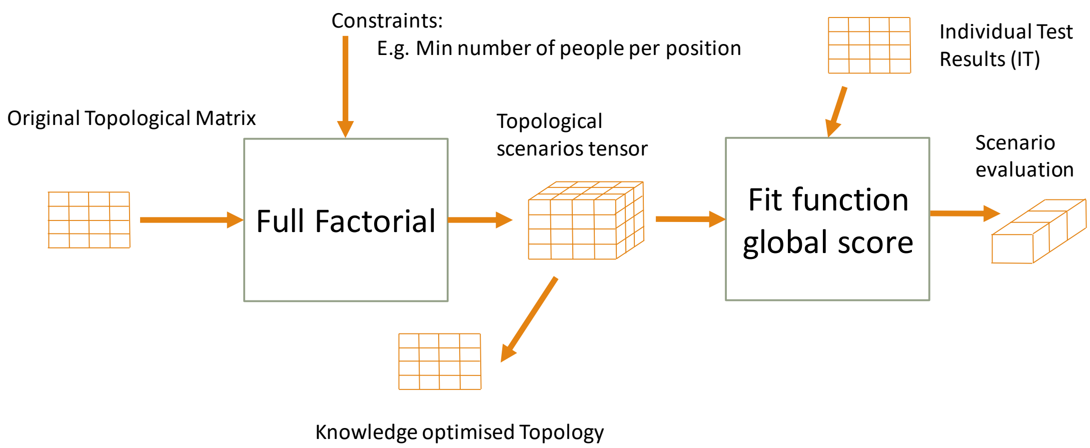

Figure 5-3 Optimising a topological matrix with a full factorial

The first step toward an establishment of such function we should define a synthetic indicator of fit.

A potential approach is to create a simulation of all possible combinations for a topological matrix using a full factorial design (Cano, Moguerza and Redchuk, 2012).

Given $a_{i,j}$ is an element of $A\epsilon\mathbb{B}^{x\times y}$ and n is an element of $N\epsilon\mathbb{B}^{x\times y}$ the Next Matrix is a function that increments a binary matrix

$nextMatrix\colon A \rightarrow NextMatrix$ where $NextMatrix\ \epsilon\mathbb{B}^{x\times y}$ and where

$$\text{nextMatrix} = \begin{cases} a_{i,j}+1,\quad n_{i,j} = !\,a_{i,j} & ;\ i=j=1 \\ a_{i,j}+1,\quad n_{i,j} = !\left(a_{i,j}+1\right) & ;\ i=1, j<y, n_{i-1,j}=1 \\ a_{i,j}+1, n_{i,j} = !\left(a_{i,j}+1\right) & ;\ 1<i\le x, j<y, \quad n_{x,j-1}=1 \\ a_{i,j} & any\ other\ case \end{cases} ,\forall i \in [1,x], \forall j \in [1,y]$$

The Full Factorial is a tensor $FF\ \epsilon\mathbb{B}^{x\times y\times 2^{x\cdot y}}$ so that

$$FF_k = \begin{cases} A & ;\ k=1 \\ \text{nextMatrix}(\text{A}_{k-1}) & ;\ \forall k \in [2, 2^{x\cdot y}] \end{cases}$$

In short with a full factorial we create all possible scenarios for a binary matrix that represent the topological matrix that we would like to implement; for instance all permutation of the matrix IP that associates the individuals to their positions. Alternatively, we can reshuffle the allocation of roles to the positions.

Given this tensor, it is then necessary to specify the topologic constraints to calculate the global score for each of the remaining matrices in the tensor. The matrix associated with the higher GScore is the best, as explained in Figure 5-3.

We understood during the experiment that the approach is valid only at a theoretical level. The number of permutations even in a limited scope like the one that we used for this test is very high because of the exponential complexity of the FF function.

Even if an individual iteration to create the next matrix takes few milliseconds, the number of matrices in our test case is 2^{55} that corresponds to few thousands of computation years.

In this thesis, the objective is to use the simulation to prove that an optimisation engine can produce an output that is actionable.

In the attempt to overtake the computational issue connected to the most general approach we decided to address the simplest case. In this regards the most straightforward topological matrix that we may want to optimise is the table IP that relates individuals with their positions.

It is the simplest way, because while the relation in tables such as the RP the possible relations *roles to positions* is many-to-many, in the IP the relation between *positions and individuals* is one-to-many, one person can hold only one position.

Another objective is to anticipate the application of the filtering criteria before starting any computation. The problem that we picked to solve is the allocation of the current staff to a set of available positions.

With this formulation, the problem can be aligned to those matching problems that in operation research are discussed within the graph theory. (Loebl, 2010)

Within the various algorithms, the one that better fit with our specific problem is the so-called "Hungarian Algorithm" (Kuhn, 1955). This algorithm solves assignment problem in polynomial time (and no longer exponential).

The assignment problem consists of identifying the cheapest association between a set and another based on a cost function.

The prerequisite is that the two sets have the same dimension and that we can always associate a cost with a possible relation. The algorithm will identify the best association that will minimise the total cost.

If therefore is $C \epsilon \mathbb{R}^{x \times y}$ the cost function where each element $C_{i,j}$ is the cost of the relation between the ith element of the first set and the jth of the second set and $X_{i,j}$ is an element of the matrix $X \epsilon \mathbb{B}^{x \times y}$ representing the existence of the relation between the ith element of the first set and the jth of the second set, X is the best assignment when $min \sum_i \sum_j C_{i,j} X_{i,j}$.

For instance, let's say that three people Matteo, Dorina and András want to work in a Pizzeria but due to their different professional background their salary may different for the position of cook, waiter or owner as represented in Figure 5-4.

Cost	**Cook**	**Waiter**	**Owner**
Matteo	3€	2€	3€
Dorina	2€	3€	3€
András	3€	3€	2€

Figure 5-4 Cost Matrix

The minimum cost will be 6€, and the topological matrix IP will look like the one in Figure 5-5.

IP	Cook	Waiter	Owner
Matteo	0	1	0
Dorina	1	0	0
András	0	0	1

Figure 5-5 IP matrix: Individuals Positions

Now let's say that instead of the cost we would like to optimise the assignment by using the "Knowledge Fit", we must identify a cost matrix that can be derived from the measurement.

A good cost matrix $IPCost \in \mathbb{R}^{i \times k}$ may be calculated from the matrix that have for every association Individual Person the calculation of the Fit Score: $IPCost = 1 - IPFitTab$

To compute this table, we can start from the table of the knowledge tested on the individuals $IT \in \mathbb{B}^{i \times k}$ and a the matrix of the knowledge required at positions P$K \in \mathbb{B}^{x \times k}$ and the function will generate a vector $IT \times PK \to IPFitTab \in \mathbb{R}^{x \times 1}$. This matrix can be calculated according to the following formula:

$$IPFitTab = \left(\frac{\left(IT \circ PK^T\right)^T}{\sum_{j=1}^{k} PK_j} \right)^T, \forall j \in [1, k] \ \in \mathbb{R}^{i \times k}.$$

Using the "Hungarian algorithm," we can obtain the optimised matrix IP so that $min \sum_i \sum_j IPCost_{i,j} \overline{IP}_{i,j}$.

6. Preparing the research implementation

The objective when we were seeking for a business case to validate the "Knowledge Fit" as a relevant measure of process improvement is to find a context that should have had the following characteristics:

- include one or more business process,
- the organisation should be considering the possibility to implement process improvement and need validation or should consider a reorganisation of the actual resources,
- the process should have an adequate number of roles (at least three) and job holders (at least five),
- there should be a reasonable motivation for change.

6.1. **Business case**

Selection of the business case where to test the hypothesis of this research was not an easy task: the methodology still needs to be validated. Therefore it cannot represent a mandatory work for an organisational unit to develop. On the other hand, as the approach spans in end-to-end processes to have significance requires involving actors from all relevant roles. Also, a test in average lasts an hour, and few people are willing to commit to such an extensive examination voluntarily.

Also to the business case, we would like to find a business context that has the right precursors for the adoption of PROKEX just discussed at the beginning of the chapter.

Fortunately since 2016 it happens to work for the Logistics of MOL Group as Operational Excellence Senior Expert. The MOL Group is a multinational oil company based in Budapest with downstream operations in 8 different countries with 12 companies. This provided us with the opportunity to have access to a large variety of organisation, and we had among ours duties to evaluate the organisational fit with their processes.

Being the largest Hungarian company MOL represent an ideal target user of the PROKEX application. In logistics, MOL has an organisation that present similar processes in different locations. We identified few processes within the logistics terminal operations. One of the reasons why this context fits the purpose is that the company has documentation that can provide extensive supporting information in the development of the process map and ontology.

MOL is a very well-structured organisation, therefore has standards and procedures at all level defining the working modalities and the responsibility.

MOL Italian Subsidiary: IES, further, has some specificities that qualify it to be a suitable candidate:

The team is smaller than flagship companies (MOL Hungary, Slovnaft and INA) but more significant than the other operating companiesI

- it has multiple sites with similar processes,
- we can speak their language, and therefore we can translate the test so that everyone can understand it,
- they are coming from strong organisational downsizing due to the closing of the refining plant. Several people were moved from their original positions to hold different job positions. This gives us the possibility to evaluate how good was the integration from a knowledge perspective;
- adding to the above, IES during the period of this thesis development was selling its retail network, and there would be some headquarter positions that need to be re-allocated.

Further, the local organisation is revising its business model and initiated an Operational Excellence program that seeks to re-evaluate the current processes considering the new organisational needs. Therefore, for this organisation is relevant to evaluate the aspect of the current and prospect state regarding available competencies, too.

In the scope, we have logistic processes in the three main distribution terminals, excluding the seaside terminal that is used for receiving the product from the sea and deliver via pipeline to the main terminal and to the smaller terminals.

We expect that the experiment will help provide a scenario related to the “Knowledge Fit” that confirms or exceed the perception of the local management.

Further, we will apply the model identified in Chapter 5.6 to optimise the organisational model as a draft canvas for the consolidation of the company’s future state.

By the dialogue on the result, we expect to:

- validate the feasibility of the overall assessment process,
- identify those elements that the model is not able to incorporate, and
- identify operational issues encountered during the implementation that may open new research streams.

6.2. The Business Process Model

In Chapter 5.5.1 we explained that one fundamental element of the PROKEX solution consists of a process described through a Business Process Model.

As agreed with the partner organisation this thesis will not be explicit regarding to the content of the processes or the results of the evaluation. These elements will be made available to the evaluation board but will not be part of the published document.

MOL Group has two standards defining the company's procedures: Global Operative Regulation (GOR) establishing the general best practice to implement a particular process and Local Operative Regulation (LOR) that specifies the site-specific procedures (MOL Group, 2015; MOL Italy/IES, 2015).

We have identified the two GOR areas that are relevant to every logistic terminal:

- terminal operations and
- secondary distribution

Within those two areas we selected six processes:

- Terminal operations
    - product acceptance,
    - product storage,
    - lifting from terminal.
- Secondary distribution
    - planning of necessary transportation capacity,
    - inventory management of filling stations,
    - routing and scheduling.

The preparation of the model using the Adonis BPM tool (BOC Products & Services AG, 2016) was quite straightforward, because the GOR was already describing each activity with an appropriate level of details.

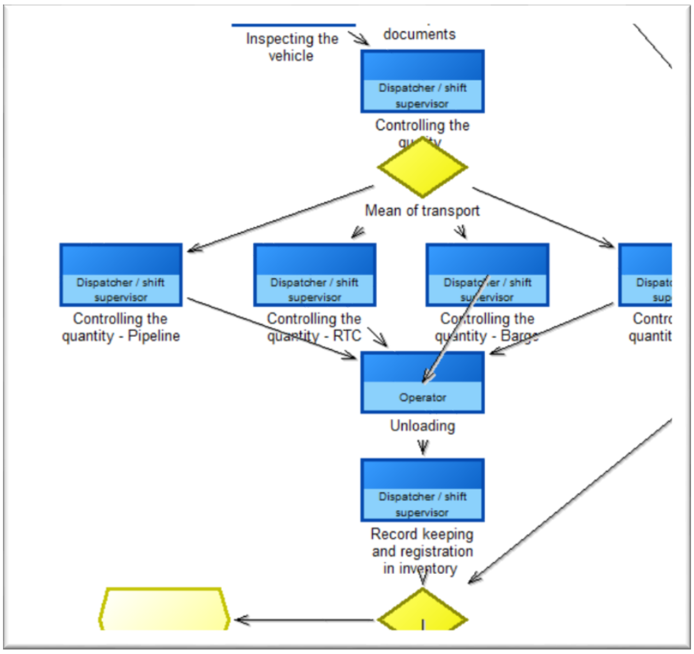

Figure 6-1 Process representation using BPM

Although GORs are not standard, from all document was possible to clearly identify a responsibility using RACI convention (Project Management Institute, 2013).

For this exercise, we are only evaluating the competence required for performers allocated to the task, more precisely, those who are identified with the *responsible* role.

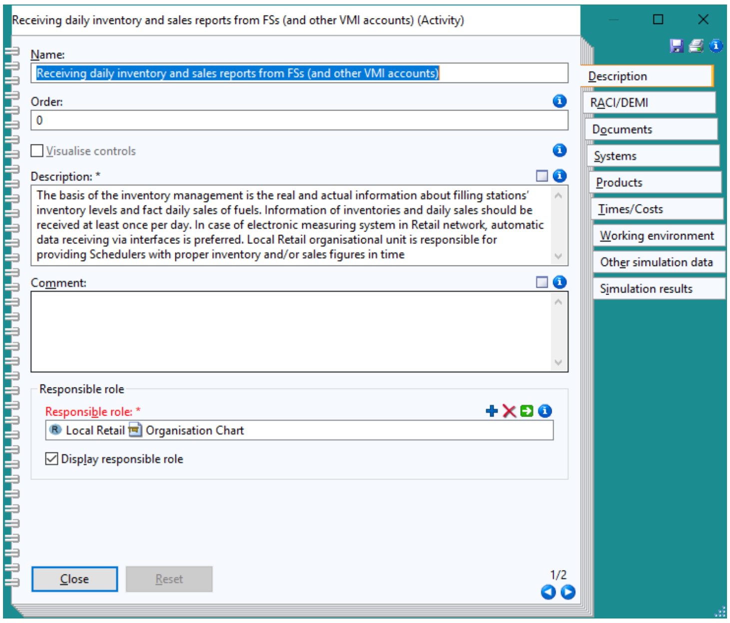

Figure 6-2 Example of activity description in Adonis BPM

Supporting document included in the GOR are referenced in each activity and provide material for further semantic enrichment.

The overall model created for this exercise includes 50 different activity/task and 12 roles.

6.3. The initial ontology

In this preliminary phase, we do not have a full-fledged ontology as described in Chapter 5.5.2. To create an ontology that may serve the purpose of this experiment, we are creating an initial ontology that we will enrich after the first iteration of the PROKEX.

We are building the first iteration based on an existing ontology developed in the STUDIO ontology (Vas, 2016) related to business economics subjects at Corvinus University.

Since the central domain area is logistics and the described ontology was not developed in this particular area, we manually enriched the initial set using the content of the handbook, entitled: "The Handbook of Logistics and Distribution Management" (Rushton, Croucher and Baker, 2017).

In this phase, we did not use the whole content of the book, but we limited to introduce the central concept as defined in the table of contents.

Developing the ontology is a time-consuming activity indeed; fortunately, the PROKEX approach provides a way to identify only the contents that worth to be elicited.

In this particular case, we were also in aware that there was some specificity of the process that was belonging to the business domain in which the subject company works, but may not be covered in full detail in the literature reference that treats logistics widely but not specifically the oil logistics.

The initial ontology that we created was considering 364 concepts.

6.4. The first iteration

With this first experiment, we aimed to study the ontology matching algorithm between the BPM and the initial ontology. By the analysis of the result, we would try to understand the precision of the available algorithms to identify correct concepts from the analysis of the activities described. Further, we would like to determine potential concepts, which are relevant to the process: those are not yet covered by the initial ontology.

6.4.1. Concept extraction

To run the ontology matching algorithm, we need first to extract keywords and phrases that the algorithm should evaluate against the ontology. The content of the tasks is encapsulated in the BPM. The commercial version of the Adonis BPM can export the model in an XML format. From the model, we extract phrases that, in the following step we try to relate to a concept in the ontology.

6.4.2. Ontology matching

The current version of PROKEX operates using a k-nearest neighbours (KNN) algorithm (Gkoumas and Vas, 2017). This algorithm is a type of supervised machine learning algorithm. KNN is extremely easy to implement in its most basic form and yet performs quite complex classification tasks. It is a lazy learning algorithm since it does not have a specific training phase. This algorithm is quite simple and does not require relevant computational resources. However previous experience with the PROKEX highlighted not optimal effectiveness identifying the related concept (Robinson, 2018).

Algorithms based on semantic similarity provides another perspective for a more sophisticated approach that may produce a better result (Li et al., 2006). Unfortunately, this methodology requires much higher computational resource that a stand-alone workstation cannot serve in a relatively short timeframe. The new algorithm will need therefore to be run in a distributed cloud environment. However, the computation time is still few days.

6.4.3. Evaluation of the matching

The result of both algorithms is composed by the association between a task (and relative role associated), phrases extracted from the task, the concept that the algorithm evaluated be relevant, and a distance indicator. This distance is a number that goes from 0 to 1 and indicates the level of confidence that the algorithm has in its evaluation. While in the k-nearest neighbour's algorithm the lowest the distance the higher the confidence, in the semantic similarity is the opposite. To evaluate the outcome of this exercise, we asked a domain expert to validate the association made by the two algorithms.

The evaluation of the model required about one working day per type to go through the about 3000 associations identified by the two algorithms.

The *k-nearest neighbour's* algorithm was able to determine the majority of concepts within the most appropriate distance as from Figure 6-3.

K-nearest neighborhood				
Distance	Wrong Associations		Correct Associations	
0	0%		100%	204
0.1	50%	1	50%	1
0.2	66%	73	34%	37
0.3	73%	172	27%	63
0.4	93%	223	7%	17
0.5	86%	145	14%	23
0.6	92%	49	8%	4
1	100%	1933	0%	

Figure 6-3 Evaluation of the K-nearest neighbourhood algorithm

Much more insecure is the result coming from the *semantic similarity* where the majority of the correct associations are spread to distance cluster where the accuracy is much lower as from Figure 6-4.

Semantic Similarity				
Distance	Wrong Associations		Correct Associations	
0	100%	181	0%	
0.1	100%	28	0%	
0.2	98%	148	2%	3
0.3	97%	573	3%	17
0.4	95%	1051	5%	52
0.5	89%	359	11%	45
0.6	71%	158	29%	64
0.7	43%	66	57%	88
0.8	33%	30	67%	61
0.9	0%		100%	19
1	0%		100%	1

Figure 6-4 Evaluation of the semantic similarity algorithm

The experiment confirms that the algorithm adopted by PROKEX can produce better result than a more sophisticated approach, so far. The new approach, however, is still under engineering and we will go in the next iterations to continue monitoring improvement of this method that has a theoretical relevance in this domain as suggested by Li et al. (Li et al., 2006).

6.5. **Ontology enrichment**

From the first iteration of the PROKEX system, we further extracted all the terms obtained from the BPM that did not match any concept.

Wwe removed all those phrases that were too general to be relevant to any concept and with the support of the domain expert I added new nodes to the ontology.

A new concept was created either if more detailed concept was available in “The Handbook of Logistics and Distribution Management” (Rushton, Croucher and Baker, 2017) or, in the majority of the cases, concepts that are related to the oil business.

The PROKEX proved to be an excellent support to create an actual ontology focusing on real need saving efforts in identifying the relevant concept to be included.

7. Empirical evidences

In the final part of this thesis research, the objective is to demonstrate the applicability of the model to a real business case where actual workers will be assessed to evaluate their fit to their job in this current assignment and following a reorganisation following a process improvement exercise.

7.1. Next steps: The Business Case

In Chapter 7.2 through the business case we demonstrate the applicability and robustness of the approach. The validation of the model will be performed by following the steps as described in Figure 7-1.

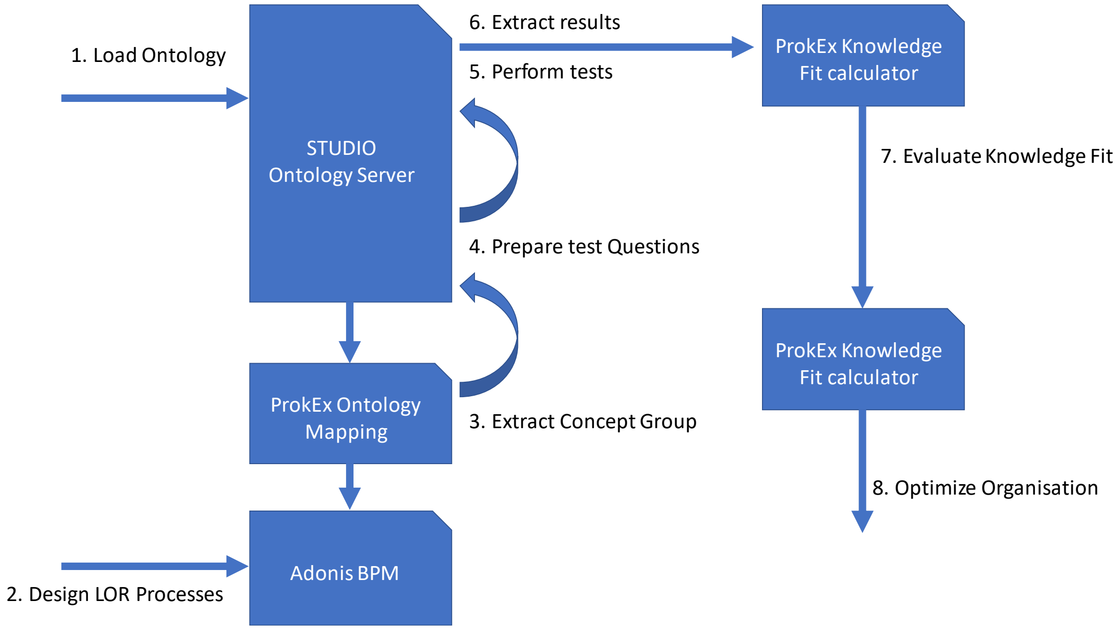

Figure 7-1 Final validation of the Thesis

7.1.1. Load ontology

To finalise the experiment and to confirm the thesis we will load the ontology completed after the second iteration in the STUDIO ontology server. We will not enrich further the ontology to demonstrate that a general ontology developed at the corporate level can produce an acceptable output when applied in a local context.

7.1.2. **Design LOR Processes**

In IES, organisation changes resulted in modification of the GOR and the implementation of a new specific LOR as a consequence of a process improvement activity.

We will test therefore the ontology generated for a generic organisation in the MOL group in the context of the specific local process as implemented in the IES logistics.

7.1.3. **Create Concept Group**

Similarly, to the approach used in Chapter 6.4.2, in Chapter 7.2.4 we will use PROKEX to match ontology with the BPM, and we will create a Concept Group containing all concepts that the system managed (Chapter 7.2.1 and 7.2.2) to identify within the process descriptions.

7.1.4. **Prepare test questions**

The extracted Concept Group will be therefore loaded in the STUDIO software and will be the domain base for the trial to the IES associates. This phase was particularly labour intensive because the domain experts need to prepare questions related to more than 200 concepts.

7.1.5. **Perform tests**

Once the test is set up, in Chapter 7.2.6, we implemented the test with the support of the actual IES associate working in the Mantovan IES site and few more people working in other locations of the company or different roles. The objective is, in fact, to evaluate that other resources in the company may have a similar or better fit for specific jobs.

7.1.6. **Extract results**

In Chapter 7.3 we process the derived results as described in section 5.6 to determine the measurements of the “Knowledge Fit”.

7.1.7. **Evaluate “Knowledge Fit”**

Chapter 7.4 focuses on the conclusions of the discussion with the local management to understand to what extent the model computed is in line with their understanding of the company and if it gives wrong indications or value added to support the process improvement initiative.

7.1.8. Optimise organisation

To conclude on the third research question, in Chapter 7.5 we use the optimisation process described in section 5.6.3 to identify an ideal best fit for the organisation to the process.

By the critics of the results, we conclude an understanding of the limits of such automatic approach and the eventual constraints that we see be relevant in this kind of optimisations.

7.2. The PROKEX process implementation

7.2.1. BPM activity extraction

The concept extraction from the business process descriptions is using the python's Natural Language Toolkit. (NLTK Project, 2017)

The *text* describing the *activities* is initially broken down into sentences.

Each word of the sentence is lower-cased and lemmatised using NLTK's library, then tag each word to obtain the grammar elements in the sentence and therefore identify those words that are stop words (like articles, prepositions, punctuation) that may separate different phrases. Those phrases individually will be ranked based on frequency and in the next phase will be matched with the existing ontology.

From this activity, we obtain some relevant input for the "Knowledge Fit" model described in Chapter 4.1. First, we get the vector of the *activities* and *roles*.

The *activities* are represented by the vector $a \in \mathbb{T}^{56\times1}$ that is annexed in Appendix 1a.

The *roles* are represented by the vector $r \in \mathbb{T}^{13\times1}$ that is annexed in Appendix 1b.

Further, we obtain the matrix that creates the relationship between the activities and the roles is the table $AR \in \mathbb{B}^{56\times13}$ in the experiment, it corresponds to the matrix in Appendix 1f.

From IES job descriptions we obtain a matrix associating roles with the positions.

We stored the related positions in the vector $p \in \mathbb{T}^{6\times1}$ that can be found in Appendix 1c and the table that relates positions with the relevant roles is the matrix $RP \in \mathbb{B}^{13\times6}$that is stored in Appendix 1g.

At this point, we can evaluate the topological table $AP \in \mathbb{B}^{56\times6}$ that is in Appendix 1j that describes the activities that should be run by people holding a specific position.

7.2.2. **Limitations of the concept extraction**

In the concept extraction described in Chapter 7.2.1, PROKEX uses NTLM WorldNet (Bird *et al.*, 2009) to identify those phrases that will have to match with the ontology.

The first limitation is the fact that in the extraction process is not accounted the contents of the STUDIO but only the Wordnet Ontology. Concepts in our knowledge base are in general described with more complex sentences that can go beyond the stop words as tagged using Wordnet. This reduces the possibility in the following phase to match the full concept but only related concepts.

7.2.3. **Ontology matching**

We downloaded the ontology from STUDIO and processed the ontology matching in the PROKEX framework.

For the ontology matching as explained in Chapter 6.4.2, we prefer to use K-neighbourhood algorithm than the Semantic Similarity algorithm. In section 7.2.2 we gave an overview of some limitation in the usage of the semantic approach that could have influenced the result of the experimentation.

The K-neighbourhood algorithm calculates the relative distance between the phrases extracted from the activities with the title of the concepts derived from the ontology.

In the experiment, we used the full STUDIO ontology that contains concept not only in the domain of Logistics Management but related to many different fields (2763 ontology nodes).

The ontology matching using a K-neighbourhood algorithm identifies 2395 matching between phrases and nodes of the ontology. However, the algorithm ranked the match very differently as shown in Figure 7-2.

Distance	# of Ontology Matching
-	77
0.10	27
0.20	221
0.30	405
0.40	238
0.50	250
0.60	55
1.00	1122
Total	2395

Figure 7-2 Ontology Matching by Distance

As we did in Chapter 6.4.3, we employed an expert to evaluate the results of the automatic ontology matching. The results are very different from those in the previous experiment as it is shown in the table, see Figure 7-3.

Distance	# of proper Ontology Matching	Total # of Ontology Matching	# of false Ontology Matching	% of false Ontology Matching	% of proper Ontology Matching
-	34	43	77	44%	56%
0.10	20	7	27	74%	26%
0.20	207	14	221	94%	6%
0.30	379	26	405	94%	6%
0.40	229	9	238	96%	4%
0.50	242	8	250	97%	3%
0.60	55		55	100%	0%
1.00	1122		1122	100%	0%
Total	2288	107	2395		

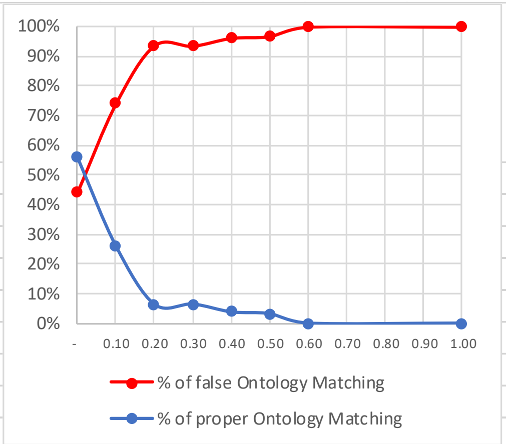

Figure 7-3 Evaluation of the automatic matching

In the case of the trials run beforehand, the K-neighbourhood was good enough to identify a perfect match when distance was 0. In the case of the PROKEX algorithm, instead recognises several false matchings and the manual selection is still required.

In this thesis, we are not investigating the reasons for this difference that may require further research. On the contrary, we are interested in the output of this phase: a list of concepts that are associated with each of the activities described in the business process. This is the matrix $AK \epsilon \mathbb{B}^{56\times125}$ described in section 4.4.2.1 that can be retrieved in Appendix 1k. The description of the knowledge elements is stored in the vector $k \epsilon \mathbb{T}^{125\times1}$ in Appendix 1e.

Once identified the knowledge that is required at the activity level we can easily derive the one needed for role and position as defined in Chapter 4.4.2.

This information is stored in the matrices $RK \epsilon \mathbb{B}^{13\times125}$ (Appendix 1l) and $PK \epsilon \mathbb{B}^{6\times125}$ (Appendix 1m).

In Chapter 7.2.4 we will further elaborate on the limitations of the current ontology matching algorithm.

7.2.4. Limitations in ontology matching

The ontology matching proved to work well in identifying in the BPM those concepts that are named exactly after the concepts in the ontology and its permutations. The expectation is, however, to be able through the ontology matching to extend the pairing to concepts that can be derived from the context. This objective seems still far from being achieved in a completely automatic way, although the algorithm managed as described in Chapter 7.2.2, to recommend potentially good concepts that a human may then classify more accurately. Using only recommended concepts, however, is not sufficient. In section 7.4 we demonstrate that the "Knowledge Fit" can suggest areas where the BPM description can be improved for a better alignment between the process description and the domain ontology.

The ontology matching is currently matching one to one the identified sentences with those in the name of the concept. There is an opportunity for extending the richness of the match by including more context in the ontology. A broader description of the ontology node content integrated with external resources could create a framework to help the disambiguation of terms and the identification of not direct affinities with higher precision.

7.2.5. Preparation of the Concept Group

PROKEX provides a simple web service to create the Concept Group in which a given a list of concepts it creates a Concept Group to test.

In this phase, STUDIO uses the semantic information in the ontology to determine if some concepts that were not in the original list may be introduced as required knowledge (Weber, Neusch and Vas, 2016). This is an exciting step because the ontology matching is enriched based on the semantic of the ontology. However, this critical feature cannot be used in our experiment due to the nature of the STUDIO's built-in logic that is only domain oriented and not process oriented. STUDIO, in fact, does not model the association between concept and task/activity that is fundamental in the PROKEX approach. As a final result in the Concept Group that will be used for the following testing phase in Chapter 7.2.6, contains all concepts defined in the ontology matching described in Chapter 7.2.2 and a set of required knowledge that however, is not associated to any node. Although we believe this being a missed opportunity for the architecture to deliver a higher quality result, during the testing phase, we will see that STUDIO will in any case use those orphan nodes during the testing to validate the knowledge.

7.2.6. **Testing**

We implemented the test by using the STUDIO testing suite. 11 users reply to the survey equally enough distributed among the various positions.

Those users are filling the vector $i \in \mathbb{T}^{11\times1}$ in Appendix 1d. From their employment record we, identify the matrix $IP \in \mathbb{B}^{11\times6}$ that associates individuals with their position (Appendix 1h). In accordance with Chapter 4.4.2.4 we can,, calculate the table of the Knowledge required by the individuals $IK \in \mathbb{B}^{11\times125}$ that is represented in Appendix 1n.

7.2.6.1. STUDIO testing algorithms

According to Weber, Neusch and Vas (2016) the STUDIO testing algorithm is based on the classical breadth-first graph traversing algorithm (Bauer and Wössner, 1972). All algorithms aim to find the “black spots” in the knowledge of the user, in other words, the aim is to discover the subset of the domain model which represents at best the user’s knowledge. To discover the knowledge of the user, the algorithm loops through the Concept Group and asks questions associated to the knowledge elements. First, it asks the questions connected to the Concept Group root, and if the answer is correct, it continually goes down the tree into the direction of the leaves, to the more specific knowledge areas (knowledge that is required for the broader knowledge). If the user does not answer correctly to a concept which represents a broader knowledge, the testing will be interrupted on the given “branch”, and the concepts that require more specific knowledge underneath will not be asked. The more extensively the domain is known by the user, the more questions will be asked. If the required knowledge (the specific knowledge) is not held satisfactorily (default threshold is 50%) the parent node is not evaluated successfully either (Gkoumas, Gausz and Vas, 2016)

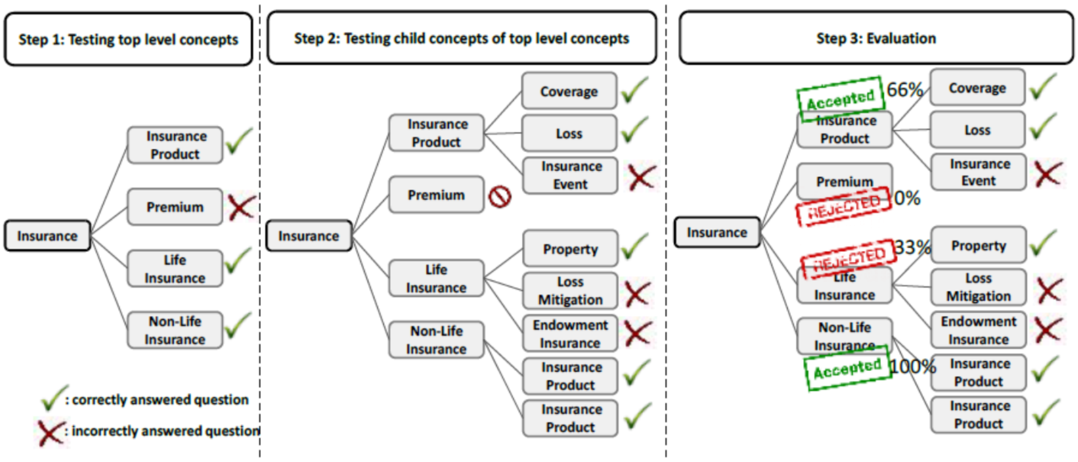

Figure 7-4 Illustration of the drill-down adaptive testing methodology in STUDIO

7.2.6.2. Limitations of the STUDIO testing algorithm when applied to the PROKEX approach

This algorithm fits very well with the finality of testing a whole knowledge domain such a University course or programme. In our case, however, the Concept Group is the combination of different domain knowledge domain related either to the task, role or position.

Although the PROKEX approach was developed on the STUDIO application, STUDIO never incorporated the process dimension. In its Database, in fact, there is semantic information of the relations between concepts but not with the processes.

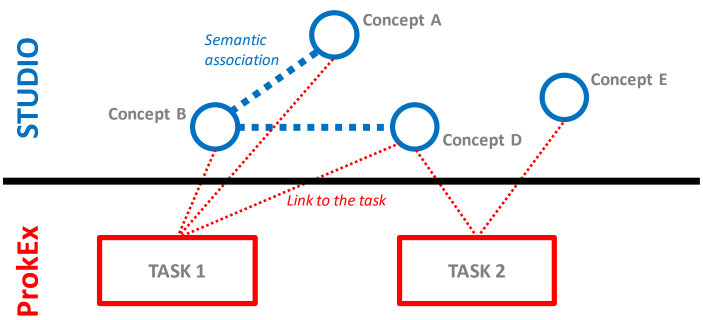

Figure 7-5 Relations in STUDIO Vs PROKEX

In Figure 7-5 is represented a Concept Group how is seen differently in STUDIO and PROKEX. In STUDIO we know that in a given Concept Group concepts relate through semantic relations (blue lines) while in PROKEX those concepts are known as associated (red lines) with the tasks.

Given the behaviour that we discussed in Chapter 7.2.6.1, it is possible that the task-taker failing the question related to Concept B will never be asked the question that is related to Concept D. The individual in this case, automatically fails both Task 1 and Task 2. If it was asked separately the questions related to Task 2 it could have passed Task 1 while failing Task 2. This could potentially happen that a limited knowledge in a particular domain can be ok for specific tasks and not sufficient in others.

We evaluated the possibility to customise the testing algorithm in STUDIO to overcome the potential failure, however despite was blueprinted (Weber and Vas, 2015) for different testing behaviours, in reality, this was never implemented in the platform. Also, as explained, STUDIO does not have the notion of the process dimension associated with the Concept Group. Adding this functionality means a substantial review of the application that goes far beyond the objectives of this thesis.

A theoretically viable alternative would have been to generate different Concept Groups for each task/activity. However, this would have meant asking the test takers to repeat the test several times and being asked the same overlapping question several times.

Given the low impact of this exception and the low feasibility of the alternative that could have mitigated it, we decided to take the risk. In the following Chapter 7.4 we, in fact, will conclude that the experiment was still able to deliver results despite some limitations that may be improved in further research or development of the STUDIO and PROKEX platforms.

7.2.6.3. Test Results

The results of the test were downloaded from STUDIO and stored in PROKEX in the table $IT \in \mathbb{B}^{11\times125}$ (Appendix 1i).

7.3. **"Knowledge Fit" elaboration**

We elaborate the "Knowledge Fit" and the "Knowledge Fit Score" as described in Chapter 4.4.3.

The matrix $IFit \in \mathbb{B}^{11\times125}$ is described in Appendix 1o is the only Fit table that is binary. We can see that the matrix is mainly constituted by ones and very few zeroes. This is because the meaning of the matrix is to pinpoint those concept that were supposed to be known and they are not. Therefore, we have ones anytime a concept is not needed by the individual or he knows the concept.

The Fit matrix at the Position level is $PFit \in \mathbb{R}^{6\times125}$ and is a matrix in the real numbers domain because each cell represents the average score for all the individuals that hold this position (Appendix 1p). In most of the cases (like for the individuals fit) the value will be 1 because the knowledge either is not required (in most of the cases) or every individual holding that position, score correctly in the test for this concept.

Similar is for the Fit matrix at the Role level $RFit\epsilon\mathbb{R}^{13\times125}$ (Appendix 1q) and the one at Activity level $AFit\epsilon\mathbb{R}^{56\times125}$ (Appendix 1r). Those are the average fit for all the individuals holding a specific role or working on a specific activity.

In the next chapter, we will analyse the Fit Scores and discuss the evidence. The Fit Score, however, is a synthetic indicator that needs to be analysed in conjunction with its reference Fit matrix.

7.4. Evidence from the "Knowledge Fit"

In this chapter, we are discussing the results of the "Knowledge Fit" elaboration not in a formal or IT perspective but rather from a business point of view. The objective is to see if the measurement can tell a story that is relevant from a management perspective. We will show that the results of the analysis will raise attention around people, organisation, processes and technology, corporate knowledge or the measurement system as anticipated in Chapter 5.6.2.

For this analysis, we will mainly use the functions Fit Score and Spare Score that we defined in Chapter 4.4.4.

Those functions create two vectors $FitScore, SpareScore \in \mathbb{R}^{n\times1}$ where n is the dimension of the topological vector (individuals, positions, roles or activity) that we would like to analyse.

7.4.1. Analysing the Fit at individuals level

We start the discussion of the results by analysing the Individuals Fit Score as represented in Figure 7-6.

The first column represents the name of the people who took the test. The following column indicates the number of concepts (of the overall 125 concepts in the Concept Group) that he/she is supposed to know as from the table IK (Appendix 1n) followed by the Fit Score and Spare Scores calculated using the equation described in Chapter 4.4.4.

Individuals	#	Fit Score	Spare Score
MAINTEINANCE2	33	0.67	0.40
Dispatcher2	57	0.42	0.49
Terminal3	27	0.78	0.66
Transportation2	62	0.45	0.62
Transportation1	62	0.65	0.79
Terminal1	27	0.78	0.59
Terminal2	27	0.81	0.44
Retail1	1	0.00	0.50
Wholesale1	3	0.33	0.69
Dispatcher1	57	0.44	0.47
Mainteinance1	33	0.64	0.42

Figure 7-6 Individuals Fit and Spare Score

In Chapter 6.1 we gave an overview of the organisation where we develop the business case. Further, we would like to give a brief description of the profiles of the test takers to give context to the following reasoning. For privacy reason, we will not disclose the name of the people (that are available for the evaluators separately), but we will use aliases.

Mainteinance2 is a Maintenance Manager working for IES for more than 10 years. He is a Mechanical Engineer coming from a position in refinery before this was closed. From the test, it results to be proper fitting the position is holding while does not score very well in other domains. This is connected to the fact that the domain relevant for maintenance are specific and not so much related to the same logic of distribution and logistics that are in scope of most of the other activities.

Dispatcher2 is the youngest among the test takers as he finished high school only two years ago. He joined IES recruited from the Race Track to work as a Dispatcher for the Racing and Agriculture fuel in one of IES subsidiaries for three months. His very junior in the position and that results from the result of the test showing that his orientation is not yet completed. He, however, results to be a bit stronger with technical related jobs as results from Figure 7-10. His flexibility is still limited, and this results from a relatively low Spare Score.

Terminal3 is not working in IES but in the MOL Head Quarter. He was tested because potentially can be a terminal manager although his specialisation is Operational Excellence. He is a Computer Engineer with an MBA and is working in the industry for 2 years. However he had previous experience as Logistics Manager among other positions he holds as specialist and manager. He has one of the highest fit that he makes him a potentially good candidate to hold that position. He has, on the other hand, a high spare score too, and this means that he is flexible to work in other positions. In fact, form Figure 7-10 we can assume that the Terminal Manager position has a high Fit

Score and a relatively high Spare Score too, therefore, there are other candidates that can hold this position and Terminal3 can eventually hold a position where competences are less available.

Transportation2 is a new Transportation Manager Assistant that joined IES 1 year ago. He has a degree in business and a brief two years' experience in the marketing department of a large consumer goods multinational company. Also, in this case, the lack of business experience is highlighted by the indicator. In this case, however, the Spare Score reflects a better fit in other positions those that anyways have several candidates holding the required knowledge. He would especially score best as a Terminal Manager. Indeed, he is now growing as a transportation expert that is a technical position where he can acquire the right competence for in the future move to a Terminal deputy manager position.

Transportation1 is with IES since he graduated from business 15 years before. He has been Secondary Distribution Transportation Manager the last five years. He is the individual who's scoring the overall best score in the test. However, in the position have an average fit. Looking at the following analysis at positions level, we see that in general, the results in this area are weaker than others. We will analyse this in the following Chapter 7.4.2. Transportation1 has a high Spare Score that is reflecting the long experience he has in the company. According to Figure 7-10 he is one of the few having for instance competence in retail and wholesale management.

Terminal1 is a new Terminal Manager in one of IES's subsidiaries. He did not go to university but has almost 20 years' experience in logistics even if it is the first time working in the oil business. Terminal1 has a high Fit Score and a relatively high Spare Score demonstrating he is a person with a good flexibility that is an essential attribute for a position of responsibility such as the Terminal Manager.

Similar conclusions can be drawn for Terminal2. He is Terminal Manager in IES for 4 years when they closed the refinery and left his position as shift leader of one of the refinery sections. Overall, he was working in oil and gas for 15 years since he graduated from chemical engineering. Terminal2 scores best in "Knowledge Fit" even if his flexibility as reported by the Spare Score is relatively low and this can be explained because his background is more technical than commercial. According to Figure 7-10, he also has the highest fit as Maintenance Manager.

Retail1 is Retail Manager in IES, and he is now managing the sale of the IES Retail network. He will therefore soon be reallocated in a different position. He graduated in business and was working as Filling Station Manager for 5 years before entering in this position 3 years ago. To understand the absolute low fit score, we will discuss further the Retail Manager Position and its roles in Chapters 7.4.2 and 7.4.3. Please note that there is only one concept required for the position as an outcome of the PROKEX iteration. For what concerns the Spare Score that is also low, must be said that the type of competencies needed in sales is very different from those that apply to logistics that is represented by this experiment.

Wholesale1 is IES Wholesale Manager for 10 years. He held a degree in business and was working in retail until 4 years ago. He has a low fit score too, and similar conclusion that we described for Retail1 can apply to Wholesale1 that on the other hand score better regarding Spare Score. The fundamental reason for this difference that retail works primarily with Business to Customer problems at the filling stations while Wholesale is much more integrated with the Terminal Operations.

Dispatcher1 is the Dispatcher for one of the subsidiaries that work mainly with the agriculture business. He works for IES since she left high school 15 years ago and she is deputy terminal manager, too. He has a low level of both Fit and Spare Score this may be a person that require formal training. In the next Chapter 7.4.2, we will discuss a bit the difference in score for the specific position.

Mainteinance1 is a Chemical Engineer working for IES for the last 30 years and now is the Chief Maintenance Manager. He is a very energetic person but very busy. We appreciate that he took the time for taking the test. His result is very similar to Terminal2's.

7.4.2. Analysing the Fit at the position level

When analysing the Fit and Spare Score about the position, we identify three categories of positions.

In the first category, we have Maintenance Managers and Terminal Managers. The Fit Score is high for both, and they are both associated with almost 30 concepts. Looking at the IP table in Appendix 1h we notice that they have at least two test-taker each. Further, from table RP in Appendix 1g, we see that the two positions for two third they share the same roles.

Positions	#	Fit Score	Spare Score
Dispatcher	57	0.43	0.48
Maintenance Manager	33	0.65	0.41
Retail Manager	1	-	0.50
Terminal Manager	27	0.79	0.56
Transportation Manager	62	0.55	0.71
Wholesale Manager	3	0.33	0.69

Figure 7-7 Positions Fit and Spare Score

In general, we can conclude that those two positions are adequately staffed, however from Figure 7-10 we can conclude that most of the test-takers were scoring slimily high despite those are the roles usually held by the most experienced people.

There are two main reasons for that: first of all, the BPM is not detailed enough, or the description is too generic that does not capture the complexity of the role. In this case, it is required to improve the description of the processes as suggested in section 5.6.2.4. The other reason is that those are managerial jobs where more than the knowledge is required the capacity to make decisions based on experience and organisational influence. Those are factors that knowledge only focused model like the one that this thesis is covering is not able to capture.

We see, on the other hand, that the Terminal Managers are resources that are very flexible and there is an opportunity for incorporating different roles that are suffering from missing competence and eventually delegate some activities to the Maintenance managers. This may happen with a simple reallocation of roles as described in section 5.6.2.2 or may require a redefinition of the processes as suggested in section 5.6.2.3.

The second group of positions are Dispatchers and Transportation Managers. According to the job description, the Transportation Manager should be able to perform the same role of the Dispatcher. Hierarchically the Dispatcher, in fact, is under the supervision of the Transportation Managers. The Fit Score resulting from the test is not particularly high. The number of concepts required for those positions is quite high and around 60.

Analysing the concepts that are related to these positions we identify few issues with the testing process and the business process. For instance, between Dispatcher and Transportation Manager, only one managed to reply correctly to the question related to *barges*. According to the testing modalities described in Chapter 7.2.6, the following questions around barges were not asked. This shows a potential for improving the testing process as advised in section 5.6.2.5. Further is not clear why the local IES procedures include a definition of either *rail* and *barge*: barge operations are related only to one of the locations where IES operates but it is out of scope in this exercise (see

Chapter 6.1), and no rail operations are happening at all. Requiring the knowledge of that concept is therefore not correct. As recommended in section 5.6.2.4 the documentation should be improved, and BPM should be more specific to the activities that are performed in each different site. Nevertheless, the results recommend that those individuals are holding those positions to increase specific competence as recommended in the Chapter 7.4.3.

In the last group of positions, we identify Wholesale and Retail Managers. The Fit Score, in this case, is unusually low. As a premise, we must clarify that the processes in the scope of this exercise are mainly logistics processes. The roles that are relevant to those positions are typically related to sales processes and only residually related to the logistics. It is not option therefore evaluate the fit for those positions and the individuals holding them. What is relevant, instead is to evaluate the Spare Score that shows that Wholesale1 have better possibility for being reallocated than Retail1. Further the analysis of the score can give some indication about the corporate knowledge: the knowledge required for those position consists of very few concepts. This require further elaboration of the description of the business process as suggested in section 5.6.2.4.

7.4.3. Analysing the Knowledge Fit at roles level

In the analysis of the Knowledge Fit and Spares Scores in Figure 7-8, I would like to clarify that the meaning of the Spare Score represents the possibility of enriching the role with new activities among the ones under evaluation described in section 5.6.2.2. In this context, there is a certain possibility with the business operation that on the other hand is connected to non-required knowledge. We saw already that considerable flexibility is held by the Terminal Managers and Maintenance Manager, but from this analysis results the possibility to use more flexibilities in some other roles like for instance local sales.

Roles	#	Fit Score	Spare Score
Business operation	0	-	0.61
Dispatcher / shift supervisor	47	0.48	0.58
Local Logistics person responsible for transportation	5	0.60	0.63
Local Retail	1	-	0.50
Local Sales	3	0.33	0.69
Local product storage management	3	0.47	0.56
Maintenance management	11	0.77	0.45
Operator	4	1.00	0.54
Quality Control	12	0.65	0.55
SSC	2	-	-
Scheduler	10	0.53	0.54
Technical execution	3	0.73	0.55
Terminal manager	5	0.87	0.60

Figure 7-8 Roles Fit and Spare Score

In this analysis, without repeating on what already discussed in the previous chapters, I would like to focus on few observations.

The low Fit Score and good Spare Score for the Dispatcher role is relevant for the position of the Dispatcher. IES is, in fact, planning two potential actions: on one side there are advanced discussions of outsourcing the truck fleet on which, however, the MOL Head Quarter is not very convinced. On the other hand, there is the possibility of introducing a scheduling tool that may strongly simplify the role of the dispatcher. In both cases, the "Knowledge Fit" supports the re-engineering of the process (as from section 5.6.2.3).

The second more evident conclusion is related to roles that have limited or null concepts connected. This will be more evident in Chapter 7.4.4 when we will see the fit at the activity level. At the role level, on the other hand, is visible the presence of a role SSC that have both Fit and Spare Scores zero. The reason is that this role is outsourced and therefore not associated with any position. In this thesis, we did not elaborate the optimisation at the level of allocation of *roles to positions*, but in Chapter 7.5, we propose an approach to optimise the allocation of *individuals to positions*. The same approach theoretical can highlight the possibility of insourcing this activity as suggested by section 5.6.2.3.

7.4.4. **Analysing the Knowledge Fit at activities level**

By reading the Figure 7-9, we can identify an extended number of activities that don't have associated any ontology concept.

Activities	#	Fit Score	Spare Score
100. Metrology	3	0.47	0.56
110.1.a Administrative return goods	0	-	0.61
110.1.b Physical Return goods handling	1	1.00	0.61
110.2. Off-spec product management	1	0.67	0.61
120. Reporting	1	1.00	0.61
Acceptance/transfer in tank	0	-	0.54
Calculating necessary transportation capacity	1	1.00	0.63
Checking loading conditions - Train	3	0.42	0.55
Checking loading conditions - Barge	1	0.50	0.54
Checking loading conditions - Road	2	0.63	0.54
Controlling the quality	4	0.63	0.54
Controlling the quantity - Barge	4	0.31	0.55
Controlling the quantity - Pipeline	1	1.00	0.54
Controlling the quantity - RTC	4	0.50	0.54
Controlling the quantity - RoTC	1	-	0.55
Create transportation plan for next day/shift	3	0.75	0.54
Defining optimal (target) replenishment inventory level	3	0.33	0.64
Ensure available capacity	0	-	0.63
Execution â€“ autonomous maintenance	0	-	0.61
Execution â€“ routine maintenance	3	0.73	0.55
Inspecting the vehicle	0	-	0.54
Inventory checking (FS & VMI accounts)	1	1.00	0.54
Inventory checking - managing data quality	0	-	0.54
Issuing the transport documents - Barge	1	-	0.55
Issuing the transport documents - Train	2	0.88	0.54
Issuing the transport documents-Road	1	1.00	0.54
Loading the transport means - Train	4	1.00	0.54
Loading the transport means - Barge	0	-	0.56
Loading the transport means -Road	0	-	0.56
Making preparations for product reception, reviewing the transport documents	2	0.83	0.61
Monitor FS (VMI) turnover	0	-	0.63
Notification	0	-	0.48
Order generation for filling stations (VMI accounts)	4	0.25	0.55
Plan-Fact evaluation, controlling	1	1.00	0.63
Planning and Scheduling	2	-	-
Quality control - Barge	0	-	0.56
Quality control - Train	9	0.53	0.56
Quality control- Road	3	1.00	0.55
Receiving Retail business plans, forecasted delivery volumes	0	-	0.50
Receiving Wholesale business plans, forecasted delivery volumes	1	-	0.69
Receiving actual information about delivery fulfilment from hauliers	0	-	0.54
Receiving customer orders, forwarding to R&S	2	0.50	0.68
Receiving daily inventory and sales reports from FSs (and other VMI accounts)	1	-	0.50
Receiving the transport means - Barge	0	-	0.54
Receiving the transport means - Train	6	0.71	0.53
Receiving the transport means-Road	3	1.00	0.53
Record keeping and registration in inventory	1	-	0.55
Sales forecasting	2	0.50	0.54
Sending confirmation of scheduled delivery time to the local Sales organisation and/or customers and/or FS	0	-	0.54
Sending information about transportation plans to haulers and/or terminals	0	-	0.54
Transferring the risk of product, registering the discharge - Train	1 1	0.23	0.57
Transferring the risk of product, registering the discharge - Barge	2	0.13	0.55
Transferring the risk of product, registering the discharge- Road	0	-	0.54
Unloading	0	-	0.56
Verification	5	0.70	0.47
Work order selection (RBWS)	6	0.83	0.46

Figure 7-9 Activities Fit and Spare Score

According to section 5.6.2.4 this requires a revision of the BPM description to increase details. On the other hand, a revision of the ontology may be also necessary to be sure that the ontology matching process identifies concepts described. In Chapter 7.2.4 we discussed some limitations related to the current ontology matching algorithm that could have impacted the poor association of concepts to certain task description in the BPR. This is an indication that an area where we need to further improve the measurement system (section 5.6.2.5). The fact is particularly interesting that for the activity *"Transferring the risk of product, registering the discharge"* is repeated for the different transportation means, but the matching is completely opposite to the actual need in the organisation. As discussed in Chapter 7.4.2 IES have no rail operations but the activity related to rail operations matches 11 concepts, have limited barge operations and matches 2 concepts and continuous road operations while matching no concept at all. This is a very serious misrepresentation of the formalised business process in comparison with the actual processes.

7.5. **Organisation optimisation**

In Chapter 5.6.3 we explained that a "brute-force" approach such as the full factorial experiment is not a suitable approach given its exponential complexity.

In accordance with the model that we built in Chapter 5.6.3 we applied the graph theory to solve the matching problem.

The IPFitTab that contains all the Fit Score values to all the associations between the IP

IPFitTab	Dispatcher	Maintenance Manager	Retail Manager	Terminal Manager	Transportation Manager	Wholesale Manager
MAINTEINANCE2	0.37	0.67	0.00	0.63	0.37	0.00
Dispatcher2	0.42	0.64	0.00	0.59	0.44	0.00
Terminal3	0.63	0.76	1.00	0.78	0.66	0.67
Transportation2	0.44	0.79	0.00	0.81	0.45	0.00
Transportation1	0.65	0.73	1.00	0.67	0.65	0.67
Terminal1	0.51	0.79	1.00	0.78	0.55	0.33
Terminal2	0.42	0.79	0.00	0.81	0.44	0.00
Retail1	0.35	0.76	0.00	0.74	0.37	0.00
Wholesale1	0.56	0.76	1.00	0.70	0.56	0.33
Dispatcher1	0.44	0.64	0.00	0.59	0.45	0.00
Mainteinance1	0.44	0.64	0.00	0.63	0.45	0.00
Average	**0.48**	**0.72**	**0.36**	**0.70**	**0.49**	**0.18**

Figure 7-10 Table of "Knowledge Fit" between individuals and positions

In creating the simulation scenario, we incorporate the requirement that the management indicated that there will no more be Retail. Therefore, the current scenario represents same positions than the original, but instead of a Retail Manager we have an additional Wholesale Manager. The matrix $\overline{\text{IPFitTab}} \in \mathbb{R}^{11\times 11}$ is represented in Figure 7-11.

IPFitTabBar	Terminal Manager	Maintenance Manager	Terminal Manager_1	Transportation Manager	Maintenance Manager_2	Dispatcher	Wholesale Manager	Terminal Manager_3	Transportation Manager_4	Dispatcher_5	Wholesale Manager_6
Transportation2	0.63	0.67	0.63	0.37	0.67	0.37	0.00	0.63	0.37	0.37	0.00
Transportation1	0.59	0.64	0.59	0.44	0.64	0.42	0.00	0.59	0.44	0.42	0.00
Terminal1	0.78	0.76	0.78	0.66	0.76	0.63	0.67	0.78	0.66	0.63	0.67
Terminal2	0.81	0.79	0.81	0.45	0.79	0.44	0.00	0.81	0.45	0.44	0.00
Retail 1	0.67	0.73	0.67	0.65	0.73	0.65	0.67	0.67	0.65	0.65	0.67
Wholesale 1	0.78	0.79	0.78	0.55	0.79	0.51	0.33	0.78	0.55	0.51	0.33
Dispatcher 1	0.81	0.79	0.81	0.44	0.79	0.42	0.00	0.81	0.44	0.42	0.00
Mainteinance1	0.74	0.76	0.74	0.37	0.76	0.35	0.00	0.74	0.37	0.35	0.00
Transportation2	0.70	0.76	0.70	0.56	0.76	0.56	0.33	0.70	0.56	0.56	0.33
Transportation1	0.59	0.64	0.59	0.45	0.64	0.44	0.00	0.59	0.45	0.44	0.00
Terminal1	0.63	0.64	0.63	0.45	0.64	0.44	0.00	0.63	0.45	0.44	0.00

Figure 7-11 $\overline{IPFitTab}$ *table for optimisation*

For the optimisation we used the Scipy linear sum assignment problem solver (Scipy Team, 2018).

The result matrix is in Figure 7-12.

IPBar	Terminal Manager	Maintenance Manager	Terminal Manager.1	Transportation Manager	Maintenance Manager.1	Dispatcher	Wholesale Manager	Terminal Manager.2	Transportation Manager.1	Dispatcher.1	Wholesale Manager.1
Transportation2	FALSE	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
Transportation1	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
Terminal1	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE	FALSE
Terminal2	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
Retail1	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	TRUE
Wholesale1	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
Dispatcher1	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE
Maintenance1	FALSE	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
Transportation2	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	TRUE	FALSE
Transportation1	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE
Terminal1	FALSE	FALSE	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE

Figure 7-12 $\overline{IP}$ matrix optimised

The optimised IP table is matching our formal expectation, but it also raises applicability concerns. As we were assuming in section 7.4.1 those individuals that were having the overall better score (including the Spare Score) generally the Terminal Manager has been allocated by the algorithm those the positions where the competence was less diffused.

Management expectation would have preferred those individuals to hold positions that are more critical. Among the highest profile positions only Mainteinance1 was reconfirmed in the position. On the other hand, those critical position were assigned to those with the overall profile weaker simply because the content for this positions were the more available.

8. Conclusions

To drive the conclusions of this research, I will take into consideration the following aspects:

- The fit to the purpose of this approach (how is it good in providing actionable information)
- Areas of further development for the approach and the technologies employed.

I will start by recall the Research Questions that were set at the beginning of this dissertation in Chapter 1.5.

For each of the questions I will show how the theoretical framework addressed it and the evidence from the business case that support the utility in the business environment.

In the last chapter I will derive some general conclusion about the architecture that we developed around the PROKEX framework and the STUDIO System to recommend areas of further developments and research.

8.1. Research Question 1: measurable knowledge capability

8.1.1. How can we determine the knowledge capability required by an organisation to run its processes?

To address this problem, we will propose a theoretical measurement framework that will provide a synthetic and analytical measurement of a "de facto" situation of a "Knowledge Fit" given a formal definition of the business processes, skill test results and formal organisational deployment. In this thesis, we emphasized determining what the level of analysis for which we should perform knowledge measures are.

8.1.2. Validation of the Research Question 1

In Chapter 4.4 we proposed a measurement framework namely "Knowledge Fit". This framework uses on one side the PROKEX approach to identify the required knowledge and on the other side uses STUDIO test environment to validate.

To validate the statement, I would like to clarify the following items related to the framework.

The "Knowledge Fit" introduces both analytical and synthetic indicators.

In Chapter 4.4.3 we defined an analytical measure of "Knowledge Fit" that aims to identify those knowledge elements - concepts - that we expect to have in a certain organisational level and are not present in the organisation. It is analytical because we can pinpoint directly what are the concepts that are not hold or partially hold. The scale is between 0 and 1: if all individuals that are accumulated at this level of analysis hold (because correctly answered to online testing) the concept the value is 1; if none hold the concept the value is 0.

The second measure types are the “Fit Scores” (Chapter 4.4.4) those measures from 0 to 1 how a specific topological element (individual, position, role or activity) holds the required knowledge. This is a synthetic indicator because for each topological element we obtain only one number that shows an average of the “Knowledge Fit”.

Like the “Fit Score”, the “Spare Score” is its complement: this synthetic indicator shows which part of the corporate knowledge not necessary for the topological element is, on the other hand hold. This is a measure of the flexibility.

Those indicators can be used at different level of the organisational deployment (see Chapter 4.4.1). The main elements of the organisational deployment are at the level of the *individuals*, the *positions*, the *roles* and the *activities*.

In Chapter 7.4 we demonstrated that the measures can address organisational issues and highlight possible interventions.

It is also possible to interpret differences between the measurements and put the measurement in context with other organisational measures such as experience, logistics and other not skill related attitudes.

Based on those consideration we conclude that the “Knowledge Fit” is a proper measure of “knowledge capability” in response to the Research Question 1.

8.2. Research Question 2: “Knowledge Fit” aware reorganisations

8.2.1. What are the possible approaches to validate a reorganisation with a knowledge capability perspective?

Answering this question requires to identify an operating system that supports the formalisation of the reorganisation and, at the same time support a systematic measure of the knowledge capability for the system. To develop this, we will show how semantic enabled BPM used in conjunction with the PROKEX system and the STUDIO semantic testing platform can provide a sound environment to support the organisational simulation. With the term reorganisation, we mean any change that impacts either people, processes or the organisation systems.

8.2.2. Validation of the Research Question 2

The proposed approach is described in Chapter 6 and validated in Chapter 7. This proposed approach lays on and extend the PROKEX approach as described in Chapter 5. Strength of this operating system is the possibility of translating from the Knowledge to the Process Domain to elicit implicit knowledge. In Chapter 5.6, we show how the "Knowledge Fit" plays an important role in closing the loop and support the process improvement of an organisation.

When validating this approach in Chapter 7, it results clear that organisational changes are complex activities that cannot be addressed only from a perspective. This is the reason of several failures in business process reengineering practices described in Chapter 3. We also saw that the more holistic is the approach the higher is the chance that the interventions are successful. It is also clear that so far there are not so many approaches that bind a process approach with the knowledge dimension. In Chapter 5.6.2 we described several ways the PROKEX approach thank to the "Knowledge Fit" measures can support the improvement of an organisation and its processes in an integrated framework. In Chapter 7.4 we highlighted them in a real case that the measure fits very well other reorganisation approaches and is a good support to recommend further.

8.3. Research Question 3: Automatic reorganisation

8.3.1. Is there any possibility for semi-automatic or automatic solution to optimize the allocation of people to perform business activities?

This third question is very connected to Research Question 2. In fact the framework that we are going to define on one side will provide knowledge indicators to support decisions at the topological level; at the same time may provide scenarios (using those indicators) that maximise the "Knowledge Fit" while variating the elements of the organisation.

By testing in a real case, we would like to highlight the pros and the limitation of an automatic solution that optimisation of the organisational deployment based on the maximisation of the "Knowledge Fit".

8.3.2. **Validation of the Research Question 3**

In Chapter 3.9 we introduced the process maturity as an indication of how close a process or organisation is to be complete and capable of continual improvement through qualitative measures and feedback (Srinivasan and Murthy, 2012; Boutros and Cardella, 2016). The levels of those maturity models are:

- Level 1 – Documented Process
- Level 2 – Partial Deployment
- Level 3 – Full Deployment
- Level 4 – Measured and Automated
- Level 5 – Continuously Improving

While structured companies are struggling to move from Level 2 to Level 3, the PROKEX is a framework that helps organisation to move toward Level 4 and 5.

The Chapter 5.6.3 suggests that an approach to automatic organisational deployment is theoretically possible based on minimising a knowledge cost function and therefore confirming the Research Question 3.

In Chapter 7.5, however, we showed that the model automatically created based on a mere knowledge dimension is not able to recommend a proper solution. This does not show that the approach is not valid in all context. Further research is necessary for proving this. Certainly, in a context where the experience is at least as important as the skills, there is a geographical dimension to be considered and where the job attractivity is playing a relevant role like in the business case that we have developed in Chapter 7 is clear that only the "Knowledge Fit" is not able to support automatic organisation deployment.

8.4. **Further Development**

This thesis reached the goal of demonstrating that the "Knowledge Fit" is a promising measure that can be used to move an organisation to a systematic evaluation of its knowledge requirements and deployment.

There are some areas that we foresee further developments in the domain of the "Knowledge Fit" aware process reorganisation and of the PROKEX and STUDIO platforms.

8.4.1. Developments in “Knowledge Fit” aware reorganisation

It is clear from Chapter 7.5 and from the conclusions in 8.3.2 that the most important limitation of the model is related to the fact that an organisational intervention requires a holistic approach. We see therefore a future development in analysing the approach we adopted integrating the different dimensions including logistics, experience, attitude.

We saw that the graph theory fits the problem of optimisation at the level of the allocation of the individuals to positions. An area of research is to identify promising approaches for the optimisation in allocation of roles to positions and creation of roles from the activities.

8.4.2. Developments for the PROKEX and STUDIO platforms

The experiment described in Chapter 7.2 highlights several limitations of the PROKEX platform and the STUDIO approach.

The most important drawback is that for the time being the PROKEX is not integrated in an automated workflow but is rather a collection of ad hoc scripts. It would require its implementation in a full application more integrated with the STUDIO platform.

In Chapter 7.2.5 we largely debate that the missing integration of the process dimension in STUDIO is a limitation for this integration.

STUDIO on the other hand is presenting as an enterprise application and in this thesis, we highlighted the potential of integrating it in an enterprise architecture. On the other hand, the software architecture is rather monolithic. We recommend a profound re-factory to increase the external interoperability.

A critical aspect that is discouraging a broader STUDIO adoption as knowledge base system is the complexity of ontology maintenance. To improve it a proper workflow should be developed.

Further studies must be developed to increase the level of automatization of the ontology matching step. The contradicting results of the experiments described in Chapter 6.4.3 and in Chapter 7.2.4 recommend specific research either to develop a full automatic or at least a semi-automatic approach.

Last part that requires further development is the testing. The current STUDIO release has one testing approach developed and hard-coded. This limits the flexibility of the platform and the adaptation to different test approaches and experimentation. The redesign of the testing module towards a more modular integration would be preferred.

Finally, at the current stage the test is biased by different difficulties among the questions of the different nodes. In this context two actions can be performed. The first include the definition a framework for evaluating the difficulties of the questionnaires and adapt to the learning style of the test taker. The second one is to include the question complexity in the “Knowledge Fit” model.

8.5. **Acknowledgments**

My deep thanks for the support in the long development of my research to Dr. András Gábor, his help was certainly going beyond the required for his supervisor role and he provided me with encouragement, ideas insights and motivation in our weekly consultation for several years in person or remote.

My thanks are particularly for IES Italiana Energia e Servizi S.p.a. and its staff for providing me the with a relevant business case to prove my research thesis.

Special thanks go to Gábor Neusch for the support in the integration with the STUDIO platform.

I would like to thank Gergő Tóth his expertise of operating research helped me to identify the right approach to the optimisation problem.

Thanks to Dorina Jamniczky for the patience, love and support in this long journey including helping me dealing with the Hungarian language.

Thanks to my family especially my parents for being a role model in my education.

Many thanks to the companies I was working while I was participating in this PhD for the support: the European Institute of Innovation and Technology (EIT), The University College Dublin (UCD) and MOL Plc.
Finally my thanks to the Hungarian people that accepted me as welcome immigrant for the last six years.

References

4C4Learn (no date). Available at: http://www.4c4learn.de/ (Accessed: 14 August 2018).

Akao, Y. (2004) *Quality Function Deployment: Integrating Customer Requirements Into Product Design*, *Productivity Press*. Productivity Press. Available at: https://books.google.hu/books/about/Quality_Function_Deployment.html?id=NS1Cuw6UQKIC&redir_esc=y (Accessed: 1 April 2017).

Allen, P. *et al.* (2006) *Service Orientation: Winning Strategies and Best Practices*. Cambridge University Press.

Alvesson, M. and Sköldberg, K. (1994) *Tolkning och reflektion: vetenskapsfilosofi och kvalitativ metod.*, *Studentlitteratur*. Lund.

Amaral, J. N. *et al.* (2011) *About Computing Science Research Methodology*. doi: 10.1.1.124.702.

Archer, R., Bowker, P. and Bowker, P. (2006) 'BPR consulting : an evaluation', *Business Process Re-engineering & Management Journal*, 1(2), pp. 28–46. doi: 10.1108/14637159510798266.

Arena, D. *et al.* (2017) 'Human resource optimisation through semantically enriched data', *International Journal of Production Research*, (December 2017), pp. 1–23. doi: 10.1080/00207543.2017.1415468.

Arias, M. *et al.* (2018) 'Human resource allocation in business process management and process mining', *Management Decision*, 56(2), pp. 376–405. doi: 10.1108/MD-05-2017-0476.

Armistead, C. G. and Rowland, A. P. (1996) *Managing business processes: BPR and beyond*. John Wiley & Son Ltd.

Arru, M. (2014) 'Application of process ontology to improve the funding allocation process at the European Institute of Innovation and Technology', *Lecture Notes in Computer Science (including subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics)*. Edited by A. Kő and E. Francesconi. Springer Verlag, 8650 LNCS, pp. 133–147. doi: 10.1007/978-3-319-10178-1_11.

Arru, M. (2016) 'Developing a Measure of Intellectual Capital fit : an Approach to Improve Business Processes', in *European Conference on Intellectual Capital*. Kidmore End: Academic Conferences International Limited, pp. 382–393. Available at: http://search.proquest.com/docview/1803415572?accountid=14507.

Arru, M. (2019) 'Business Processes and Knowledge Management: a Marriage of Convenience for the Fluid Organisation's process improvement', *SEFBIS Journal. John v Neumann Computer Society*, 13, p. 12.

Arru, M., Teeling, S. P. and Igoe, A. (2016a) *Managing the Change*, *Lean Six Sigma Green Belt for Health Sector - NMHS32280 - Course Presentation*.

Arru, M., Teeling, S. P. and Igoe, A. (2016b) *Understanding Customer Requirements*, *Lean Six Sigma Green Belt for Health Sector - NMHS32280 - Course Presentation*. Dublin.

Arru, M., Teeling, S. P. and Igoe, A. (2016c) *Value Stream Mapping Current State*, *Lean Six Sigma Black Belt Theory - NMHS43400 - Course Presentation*. Dublin.

Atkinson, H. (2006) 'Strategy implementation: a role for the balanced scorecard?', *Management Decision*, 44(10), pp. 1441–1460. doi: 10.1108/00251740610715740.

Aviso, K. B. B. *et al.* (2018) 'Allocating human resources in organizations operating

under crisis conditions: A fuzzy input-output optimization modeling framework', *Resources, Conservation and Recycling*, 128(8), pp. 250–258. doi: 10.1016/j.resconrec.2016.07.009.
Babbie, E. R. (2015) *The practice of social research*. 14 th. Cengage Learning.
Badaracco, M. and Martínez, L. (2013) 'A fuzzy linguistic algorithm for adaptive test in Intelligent Tutoring System based on competences', *Expert Systems with Applications*, 40(8), pp. 3073–3086. doi: 10.1016/j.eswa.2012.12.023.
Bal, J. (1998) 'Process analysis tools for process improvement', *The TQM Magazine*, 10, pp. 342–354. doi: 10.1108/09544789810231225.
Balaton, K. and Dobák, M. (1982) 'Mennyiségi es minőségi módszerek az empirikus szervezetkutatásban', *Egyetemi Szemle*, 4(1/2), pp. 87–101. Available at: http://www.jstor.org/stable/41484631.
Barbosa, J. L. V. *et al.* (2015) 'DeCom: A model for context-aware competence management', *Computers in Industry*. Elsevier, 72, pp. 27–35. doi: 10.1016/j.compind.2015.03.012.
Barrett, J. L. (1994) 'Process visualization - Getting the Vision right is key', *Information Systems Management*, 11(2), p. 14. Available at: http://search.ebscohost.com.ucd.idm.oclc.org/login.aspx?direct=true&db=bth&AN=9706096727&site=ehost-live.
Bartlett, C. A. and Ghoshal, S. (1995) 'Rebuilding Behaviour Contex: Turn Process Reengineering into People Rejuvenation', *Sloan Management Review*, 37(1), pp. 11–23. Available at: http://search.proquest.com/docview/224970589?accountid=14507.
Bauer, F. L. and Wössner, H. (1972) 'The "Plankalkül" of Konrad Zuse: a forerunner of today's programming languages', *Communications of the ACM*, 15(7), pp. 678–685. doi: 10.1145/361454.361515.
Becker, G. S. (1993) *Human capital: a theoretical and empirical analysis, with special reference to education*. 3rd edn. Chicago: The University of Chicago Press.
Bel, E. J. van., Sander, E. and Weber, A. (no date) *Follow That Customer! : The Event-Driven Marketing Handbook*.
Benbasat, I., Goldstein, D. K. D. K. and Mead, M. (1987) *The Case Research Strategy in Studies of Information Case Research*, *Management Information Systems Quarterly*. doi: 10.2307/248684.
Bennis, W. (1992) *Leaders on leadership: interviews with top executives*. Harvard Business School Press.
Bernus, P. (2006) 'Business process modeling through the knowledge management perspective', 10(3), pp. 40–56. doi: 10.1108/13673270610670849.
Bird, S. *et al.* (2009) *Natural Language Processing with Python*. O'Reilly.
Blattberg, R. C., Getz, G. and Thomas, J. S. (2001) *Customer Equity: Building and Managing Relationship as Valuable Assets*. Harvard Business Review Press.
BOC Products & Services AG (2016) 'ADONIS Pro'. Vienna. Available at: http://en.adonis-community.com/welcome/legal/.
Bohlouli, M. *et al.* (2015) 'An Adaptive Model for Competences Assessment of IT Professionals', in *Integrated Systems: Innovations and Applications*. Cham: Springer International Publishing, pp. 91–110. doi: 10.1007/978-3-319-15898-3_6.
Bohlouli, M. *et al.* (2017) 'Competence assessment as an expert system for human resource management: A mathematical approach', *Expert Systems with Applications*. Elsevier Ltd, 70, pp. 83–102. doi: 10.1016/j.eswa.2016.10.046.
Boutros, T. and Cardella, J. (2016) *The basics of process improvement*. Productivity

Press.
Boutros, T. and Purdie, T. (2014) 'The process improvement handbook: a blueprint for managing change and increasing organizational performance', (May), p. 382.
Brandmeier, M. *et al.* (2017) 'Development of an ontology-based competence management system', in *2017 IEEE 15th International Conference on Industrial Informatics (INDIN)*. IEEE, pp. 601–608. doi: 10.1109/INDIN.2017.8104840.
Van Breda-Verduijn, H. and Heijboer, M. (2016) 'Industrial and Commercial Training Learning culture, continuous learning, organizational learning anthropologist', *Industrial and Commercial Training Iss Journal of Workplace Learning*, 48(3), pp. 123–128. doi: 10.1108/ICT-11-2015-0074.
Brewster, C. and O'Hara, K. (2004) 'Knowledge representation with ontologies: the present and future', *IEEE Intelligent Systems*, 19(1), pp. 72–81. doi: 10.1109/MIS.2004.1265889.
Brian Harrison, D. and Pratt, M. D. (1993) 'A Methodology for reengineering businesses', *Planning Review*, 21(2), pp. 6–11. doi: 10.1108/eb054403.
Brooking, A. (1996) *Intellectual Capital: Core asset for the third millennium*. 1st edn. Cengage Learning.
Bruss, L. R. and Roos, H. T. (1993) 'Operations, readiness, and culture: don't reengineer without considering them.', *Inform*, p. 57.
Burke, G. and Peppard, J. (1995) *Examining Business Process Re-engineering: Current Perspectives and Research Directions*, *Strategic Change*. John Wiley & Sons, Ltd. doi: 10.1002/(SICI)1099-1697(199701)6:1<57::AID-JSC257>3.0.CO;2-A.
Burton-Jones J.C., A. S. (2011) *The Oxford Handbook of Human Capital*. Edited by A. Burton-Jones and J. -C. Spender. Oxford University Press. doi: 10.1093/oxfordhb/9780199532162.001.0001.
Business Architecture Guild (2013) *A Guide to the Business Architecture Body of Knowledge™ - part 1*. 4.1, *Business Architecture Guide*. 4.1. Available at: www.businessarchitectureguild.org%5Cn.
Cano, E. L., Moguerza, J. M. and Redchuk, A. (2012) *Six Sigma with R*, *Appl. Spat. Data Anal. with R*. New York, NY: Springer New York. doi: 10.1007/978-1-4614-3652-2.
Carr, D. K. and Johansson, H. J. (1995) *Best practices in reengineering: What works and what doesn't work in the reengineering process.* New York: McGraw-Hill.
Carrillo, P. M. *et al.* (2003) 'IMPaKT : a framework for linking knowledge management to business performance', *Electronic Journal of Knowledge Management*, 1(1), pp. 1–12. Available at: http://ejkm.com.
Cetis (2007) *IEEE-RCD - InLOC*. Available at: http://www.cetis.org.uk/inloc/IEEE-RCD (Accessed: 30 August 2018).
Champy, J. and Cohen, L. (1995) *Reengineering management*. London: Harper Collins. Available at: http://altfeldinc.com/pdfs/ReengineeringManagement.pdf (Accessed: 27 November 2016).
Chan, S. L. and Choi, C. F. (1997) 'A conceptual and analytical framework for business process reengineering', *International Journal of Production Economics*, 50(2–3), pp. 211–223. doi: 10.1016/S0925-5273(97)00042-X.
Chang, R. Y. (1994) 'Improve processes, reengineer them, or both', *Training & Development*, 48(3), pp. 54–58. Available at: http://search.ebscohost.com/login.aspx?direct=true&db=buh&AN=8561081&site=ehost-live.
Chen, L. F. and Chien, C. F. (2011) 'Manufacturing intelligence for class prediction and rule generation to support human capital decisions for high-tech industries',

Flexible Services and Manufacturing Journal. Springer US, 23(3), pp. 263–289. doi: 10.1007/s10696-010-9068-x.
Chien, C.-F. and Chen, L.-F. (2008) 'Data mining to improve personnel selection and enhance human capital: A case study in high-technology industry', *Expert Systems with Applications*. Pergamon, 34(1), pp. 280–290. doi: 10.1016/j.eswa.2006.09.003.
Chien, T.-H., Lin, Y.-I. and Tien, K.-W. (2013) 'Agent-based negotiation mechanism for multi-project human resource allocation', *Journal of Industrial and Production Engineering*. Taylor & Francis, 30(8), pp. 518–527. doi: 10.1080/21681015.2013.861521.
Cimiano, P. and Staab, S. (2004) 'Learning by googling', *ACM SIGKDD Explorations Newsletter*, 6(2), pp. 24–33. doi: 10.1145/1046456.1046460.
Cobo, M. J. *et al.* (2015) '25 years at Knowledge-Based Systems: A bibliometric analysis', *Knowledge-Based Systems*, 80, pp. 3–13. doi: 10.1016/j.knosys.2014.12.035.
Cole, R. E. (1994) 'Reengineering the Corporation: A Review Essay', *Quality Management Journal*, 1(4), pp. 77–85. Available at: http://asq.org/qic/display-item/index.pl?item=12057.
Costin, A. A. (2008) 'Discovering a project', in *Managing Difficult Projects*. Elsevier, pp. 1–16. doi: 10.1016/B978-0-7506-8591-7.00001-5.
Coulson-Thomas, C. J. (1993) 'Corporate Transformation and Business Process Re-engineering', *Executive Development*, 6(1), p. 14. doi: 10.1108/09533239310026888.
Currid, C. (1996) *The reengineering toolkit: 15 tools and technologies for reengineering your organization*. Prima Lifestyles.
Cypress, M. L. (1994) 'Re-engineering.', in *OR/MS Today*. Catonsville, MD: Institute for Operations Research and the Management Science, pp. 18–29. Available at: https://www.informs.org/ORMS-Today.
D'Aveni, R. A. and Gunther, R. (2007) 'Hypercompetition. Managing the Dynamics of Strategic Maneuvering', in *Das Summa Summarum des Management*. Wiesbaden: Gabler, pp. 83–93. doi: 10.1007/978-3-8349-9320-5_8.
Danermark, Berth; Ekstrom, Mats; Jakobsen, Liselotte; Karlsson, J. (2002) *Explaining Society: Critical Realism in the Social Sciences*. Routledge. Available at: https://books.google.hu/books?id=uw6N9nQc5TsC&dq=Explaining+Society:+An+Introduction+to+Critical+Realism+in+the+Social+Sciences&lr=&source=gbs_navlinks_s (Accessed: 26 March 2017).
Darnton, G. (2002) 'Modelling Requirements and Architecting Large-Scale On-Line Competence-Based Learning Systems', *Proceedings of IEEE International Conference on Advanced Learning Technologies (ICALT 2002), . pp. Available at:*, pp. 170–174. Available at: http://lttf.ieee.org/icalt2002/proceedings/t411_icalt119_End.pdf (Accessed: 16 August 2018).
Davenport, T. H. (1993a) 'Need radical innovation and continuous improvement? Integrate process reengineering and TQM', *Planning Review*, 21(3), pp. 6–12. doi: 10.1108/eb054413.
Davenport, T. H. (1993b) 'Selecting Processes for Innovation', *Process Innovation: Reengineering Work Through Information Technology*, pp. 27–36. doi: 10.5465/AME.1993.9411302338.
Davenport, T. H. and Short, J. E. (1990) 'The New Industrial Engineering: Information technology and business process redesign', *Sloan management review*, 31(4),

pp. 11–27. doi: 10.1007/978-1-4614-6067-1.
Davis, S. M. (1984) *Managing Corporate Culture*. Ballinger Pub. Co.
Day, G. S. (1994) 'The Capabilities of Market-Driven Organizations', *Journal of Marketing*, 58(4), p. 37. doi: 10.2307/1251915.
Deming, W. E. (1950) 'Statistical Product Quality Administration', in Haga, T. (ed.) *Hakone Convention Center*. Tokyo. Available at: http://hclectures.blogspot.hu/1970/08/demings-1950-lecture-to-japanese.html (Accessed: 5 November 2016).
Deming, W. E. (2000) *The new economics : for industry, government, education*. MIT Press.
Department for Business Enterprise and Regulatory Reform (2007) *Guidelines for managing projects*. London: Crown Business. Available at: http://webarchive.nationalarchives.gov.uk/20090609003228/http://www.berr.gov.uk/files/file40647.pdf.
Dictionaries, O. and Oxford Dictionaries (2010) 'process.', in *Oxford Dictionary of English*. 2nd edn. Oxford, UK: Oxford University Press., p. Kindle Locations 560001-560002. Available at: http://www.oxforddictionaries.com/definition/english/process.
Dombrowski, U. and Mielke, T. (2013) 'Lean Leadership - Fundamental principles and their application', in *Procedia CIRP*. Elsevier, pp. 569–574. doi: 10.1016/j.procir.2013.06.034.
Dubois, A. and Gadde, L. E. (2002) 'Systematic combining: An abductive approach to case research', *Journal of Business Research*, 55(7), pp. 553–560. doi: 10.1016/S0148-2963(00)00195-8.
Dubois, D. D. (1998) *The Competency Casebook*. HRD Press.
Duffy, D. (1994) 'Managing the white space (cross-functional processes).', *Management*, April, pp. 35–36.
Earl, M. and Khan, B. (1994) 'How new is business process redesign?', *European Management Journal*. Pergamon, 12(1), pp. 20–30. doi: 10.1016/0263-2373(94)90043-4.
Eccles, R., Nohria, N. and Berkley, J. D. (1992) *Beyond the Hype: Rediscovering the Essence of Management.* 1st edn. Harvard Business School Press.
Edvinsson, L. and Malone, M. S. (1997) *Intellectual Capital: Realizing Your Company's True Value by Finding Its Hidden Brainpower*. 1st edn. London: HarperBusiness.
Eisenhardt, K. M. (1989) 'Building Theories from Case Study Research.', *Academy of Management Review*, 14(4), pp. 532–550. doi: 10.5465/AMR.1989.4308385.
Emami, F. (2017) *Application of Competency Management System in Safety Performance: A Case Study of a Canadian Structural Steel and Erection Industry*. University of Alberta.
Ermilova, E. and Afsarmanesh, H. (2007) 'Modeling and management of profiles and competencies in VBEs', *Journal of Intelligent Manufacturing*, 18(5), pp. 561–586. doi: 10.1007/s10845-007-0066-0.
European Council Presidency (no date) *Lisbon European Council 23-24.03.2000: Conclusions of the Presidency*. Available at: http://www.europarl.europa.eu/summits/lis1_en.htm (Accessed: 19 March 2017).
Evans, M. M. and Ali, N. (2013) 'Bridging knowledge management life cycle theory and practice', in *International Conference on Intellectual Capital, Knowledge Management and Organisational Learning ICICKM 2013--Conference*

Proceedings, pp. 156–165. Available at: https://books.google.hu/books?id=mZ4TBAAAQBAJ&lpg=PA156&ots=ywLtz8dpas&dq=Evans%2C M. M. and Ali%2C N. (2013) 'Bridging knowledge management life cycle theory and practice'%2C International Conference on Intellectual Capital%2C Knowledge Management and Or.

Evers, A. T. *et al.* (2011) 'An Organizational and Task Perspective Model Aimed at Enhancing Teachers' Professional Development and Occupational Expertise', *Human Resource Development Review*, 10(2), pp. 151–179. doi: 10.1177/1534484310397852.

FASB (1999) *Preliminary Views on Major Issues Related to Reporting Financial Instruments and Certain Related Assets and Liabilities at Fair Value*. Financial Accounting Standards Board of the Financial Accounting Foundation (Financial accounting series). Available at: https://books.google.hu/books?id=YoorAAAAYAAJ.

Fazel-Zarandi, M. and Fox, M. S. (2012) 'An ontology for skill and competency management', in *Frontiers in Artificial Intelligence and Applications*, pp. 89–102. doi: 10.3233/978-1-61499-084-0-89.

Fazel-Zarandi, M. and Fox, M. S. (2013) 'Inferring and Validating Skills and Competencies over Time', *Applied Ontology*, 0, pp. 1–32. doi: 10.3233/AO-130126.

Fernandes, K. J., Raja, V. and Whalley, A. (2006) 'Lessons from implementing the balanced scorecard in a small and medium size manufacturing organization', *Technovation*, 26(5–6), pp. 623–634. doi: 10.1016/j.technovation.2005.03.006.

Forster, F. (2006) 'The Idea behind Business Process Improvement: Toward a Business Process Improvement Pattern Framework', *BPTrends*, (1999), pp. 1–13.

Furey, T. R. (1993) 'A six-step guide to process reengineering', *Planning Review*, 21(2), pp. 20–23. doi: 10.1108/eb054407.

Gábor, A. *et al.* (2013) 'Compliance Check in Semantic Business Process Management', *OTM 2013 Workshops,*. Edited by Y. T. Demey and H. Panetto. Berlin: Springer Verlag, pp. 353–362.

Gábor, A. *et al.* (2016) *Corporate Knowledge Discovery and Organizational Learning*. Edited by A. Gábor and A. Kő. ham: Springer International Publishing (Knowledge Management and Organizational Learning). doi: 10.1007/978-3-319-28917-5.

Gábor, A. and Arru, M. (2014) 'Process Oriented Knowledge Transfer in the Public Administration', in *International Scientific-Practical Conference 'Smart Government: Science and Technology'*. Astana, Kazakhstan: ACM Press, pp. 179–184.

Gábor, A. and Szabó, Z. (2013) 'Semantic Technologies in Business Process Management', in *Integration of Practice-Oriented Knowledge Technology: Trends and Prospectives*. Berlin, Heidelberg: Springer Berlin Heidelberg, pp. 17–28. doi: 10.1007/978-3-642-34471-8_2.

Gadd, K. W. and Oakland, J. S. (1996) 'Chimera or Culture? Business Process Reengineering for Total Quality Management', *Quality Management Journal*. American Society for Quality, 3(3), pp. 50–51. Available at: https://secure.asq.org/perl/msg.pl?prvurl=http://asq.org/data/subscriptions/qmj_open/1996/april/qmjv3i3gadd.pdf (Accessed: 30 September 2016).

Gaeta, M. *et al.* (2012) 'A Semantic Approach for Improving Competence Assessment in Organizations', *Advanced Learning Technologies (ICALT), 2012 IEEE 12th International Conference on*, pp. 85–87. doi: 10.1109/ICALT.2012.168.

Galliers, R. (1992) *Information Systems Research: Issues, Methods and Practical Guidelines*. Alfred Waller Ltd.
Gilbert, T. F. (1996) *Human Competence: Engineering Worthy Performance*. Pfeiffer.
Gillani, S. A. and Kő, A. (2014) 'Process-Based Knowledge Extraction in a Public Authority: A Text Mining Approach', in *Electronic Government and the Information Systems Perspective*. Springer, pp. 91–103. doi: 10.1007/978-3-319-10178-1_8.
Giordani Da Silveira, W. *et al.* (2013) 'Development of guidelines to base Hoshin Kanri application', in *22nd International Conference on Production Research, ICPR 2013*. Available at: http://www.scopus.com/inward/record.url?eid=2-s2.0-84929359678&partnerID=tZOtx3y1.
Gkoumas, D., Gausz, B. and Vas, R. (2016) 'an Analysis of Learning Behaviour and Patterns in a Technology-Enhanced', in *AIS SIGED 2016 Conference*.
Gkoumas, D. and Vas, R. (2017) 'Topic Models to Contextualize and Enhance Text-Based Discourses Using Ontologies', in *The International Workshop on Knowledge Extraction and Semantic Annotation KESA 2017*. Venice, Italy: IARIA XPS Press.
Gluck, F., Kaufman, S. and Walleck, A. S. (1982) 'The Four Phases of Strategic Management', *The Journal of Business Strategy*, 2(3), pp. 9–21. doi: 10.1108/eb040197.
Goodwin, K. (2009) *Designing for the digital Age*, *Indiana: Wiley*. Wiley Pub. doi: 10.1075/idj.19.3.09ehr.
Gordeev, B., Baraniuc, O. and Kashevnik, A. (2016) 'Web-Based Competency Management System for Technopark of ITMU University', in *Proceeding of the 18Th Conference of Fruct Association*, p. 2.
Goss, T., Pascale, R. and Athos, A. (1993) 'The Reinvention Roller Coaster: Risking the Present for a Powerful Future', *Harvard Business Review*, 71, pp. 97–108. Available at: http://ezproxy.lib.monash.edu.au/login?url=http://search.ebscohost.com/login.aspx?direct=true&db=bth&AN=9402241879&site=ehost-live&scope=site.
Grover, V. and Malhotra, M. K. (1997) 'Business process reengineering: A tutorial on the concept, evolution, method, technology and application', *Journal of Operations Management*, 15(3), pp. 193–213. doi: 10.1016/S0272-6963(96)00104-0.
Gruber, T. R. (1993) 'A translation approach to portable ontology specifications', *Knowledge Acquisition*, 5(2), pp. 199–220. doi: http://dx.doi.org/10.1006/knac.1993.1008.
Grüninger, M. and Menzel, C. (2003) 'The process specification language (PSL) theory and applications', *AI Magazine*, 24(3), pp. 63–74. doi: 10.1609/aimag.v24i3.1719.
Guha, S., Kettinger, W. J. and Teng, J. T. C. (1993) 'Business Process Reengineering', *Information Systems Management*, 10(3), pp. 13–22. doi: 10.1080/10580539308906939.
Gulden, G. K. and Reck, R. H. (1992) 'Combining quality and reengineering efforts for process excellence.', *Information Strategy: The Executive's Journal*, 10(1), pp. 10–16.
Gupta, S., Sharma, M. and Sunder M., V. (2016) 'Lean services : a systematic review', *International Journal of Productivity and Performance Management*, 65(8), pp. 1025–1056. doi: 10.1108/IJPPM-02-2015-0032.
Hagel, J. I. (1993) 'Keeping CPR on track', *The McKinsey Quarterly*, p. 59. Available

at:
http://ucd.summon.serialssolutions.com/#!/search?bookMark=ePnHCXMwTV09C8IwEO3g4AdurkJxlYDGfHijFEVwEekeLmnaQahD9P9719biEgg5QuDg7r1cLm-eLZHfZrfvroermnQVXiv0AdR0vN43GmbZ6hYjNwXlxf2Rv9qcqH14LrLyci6Lqxi0AERz1CCkQcpsUaPX3khECRVCICqBCq3c0TxgrCx_NwdeWS0Deu-DAlXL2.
Hall, G., Wade, J. and Rosenthal, J. (1993) 'How to make reengineering really work', *Harvard Business Revue*, 71(6), pp. 119–132. doi: 10.1225/93604.
Hamel, G. and Prahalad, C. K. (1990) 'Corporate imagination and expeditionary marketing.', *Harvard Business Review Press*, 69(4), pp. 81–89.
Hamel, G. and Prahalad, C. K. (1994) *Competing for the future*. Harvard Business School Press.
Hammer, M. (1990) 'Reengineering Work: Don't Automate, Obliterate.', *Harvard Business Review*, 68(4), pp. 104–112. doi: 10.1225/90406.
Hammer, M. (1991) 'Why we need both continuous and discontinuous improvement', *Perspectives on the Management of Information Technology*, 8(1), pp. 6–7.
Hammer, M. (1996) *Beyond Reengineering: How the Process-Centered Organization Is Changing Our Work and Our Lives*. HarperBusiness.
Hammer, M. and Champy, J. (1993) 'Reengineering the Corporation: A Manifesto for Business Revolution', *JONA: The Journal of Nursing Administration*. New York: HarperBusiness, 18(11), p. 65. Available at: http://search.ebscohost.com/login.aspx?direct=true&db=bth&AN=9086610&site=ehost-live%5Cnhttp://content.ebscohost.com/ContentServer.asp?T=P&P=AN&K=9086610&S=R&D=bth&EbscoContent=dGJyMMvl7ESep7A4y9f3OLCmr0yep7JSr664S7CWxWXS&ContentCustomer=dGJyMPGutk6wp7BNu.
Al Hanaei, E. H. and Rashid, A. (2014) 'DF-C2M2: A Capability Maturity Model for Digital Forensics Organisations', in *2014 IEEE Security and Privacy Workshops*. IEEE, pp. 57–60. doi: 10.1109/SPW.2014.17.
Harland, T. (2014) 'Learning about case study methodology to research higher education', *Higher Education Research & Development*, 33(6), pp. 1113–1122. doi: 10.1080/07294360.2014.911253.
Harmon, P. and Wolf, C. (2016) 'The State of Business Process Management', *A BPTtrends Report*. Available at: http://www.bptrends.com/bpt/wp-content/surveys/2012-_BPT SURVEY-3-12-12-CW-PH.pdf.
Harrington, H. J. (1991) 'Improving business processes', *The TQM Magazine*, 3(1). doi: 10.1108/eb059514.
Harrington, H. J. (1998) 'Performance improvement: the rise and fall of reengineering', *The TQM Magazine*, 10(2), pp. 69–71. doi: 10.1108/09544789810211353.
Harzallah, M. and Vernadat, F. (2002) 'IT-based competency modeling and management: from theory to practice in enterprise engineering and operations', *Computers in Industry*. Elsevier, 48(2), pp. 157–179. doi: 10.1016/S0166-3615(02)00003-9.
Hill, S. and Wilkinson, A. (1995) 'In search of TQM', *Employee Relations*, 17(3), p. 8. Available at: http://search.proquest.com/docview/235227907?accountid=14507.
Iaea (2006) 'Management of continual improvement for facilities and activities', *Nuclear Power Engineering Section International Atomic Energy Agency*, (April), p. 69.
IASC (1998) 'IAS 38 — Intangible Assets'. London: International Accounting

Standards Committee. Available at: https://www.iasplus.com/en/standards/ias/ias38 (Accessed: 1 April 2017).
Irvin, R. A., Michaels Iii, E. G. and Walker, P. (1989) ‘Core Skills: Doing the Right Things Right’, *McKinsey Quarterly*, (2), pp. 4–19. Available at: http://search.ebscohost.com/login.aspx?direct=true%7B&%7Ddb=bth%7B&%7DAN=6990730%7B&%7Dsite=ehost-live.
Jashapara, A. (2010) *Knowledge Management: An Integrated Approach*, *Fisheries Research*. Financial Times/ Prentice Hall.
Jing, S., Liu, J. and Zhan, H. (2013) ‘A New Design Rationale Knowledge Evaluation Method’, *2013 International Conference on Computer-Aided Design and Computer Graphics*, pp. 385–386. doi: 10.1109/CADGraphics.2013.59.
Jochem, R., Geers, D. and Heinze, P. (2011) ‘Maturity measurement of knowledge-intensive business processes’, *The TQM Journal*, 23(4), pp. 377–387. doi: 10.1108/17542731111139464.
Johansson, H. J. *et al.* (1993) *Business Process Reengineering Break Point Strategies for Market Dominance*. Wiley.
Jones, D. (2003) *The Beginner’s Guide To Lean*, *Lean Enterprise Institute*. Available at: https://www.lean.org/common/display/?o=15 (Accessed: 15 May 2017).
Juran, J. M. (1964) *Managerial breakthrough: A new concept of the manager’s job.* McGraw-HIll Companies, Inc. All.
Jurisica, I., Mylopoulos, J. and Yu, E. (1999) ‘Using Ontologies for Knowledge Management : An Information Systems Perspective’, *In Proceedings of the 62nd Annual Meeting of the American Society for Information Science*, pp. 482–496. doi: 10.1007/s10115-003-0135-4.
Kallet, R. H. (2004) ‘How to write the methods section of a research paper.’, *Respiratory care*, 49(10), pp. 1229–1232.
Kano, N. (1993) ‘A Perspective on Quality Activities in American Firms’, *California Management Review*, 35(3), pp. 12–31. doi: 10.2307/41166741.
Kaplan, R. B. and Murdock, L. (1991) ‘Core process redesign’, *The McKinsey Quarterly*, 2(2), pp. 27–43. Available at: http://search.ebscohost.com/login.aspx?direct=true&db=buh&AN=9707250134&site=ehost-live.
Kaplan, R. S. and Norton, D. P. (1996) ‘Using the Balanced Scorecard as a Strategic Management System’, *Harvard Business Review*, 74(1), pp. 75–85. doi: 10.1016/S0840-4704(10)60668-0.
Kennedy, C. (1995) ‘Re-engineering: the human costs and benefits.’, *Long Range Planning*. Pergamon, pp. 64–72. doi: 10.1016/0024-6301(95)91045-X.
Kew, C. (2007) ‘The TENCompetence personal competence manager’, *CEUR Workshop Proceedings*, 280.
King, J. (1991) ‘Re-engineering: rip it up!’, *Computerworld*, 25(28), pp. 55–57.
Kirkeby, O.-F. (1990) *Abduktion ur Vetenskapsteori och metodlära red.* Lund University.
Kish-Gephart, J. J. *et al.* (2009) ‘Silenced by fear:. The nature, sources, and consequences of fear at work’, *Research in Organizational Behavior*, pp. 163–193. doi: 10.1016/j.riob.2009.07.002.
Kismihók, G. and Vas, R. (2006) ‘Ontology Based Adaptive Examination System in E-Learning Environment’, *Management*, pp. 77–82.
Klein, M. M. (1993) ‘IEs fill facilitator role in benchmarking operations to improve performance’, *Industrial Engineering*, pp. 40–42.
Klein, M. M. (1994) ‘Reengineering Methodologies and Tools’, *Information Systems*

Management, 11(2), pp. 30–35. Available at: http://web.a.ebscohost.com/ehost/detail/detail?sid=4bd322ab-7752-4959-ac63-b491974b9dfd%40sessionmgr4007&vid=0&hid=4106&bdata=JnNpdGU9ZWhvc3QtbGl2ZQ%3D%3D#AN=9706096729&db=bth.

Klimkó, G. (2001) *Mapping organisational knowledge*. Budapesti Corvinus Egyetem. Available at: http://phd.lib.uni-corvinus.hu/179/.

Koc, T. and Bozdag, E. (2017) 'Measuring the degree of novelty of innovation based on Porter's value chain approach', *European Journal of Operational Research*. Elsevier B.V., 257(2), pp. 559–567. doi: 10.1016/j.ejor.2016.07.049.

Koch, T. *et al.* (2012) '10 Commandments for the boss of a company implementing Lean philosophy', *Management and Production Engineering Review*, 3(2), pp. 62–78. doi: 10.2478/v10270-012-0016-y.

Kock Jr, N. F. and McQueen, R. J. (1996) 'Product flow, breadth and complexity of business processes', *Business Process Re-engineering & Management Journal*, 2(2), pp. 8–22. doi: 10.1108/14637159610148040.

Kompetenzen im Hochschulsektor (no date). Available at: https://www.kompetenzen-im-hochschulsektor.de/ (Accessed: 17 August 2018).

Kovács, G. and Spens, K. M. (2005) 'Abductive reasoning in logistics research', *International Journal of Physical Distribution & Logistics Management*. Edited by R. van Hoek, 35(2), pp. 132–144. doi: 10.1108/09600030510590318.

Kroll, K. M. (2000) 'Data-mining technology lets retailers identify which job candidates are likely to remain on the job', *Stores*. Proquest ABI / INFORM, 83(7), p. 62.

Kuhn, H. W. (1955) 'The Hungarian method for the assignment problem', *Naval Research Logistics Quarterly*, 2(1–2), pp. 83–97. doi: 10.1002/nav.3800020109.

De la Fuente, Á. and Ciccone, A. (2003) *Human capital in a global and knowledge-based economy*, *Employment & social affairs*. Available at: http://www.antoniociccone.eu/wp-content/uploads/2007/07/humancapitalpolicy.pdf.

Lakshmipathi, R. *et al.* (2010) 'Intelligent Agent Based Talent Evaluation Engine Using a Knowledge Base', *International Journal of Information Technology and Knowledge Management*. IEEE, 2(2), p. 231 236. Available at: http://ieeexplore.ieee.org/document/5329500/.

Lee, A. S. (1989) 'A Scientific Methodology for MIS Case Studies', *MIS Quarterly*, 13(1), pp. 33–50. doi: 10.1017/CBO9781107415324.004.

Lewin, K. (1947) 'Group Decisions and Social Change', *Readings in Social Psychology*, (C), pp. 340–344.

Li, T. *et al.* (2011) 'Human Resource Demand and Supply Model for National Research Institutions of China-', *Management Review*, 4(10). Available at: http://en.cnki.com.cn/Article_en/CJFDTOTAL-ZWGD201104010.htm (Accessed: 21 August 2018).

Li, Y. *et al.* (2006) 'Sentence similarity based on semantic nets and corpus statistics', *IEEE Transactions on Knowledge and Data Engineering*, 18(8), pp. 1138–1150. doi: 10.1109/TKDE.2006.130.

Li, Y., Guohui, S. and Eppler, M. J. (2010) *Making Strategy Work: A Literature Review on the Factors Influencing Strategy Implementation*, *Handbook of Research on Strategy Process* . doi: 10.4337/9781849807289.

Li, Y. and Wang, J. (2016) 'Marginal utility function based optimal human resource management model', *Xitong Gongcheng Lilun yu Shijian/System Engineering Theory and Practice*, 36(1), pp. 106–112. doi: 10.12011/1000-6788(2016)01-0106-07.

Liesener, T. (2015) *PDCA, A3, DMAIC, 8D/PSP – what are the differences?*, *Kaizen Factory*. Available at: http://www.kaizen-factory.com/2013/09/11/pdca-a3-dmaic-8dpsp-what-are-the-differences/ (Accessed: 5 November 2016).
Lili, Z. (2017) 'An Inverse Optimization Model for Human Resource Allocation Problem Considering Competency Disadvantage Structure', *Procedia Computer Science*, 112, pp. 1611–1622. doi: 10.1016/j.procs.2017.08.248.
Loebl, M. (2010) 'Introduction to Graph Theory', in *Discrete Mathematics in Statistical Physics*. Wiesbaden: Vieweg+Teubner, pp. 13–49. doi: 10.1007/978-3-8348-9329-1_2.
Lowendahl, B. (2000) *Strategic Management of Professional Service Firms*. Handelshøjskolens forlag.
Lowenthal, J. N. (1994) 'Reengineering the organization: a step-by-step approach to corporate revitalization', *Quality Progress*. ASQC Quality Press, 27(2), pp. 61–63.
Masum, A.-K. *et al.* (2018) 'Intelligent Human Resource Information System (i-HRIS): A Holistic Decision Support Framework for HR Excellence', *INTERNATIONAL ARAB JOURNAL OF INFORMATION TECHNOLOGY*, 15(1), pp. 121–130.
Meier, R., Williams, M. and Singley, R. (2010) 'Using Hoshin X-matrix to Align Corporate Strategy with Projects, Risks, and Quality metrics', *The Quality Management Forum*, 36(1), pp. 6–16.
Melander, A. *et al.* (2016) 'Introducing the Hoshin Kanri strategic management system in manufacturing SMEs', *Management Decision*, 54(10), pp. 2507–2523. doi: 10.1108/MD-03-2016-0148.
Melão, N. *et al.* (2000) 'A conceptual framework for understanding business processes and business process modelling', *Info Systems J*, 10(2), pp. 105–129. doi: 10.1046/j.1365-2575.2000.00075.x.
Miao, Y. *et al.* (2013) 'Staffing model for call center with customer patience variation'.
Million, E. (2007) 'The Hadamard Product', p. 7. doi: 10.1016/S0895-7177(98)00155-1.
Miranda, S. *et al.* (2017) 'An ontology-based model for competence management', *Data and Knowledge Engineering*. doi: 10.1016/j.datak.2016.12.001.
Mittas, N. *et al.* (2016) 'ComProFITS: A web-based platform for human resources competence assessment', *IISA 2015 - 6th International Conference on Information, Intelligence, Systems and Applications*. IEEE, (January), pp. 1–6. doi: 10.1109/IISA.2015.7388113.
Moe, T. (1999) 'Operating in the Dark in the Knowledge Economy', in *International Symposium Measuring and Reporting Intellectual Capital: Experience, Issues, and Prospects*. Amsterdam: OECD. Available at: http://www.oecd.org/sti/ind/1932632.htm (Accessed: 1 April 2017).
MOL Group (2015) 'MOL Group Global Operative Regulation'. Budapest.
MOL Italy/IES (2015) 'MOL Italy Local Operative Regulation'. Mantova.
Mumford, E. and Beekman, G. J. (1994) *Tools for change & progress: a socio-technical approach to business process re-engineering.* CSG Publications.
Naykhanova, L. V and Naykhanova, I. V (2018) 'Conceptual model of knowledge base system', *Journal of Physics: Conference Series*, 1015, p. 032097. doi: 10.1088/1742-6596/1015/3/032097.
Niemi, E. and Laine, S. (2016) 'Competence management as a dynamic capability: A strategic enterprise system for a knowledge-intensive project organization', *Proceedings of the Annual Hawaii International Conference on System Sciences*, 2016–March, pp. 4252–4261. doi: 10.1109/HICSS.2016.528.

Nishioka, Y. (2016) 'The Industrial Value Chain Initiative', in *Forum Industrie 4.0 meets the Industrial Internet*. Available at: https://iv-i.org/en/docs/doc_160428_hannover.pdf.

NLTK Project (2017) *Natural Language Toolkit — NLTK 3.2.5 documentation*. Available at: http://www.nltk.org/ (Accessed: 25 February 2018).

Nonaka, I. and Takeuchi, H. (1995) 'The Knowledge-Creating Company: How Japanese Companies Create the Dynamics of Innovation', *Oxford University Press*. Oxford University Press, 3(4–5), pp. 25–27. doi: 10.1016/S0048-7333(97)80234-X.

O'Neill, P. and Sohal, A. S. (1998) 'Business process reengineering: application and success - an Australian study', *International Journal of Operations & Production Management*, 18(9/10), pp. 832–864. doi: 10.1108/01443579810225487.

O'Neill, P. and Sohal, A. S. (1999) 'Business process reengineering a review of recent literature', *Technovation*, 19(9), pp. 571–581. doi: 10.1016/S0166-4972(99)00059-0.

O'Neill, P., Sohal, A. and Teng, C. W. (2016) 'Quality management approaches and their impact on firms?? financial performance - An Australian study', *International Journal of Production Economics*, 171, pp. 381–393. doi: 10.1016/j.ijpe.2015.07.015.

Oackland, J. S. (1995) *Total Quality Management. The Route to Improving Performance*. Butterworth-Heinemann. Available at: https://scholar.google.co.uk/scholar?q=Total+Quality+Management%3A+The+Route+to+Improving+Performance&btnG=&hl=en&as_sdt=0%2C5#5 (Accessed: 27 November 2016).

Olney, W. (2012) *Facebook IPO: A Touchstone Cultural Moment for America?* Available at: http://www.kcrw.com/news-culture/shows/to-the-point/facebook-ipo-a-touchstone-cultural-moment-for-america.

OMG (no date) *BPMN 2.0.2*. Available at: http://www.omg.org/spec/BPMN/2.0.2/ (Accessed: 19 March 2017).

Osada, H. (1998) 'Strategic management by policy in total quality management', *Strategic Change*, 287(August), pp. 277–287. Available at: http://www.hksq.org/1998SMBPWiley.pdf.

Oztemel, E. and Gursev, S. (2018) 'Literature review of Industry 4.0 and related technologies', *Journal of Intelligent Manufacturing*. Springer US, pp. 1–56. doi: 10.1007/s10845-018-1433-8.

Petrash, G. (1996) 'Dow's journey to a knowledge value management culture', *European Management Journal*, 14(4), pp. 365–373. doi: 10.1016/0263-2373(96)00023-0.

PetroSkills Compass - Competency Management solution (no date). Available at: http://www.petroskills.com/compass (Accessed: 16 August 2018).

Petrozzo, D. P. and Stepper, J. C. (1994) *Successful Reengineering*, *New York : Van Nostrand Reinhold*. Van Nostrand Reinhold. Available at: https://www.goodreads.com/book/show/5667796-successful-reengineering (Accessed: 30 September 2016).

Piatetsky, G. (2015) *Poll: How much did you use text analytics / text mining in the past 12 months?*, *KDNuggets*. Available at: http://www.kdnuggets.com/polls/2014/text-analytics-text-mining-use.html (Accessed: 19 March 2017).

Piatetsky Gregory (2016) *R, Python Duel As Top Analytics, Data Science software –*

KDnuggets 2016 Software Poll Results, *KDnuggets*. Available at: http://www.kdnuggets.com/2016/06/r-python-top-analytics-data-mining-data-science-software.html (Accessed: 19 March 2017).
Pidd, M. (1997) 'Tools for Thinking—Modelling in Management Science', *Journal of the Operational Research Society*, 48(11), pp. 1150–1150. doi: 10.1057/palgrave.jors.2600969.
Pooler, W. S. and Morgan, G. (1989) 'Images of Organization.', *Contemporary Sociology*, 18(6), p. 901. doi: 10.2307/2074189.
Porter, M. E. (1985) *Competitive Advantage:Creating and sustaining superior performance*, *New York*. doi: 10.1182/blood-2005-11-4354.
Project Management Institute (2013) 'Organization Charts and Position Descriptions', in *A Guide to the Project Management Body of Knowledge (PMBOK Guide)*. 5th editio, p. 262.
Quinn, A., Rycraft, J. R. and Schoech, D. (2002) 'Building a Model to Predict Caseworker and Supervisor Turnover Using a Neural Network and Logistic Regression', *Journal of Technology in Human Services*, 19(4), pp. 65–85. doi: 10.1300/J017v19v04_05.
Ravenswood, K. (2011) 'Eisenhardt's impact on theory in case study research', *Journal of Business Research*, 64(7), pp. 680–686. doi: 10.1016/j.jbusres.2010.08.014.
Reinhardt, R. *et al.* (2002) 'Intellectual Capital and Knowledge Management: Perspective on measuring knowledge', *Handbook of Organizational Learning and Knowledge*. Edited by M. Dierkes et al. Oxford: Oxford University Press, (December), pp. 794–820.
Richman, T. and Koontz, C. (1993) 'How benchmarking can improve business reengineering', *Planning Review*, 21(6), pp. 26–55. doi: 10.1108/eb054447.
Robert D., M. (2016) 'The Shingo Model for Operational Excellence', *The Shingo Prize*. Available at: http://lean.nh.gov/documents/Shingo Model Handbook.pdf.
Robinson, S. (2018) *K-Nearest Neighbors Algorithm in Python and Scikit-Learn*, *Stack Abuse*. Available at: http://stackabuse.com/k-nearest-neighbors-algorithm-in-python-and-scikit-learn/ (Accessed: 17 February 2018).
Röglinger, M. *et al.* (2012) 'Maturity models in business process management', *Business Process Management Journal*, 18(2), pp. 328–346. doi: 10.1108/14637151211225225.
Rogushina, J. and Pryima, S. (2017) 'Use of ontologies and semantic web to provide for the transparency of qualifications frameworks', *Eastern-European Journal of Enterprise Technologies*, 1(2 (85)), pp. 25–31. doi: 10.15587/1729-4061.2017.92815.
Roos, G. G. and Roos, J. (1997) 'Measuring your company's intellectual performance', *Long Range Planning*. Pergamon, 30(3), pp. 413–426. doi: 10.1016/S0024-6301(97)90260-0.
Roscioli, D., Arru, M. and Castellucci, F. (2012) 'Lean Accounting: the system for determining and controlling costs in lean manufacturing environments', *Lean Champion - Supporting Material*. Milano.
Rosemann, M. (2001) *Business Process Lifecycle Management*.
Rushton, A., Croucher, P. and Baker, P. (2017) 'The handbook of logistics and distribution management', in *Project Management Journal*. 6th editio. Kogan Page;, p. 912. Available at: https://www.amazon.com/Handbook-Logistics-Distribution-Management-Understanding-ebook/dp/B01MR2CG0S/.
Da Sa Sousa, H. P. and Leite, J. C. S. D. P. (2017) 'Toward an organizational alignment modeling language: The human resource competency perspective', in

Proceedings - 2017 IEEE 19th Conference on Business Informatics, CBI 2017. IEEE, pp. 277–286. doi: 10.1109/CBI.2017.65.
Schaffer, R. H. and Thomson, H. A. (1992) 'Successful change programs begin with results.', *Harvard Business Review*, 70(1), pp. 80–89.
Schneiderman, A. M. (2000) 'The 7-steps of process management.', *Strategy and Business*. Available at: http://www.schneiderman.com/Concepts/PM_Model/PM_Model.doc.
Schultz, T. W. (1961) 'Investment in Human Capital', *The American Economic Review*, April, pp. 1–17. doi: 10.1007/sl0649-007-9105-l.
Scipy Team (2018) *scipy.optimize.linear_sum_assignment*, *SciPy v0.18.1 Reference Guide*. Available at: https://docs.scipy.org/doc/scipy-0.18.1/reference/generated/scipy.optimize.linear_sum_assignment.html (Accessed: 30 May 2018).
Senge, P. M. (2010) *The fifth discipline : the art and practice of the learning organization*. Revised &. Doubleday.
Shapiro, B. P., Rangan, V. K. and Sviokla, J. J. (1992) 'Staple Yourself to an Order', *Harvard Business Review*, 70(4), pp. 113–122. Available at: http://www.scilab.nl/Scilab/Downloads_files/staple yourself to an order.pdf.
Shewhart, W. A. (1917) *Economic Control of Quality Of Manufactured Product*. Martino Fine Books.
Shook, J. (2009) 'Toyota's Secret', *MIT Sloan Management Review*, 50(4), pp. 30–33. Available at: http://search.proquest.com.library.capella.edu/docview/224959929?accountid=27965%5Cnhttp://wv9lq5ld3p.search.serialssolutions.com.library.capella.edu/?ctx_ver=Z39.88-2004&ctx_enc=info:ofi/enc:UTF-8&rfr_id=info:sid/ProQ:abiglobal&rft_val_fmt=info:ofi/fmt:k.
Singh, A. *et al.* (2018) 'Method and System for auto-selection of Employee for training in an organization'. United States.
Smirnov, A. *et al.* (2017) 'Ontology-based cloud platform for human-driven applications', in *2017 21st Conference of Open Innovations Association (FRUCT)*. IEEE, pp. 304–310. doi: 10.23919/FRUCT.2017.8250197.
Smith, H. H. I. I. I. and Smarkusky, D. L. (2005) 'Competency matrices for peer assessment of individuals in team projects', *Proceedings of the 6th conference on*, pp. 155–162. doi: 10.1145/1095714.1095751.
Snyder, D. and Jowa, A. (2004) '8-D Problem Solving Overview', in *Ford Truck Quality Program Guidelines*. Ford Motors, p. 9.
Srinivasan, S. and Murthy, M. A. N. (2012) *Process Maturity Model Can Help Give a Business an Edge*, *iSixSigma.com*. Available at: https://www.isixsigma.com/methodology/business-process-management-bpm/process-maturity-model-can-help-give-business-edge/ (Accessed: 1 November 2016).
Stabell, C. B. and Fjeldstad, Ø. D. (1998) 'Configuring value for competitive advantage: on chains, shops, and networks', *Strategic Management Journal*, 19(5), pp. 413–437. doi: 10.1002/(SICI)1097-0266(199805)19:5<413::AID-SMJ946>3.0.CO;2-C.
Steenhuis, H.-J. and De Bruijn, E. J. (2006) 'Building theories from case study research: the progressive case study'.
Stentoft Arlbjørn, J. and Halldorsson, A. (2002) 'Logistics knowledge creation: reflections on content, context and processes', *International Journal of Physical Distribution & Logistics Management*, 32(1), pp. 22–40. doi:

10.1108/09600030210415289.
Stepanenko, V. and Kashevnik, A. (2017) ‘Competence Management Systems in Organisations : a Literature Review’, *MIS Quarterly*, 28(3), p. 435. doi: 10.2307/25148646.
Stewart, T. A. (1998) *Intellectual Capital: the New Wealth of Organizations*. 1st edn. New York: Crown Business.
Stoddard, D. B. and Jarvenpaa, S. L. (1995) ‘Business process redesign: Tactics for managing radical change’, *Journal of Management Information Systems*, 12(1), p. 81. Available at: http://search.proquest.com/docview/218959557?accountid=14507.
Strohmeier, S. and Piazza, F. (2013) ‘Domain driven data mining in human resource management: A review of current research’, *Expert Systems with Applications*. Elsevier Ltd, 40(7), pp. 2410–2420. doi: 10.1016/j.eswa.2012.10.059.
Sugimori, H. *et al.* (2003) ‘Data Mining for Seeking Relationships between Sickness Absence and Japanese Worker’s Profile’, in *LECTURE NOTES IN COMPUTER SCIENCE*. Springer, Berlin, Heidelberg, pp. 410–416. doi: 10.1007/978-3-540-45226-3_56.
Sullivan, P. H. (2001) *Profiting from intellectual capital : extracting value from innovation*. Wiley.
Sveiby, K. E. (1997) *The New Organizational Wealth: Managing and Measuring Knowledge Based Assets*. 1st edn. Berrett-Koehler Publishers.
System2Win (no date) *Catchball for lean hoshin planning policy deployment*, *System2win - Continuously improving tools for continuous improvement*. Available at: http://www.systems2win.com/c/catchball.htm (Accessed: 15 November 2016).
Szabó, Z. (2000) *A szervezeti információfeldolgozás strukturális és technológiai tényezőinek összerendelése.* Budapesti Corvinus Egyetem. Available at: http://phd.lib.uni-corvinus.hu/212/.
Tague, N. R. (2005) ‘Plan-Do-Check-Act (PDCA) Cycle’, in *Quality Toolbox*. 2nd edn. American Society for Quality (ASQ), pp. 390–392. doi: 10.1002/tqem.
Tai, W.-S. and Hsu, C.-C. (2006) ‘A Realistic Personnel Selection Tool Based on Fuzzy Data Mining Method’, *Proceedings of the 9th Joint Conference on Information Sciences (JCIS)*. doi: 10.2991/jcis.2006.46.
Talwar, R. (1993) ‘Business re-engineering-a strategy-driven approach’, *Long Range Planning*, 26(6), pp. 22–40. doi: 10.1016/0024-6301(93)90204-S.
Tapping, D. and Shuker, T. (2004) *Value Stream Management for The Lean Office*. New York: Productivity Press.
Tarhan, A., Turetken, O. and Reijers, H. A. (2016) ‘Business process maturity models: A systematic literature review’, *Information and Software Technology*, 75, pp. 122–134. doi: 10.1016/j.infsof.2016.01.010.
Taylor, F. W. (1911) *The principles of scientific management*, *Management*. doi: 10.2307/257617.
Taylor, G. D., Aken, E. M. Van and Tech, V. (no date) ‘Improving Organizational Culture Using Core Values’, (0118).
Taylor, S. (1993) ‘Eastman Chemical strives for better than world class.’, *Industrial Engineering*, 25(11), p. 28. Available at: http://search.ebscohost.com/login.aspx?direct=true&db=buh&AN=9402182466&site=ehost-live&scope=site.
Teng, J. T. C., Grover, V. and Fiedler, K. D. (1994) ‘Re-designing business processes using information technology’, *Long Range Planning*. Pergamon, 27(1), pp. 95–

106. doi: 10.1016/0024-6301(94)90010-8.
Tennant, C. and Roberts, P. (2001) 'Hoshin Kanri: Implementing the Catchball Process', *Long Range Planning*, 34(3), pp. 287–308. doi: 10.1016/S0024-6301(01)00039-5.
Tennant, G. (2000) *Six Sigma: SPC and TQM in Manufacturing and Services2*. Gower Publishing Limited. Available at: https://books.google.com/books?id=O6276jidG3IC&pgis=1.
Ternai, K. and Torok, M. (2011) 'A new approach in the development of ontology based workflow architectures', *17th International Conference on Concurrent Enterprising (ICE 2011)*, (Ice), pp. 1–10. Available at: http://ieeexplore.ieee.org/articleDetails.jsp?arnumber=6041251.
Ternai, K., Török, M. and Varga, K. (2014) 'Combining Knowledge Management and Business Process Management – A Solution for Information Extraction from Business Process Models Focusing on BPM Challenges', in *Electronic Government and the Information Systems Perspectiv*. Springer International Publishing, pp. 104–117. doi: 10.1007/978-3-319-10178-1_9.
The Economist and Economist, T. (1999) 'Measuring intangible assets A price on the priceless', *The Economist Newspaper Limited*, 10 June.
Thomas, R. J. (1994) *What Machines Can't Do: Politics and Technology in the Industrial Enterprise*. University of California Press.
Tinaikar, R., Hartman, A. and Nath, R. (1995) 'Rethinking business process re-engineering: a social constructionist perspective.', in *Examining Business Process Re-engineering: Current Perspectives and Research Directions*. London: Kogan Page, pp. 107–16.
Tinelli, E. *et al.* (2009) 'I.M.P.A.K.T.: an innovative, semantic-based skill management system exploiting standard SQL', *ICEIS 2009 - 11th International Conference on Enterprise Information Systems, Proceedings*.
Tomer, J. F. (1987) *Organizational Capital: The Path to Higher Productivity and Well-Being*. 1st edn. Praeger.
Török, M. (2014) *Organizational knowledge extraction from business process models*. Corvinus University of Budapest. doi: 10.14267/phd.2014077.
Tzeng, H.-M., HSier, J.-G. and Lin, Y.-L. (2004) 'Predicting Nurses' Intention to Quit With a Support Vector Machine', *CIN: Computers, Informatics, Nursing*, 22(4), pp. 232–242. doi: 10.1097/00024665-200407000-00012.
Ueki, Y. (2016) 'Customer pressure, customer-manufacturer-supplier relationships, and quality control performance', *Journal of Business Research*, 69(6), pp. 2233–2238. doi: 10.1016/j.jbusres.2015.12.035.
Ulric, W. and McWorther, N. (2010) *Defining Requirements for a Business Architecture Standard*, *The OMG, Business Architecture Special Interest G roup*.
Unions, D. C. of T. (1999) 'Your knowledge – can you book it?', in *Your knowledge – can you book it?* Amsterdam.
Vantrappen, H. (1992) 'Creating customer value by streamlining business processes', *Long Range Planning*. Pergamon, 25(1), pp. 53–62. doi: 10.1016/0024-6301(92)90310-X.
Vas, R. (2016) 'STUDIO – Ontology-Centric Knowledge-Based System', in Gabor, A. and Ko, A. (eds) *Corporate Knowledge Discovery and Organizational Learning*. Springer International Publishing (Knowledge Management and Organizational Learning).
Venkataiah, C. H. and Sagi, S. (2013) 'Business Process Re-Engineering in Manufacturing and Service Industries-Some Perspectives', *ZENITH*

International Journal of Multidisciplinary Research, 3(1), pp. 45–56.
Venkatraman, N. (1994) ‘It-Enabled Business Transformation - From Automation To Business Scope Redefinition’, *Sloan management review*, 35(2), pp. 73–87. Available at: http://my.woodbury.edu/SiteDirectory/IR/PublishingImages/Venkatraman - IT Enabled Business Transformation - From Automation to Business Scope Redefinition.pdf.
Vennix, J. A. M. (1996) *Group Model Building: Facilitating Team Learning Using System Dynamics*, *Journal of the Operational Research Society*. doi: 10.1057/palgrave.jors.2600567.
Warier, S. (2014a) ‘Competency Mapping & Management - A Comprehensive Survey Report’, p. 188.
Warier, S. (2014b) *Competency Quotient*. reateSpace Independent Publishing Platform.
Wastell, D. G., White, P. and Kawalek, P. (1994) ‘A methodology for business process redesign: experiences and issues’, *Journal of Strategic Information Systems*. North-Holland, 3(1), pp. 23–40. doi: 10.1016/0963-8687(94)90004-3.
Watkins, J., Skinner, C. and Pearson, J. (1993) ‘Business process re-engineering: hype, hazard or heaven?’, *Business Change and Re-engineering*, 1(2).
Watkins, K. E. (1996) *Creating the learning organization (In Action)*. Amer Society for Training.
Watson, G. (2002) ‘Peter F. Drucker: Delivering value to customers’, *Quality Progress*, 5, pp. 55–61. Available at: http://www.gregoryhwatson.eu/images/5-QP_Watson_-_May2002_-_Drucker_-_Delivering_Value_to_Customers.pdf.
Weber, C. (2017) *Creating a Concept Importance Measure for Domain Knowledge in the Context of Learning*. Corvinus University Budapest. Available at: http://phd.lib.uni-corvinus.hu/963/5/Christian_Weber_ten.pdf.
Weber, C., Neusch, G. and Vas, R. (2016) ‘Studio : A Domain Ontology Based Solution for Knowledge Discovery in Learning and Assessment’, in *SIGED: IAIM Conference*. Available at: http://aisel.aisnet.org/siged2016/12?utm_source=aisel.aisnet.org%2Fsiged2016%2F12&utm_medium=PDF&utm_campaign=PDFCoverPages.
Weber, C. and Vas, R. (2014) ‘Extending Computerized Adaptive Testing to Multiple Objectives: Envisioned on a Case from the Health Care’, *Proceedings of the 3rd International Conference on Electronic Government and the Information Systems Perspective (EGOVIS 2014)*. Springer Verlag, 8650, pp. 148–162. doi: 10.1007/978-3-319-10178-1_12.
Weber, C. and Vas, R. (2015) ‘Studio: Ontology-Based Educational Self-Assessment.’, in *Workshops Proceedings of EDM 2015 8th International Conference on Educational Data Mining*. Madrid: EDM, pp. 33–40. Available at: http://ceur-ws.org/Vol-1446/edm2015ws_proc.pdf (Accessed: 15 August 2016).
Weisstein, E. W. (no date) ‘Unit Matrix’. Wolfram Research, Inc. Available at: http://mathworld.wolfram.com/UnitMatrix.html (Accessed: 12 May 2017).
White, J. C. (2014) ‘Reengineering and Continuous Improvement’, pp. 4–7. Available at: http://www.qualitydigest.com/jul/contimp.html.
Wick, C. W. and León, L. S. (1995) ‘From ideas to action: Creating a learning organization’, *Human Resource Management*. Wiley Subscription Services, Inc., A Wiley Company, 34(2), pp. 299–311. doi: 10.1002/hrm.3930340207.
Woitsch, R. (2009) *Plug Your Business Into IT - plugIT Project*. Available at: https://plug-it-project.eu/ADOwebCMS/transformHTML/4.html (Accessed: 22 August 2018).

Woitsch, R. (2011) *plugIT - Final Publishable Summary Report*. Available at: http://www.openmodels.at.
World at Work, The WorldatWork and World at Work (2007) *The WorldatWork Handbook of Compensation, Benefits and Total Rewards: A Comprehensive Guide for HR Professionals*, *M2 Presswire*. John Wiley & Sons Inc.
Wray, R. (2009) 'Internet data heads for 500bn gigabytes | Business | The Guardian', *The Guardian*, May. Available at: https://www.theguardian.com/business/2009/may/18/digital-content-expansion (Accessed: 19 March 2017).
Xian-ying, M. (2012) 'Application of Assignment Model in PE Human Resources Allocation', *Energy Procedia*, 16(PART C), pp. 1720–1723. doi: 10.1016/j.egypro.2012.01.266.
Yang, C. C. *et al.* (2009) 'Improving scheduling of emergency physicians using data mining analysis', *Expert Systems with Applications*. Elsevier Ltd, 36(2), pp. 3378–3387. doi: 10.1016/j.eswa.2008.02.069.
Yewno.com (no date) *Business Process Improvement*, *Yewno Discover*. Available at: https://yewno.com/edu/ (Accessed: 2 March 2017).
Yin, R. K. (1994) 'Discovering the future of the case study method in evaluation research', *Evaluation Practice*, 15(3), pp. 283–290. doi: 10.1016/0886-1633(94)90023-X.
Yolles, M. (2009) 'Competitive advantage and its conceptual development: An exploration', *Business Information Review*, 26(2), pp. 93–111. doi: 10.1177/0266382109104411.
Yu, B. and Wright, D. T. (1997) 'Software tools supporting business process analysis and modelling', *Business Process Management Journal*, 3(2), pp. 133–150. Available at: http://www.emeraldinsight.com/doi/full/10.1108/14637159710173096.
Zachman, J. a (2003) 'The Zachman Framework For Enterprise Architecture, Primer for Enterprise Engineering and Manufacturing', *CA Magazine*, 128(9), p. 15. doi: 10.1109/CSIE.2009.478.
Zairi, M. (1997) 'Business process management: a boundaryless approach to modern competitiveness', *Business Process Management Journal*, 3(1), pp. 64–80. doi: 10.1108/14637159710161585.
Zairi, M. and Léonard, P. (1994) *Practical benchmarking: the complete guide*. Dordrecht: Springer Netherlands. doi: 10.1007/978-94-011-1284-0.
Zairi, M. and Sinclair, D. (1995) 'Business process re-engineering and process management: A survey of current practice and future trends in integrated management', *Business Process Re-engineering & Management Journal*, 1(1), pp. 8–30. doi: 10.1108/14637159510798248.
Zhang, L. L., Zhao, X. N. and Zang, Y. Y. (2013) '"Four-in-one" Human Capital Matching Method Based on Advantage Structure Identification[', *Systems Engineering-Theory & Practice*, 33(8), pp. 2047–2056.
Zhang, Z. *et al.* (2018) 'System for automatically extracting job skills from an electronic document'. United States.

Published Research Results

Arru, M. (2014) 'Application of process ontology to improve the funding allocation process at the European Institute of Innovation and Technology', Lecture Notes in Computer Science (including subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics). Edited by A. Kő and E. Francesconi. Springer Verlag, 8650 LNCS, pp. 133–147. doi: 10.1007/978-3-319-10178-1_11.

Gábor, A. and Arru, M. (2014) 'Process Oriented Knowledge Transfer in the Public Administration', in *International Scientific-Practical Conference 'Smart Government: Science and Technology'*. Astana, Kazakhstan: ACM Press, pp. 179–184.

Arru, M. (2016) 'Developing a Measure of Intellectual Capital fit: An Approach to Improve Business Processes', in European Conference on Intellectual Capital. Kidmore End: Academic Conferences International Limited, pp. 382–393. Available at: http://search.proquest.com/docview/1803415572?accountid=14507.

Arru, M. (2019) 'Business Processes and Knowledge Management: A Marriage of Convenience for the Fluid Organisation's process improvement', SEFBIS Journal. John v Neumann Computer Society, 13, p. 12.

Appendix 1 Topologic tables

a. a: Activities

#	Activity
1	100. Metrology
2	110.1.a Administrative return goods
3	110.1.b Physical Return goods handling
4	110.2. Off-spec product management
5	120. Reporting
6	Acceptance/transfer in tank
7	Calculating necessary transportation capacity
8	Checking loading conditions - Train
9	Checking loading conditions - Barge
10	Checking loading conditions - Road
11	Controlling the quality
12	Controlling the quantity - Barge
13	Controlling the quantity - Pipeline
14	Controlling the quantity - RTC
15	Controlling the quantity - RoTC
16	Create transportation plan for next day/shift
17	Defining optimal (target) replenishment inventory level
18	Ensure available capacity
19	Execution – autonomous maintenance
20	Execution – routine maintenance
21	Inspecting the vehicle
22	Inventory checking (FS & VMI accounts)
23	Inventory checking - managing data quality
24	Issuing the transport documents - Barge
25	Issuing the transport documents - Train
26	Issuing the transport documents-Road
27	Loading the transport means - Train
28	Loading the transport means - Barge
29	Loading the transport means -Road
30	Making preparations for product reception, reviewing the transport documents
31	Monitor FS (VMI) turnover
32	Notification
33	Order generation for filling stations (VMI accounts)
34	Plan-Fact evaluation, controlling
35	Planning and Scheduling
36	Quality control - Barge
37	Quality control - Train
38	Quality control- Road
39	Receiving Retail business plans, forecasted delivery volumes
40	Receiving Wholesale business plans, forecasted delivery volumes
41	Receiving actual information about delivery fulfillment from haulers
42	Receiving customer orders, forwarding to R&S
43	Receiving daily inventory and sales reports from FSs (and other VMI accounts)
44	Receiving the transport means - Barge
45	Receiving the transport means - Train
46	Receiving the transport means-Road
47	Record keeping and registration in inventory
48	Sales forecasting
49	Sending confirmation about scheduled delivery time to local Sales organisation and/or customers and/or FS
50	Sending information about transportation plans to haulers and/or terminals
51	Transferring the risk of product, registering the discharge - Train
52	Transferring the risk of product, registering the discharge - Barge
53	Transferring the risk of product, registering the discharge- Road
54	Unloading
55	Verification
56	Work order selection (RBWS)

b. r: Roles

#	Roles
1	Business operation
2	Dispatcher / shift supervisor

#	Roles
3	Local Logistics person responsible for transportation
4	Local Retail
5	Local Sales
6	Local product storage management
7	Maintenance management
8	Operator
9	Quality Control
10	SSC
11	Scheduler
12	Technical execution
13	Terminal manager

c. p: Positions

#	Positions
1	Dispatcher
2	Maintenance Manager
3	Retail Manager
4	Terminal Manager
5	Transportation Manager
6	Wholesale Manager

d. i: Individuals

#	Individual
1	MAINTEINANCE2
2	Dispatcher2
3	Terminal3
4	Transportation2
5	Transportation1
6	Terminal1
7	Terminal2
8	Retail1
9	Wholesale1
10	Dispatcher1
11	Mainteinance1

e. k: Knowledge Concepts

#	Concept
1	AF-Actual_Performance
2	AF-Adat
3	AF-Availability
4	AF-Contamination
5	AF-Delivery
6	AF-Guideline
7	AF-KockÃ¡zat
8	AF-Performance
9	AF-Purchase
10	AF-Quality_of_the_Sample
11	AF-Risk_Assessment
12	AF-Szervezet
13	AF-pm_cost
14	TT-Acceptance_Procedure
15	TT-Ad_hoc_Sampling
16	TT-Asset
17	TT-Automatic_Tanker_Loading_Station
18	TT-Barge
19	TT-Barge_Gauging
20	TT-Chargeable_Loss
21	TT-Commercial_Law
22	TT-Compliance_Objective
23	TT-Control_Measurement_Accuracy
24	TT-Cost_Reduction
25	TT-Cost_and_Resource_Analysis
26	TT-Customer_Order
27	TT-Dead_Stock
28	TT-Decision_Making_Process

#	Concept
29	TT-Discharging_Procedure
30	TT-Dispatcher
31	TT-Document
32	TT-Document_type
33	TT-Electronic_Dip_Stick
34	TT-Emptiness_Check
35	TT-European_Union_s_Transport_Regulations
36	TT-Excise_Duty_Licence
37	TT-Excise_Duty_Regulation
38	TT-Filling_Station
39	TT-Finance_Guard_Agency
40	TT-Finance_and_accounting
41	TT-Financial_accounting
42	TT-Folyamat
43	TT-Forecasted_Daily_Sale
44	TT-Forecasting
45	TT-Free_Circulation_of_Goods
46	TT-Freight_Forwarding_Documentation
47	TT-Fuel_Density
48	TT-FÃ¶ldgÃ¡z
49	TT-Gauge_Loss_Management
50	TT-Gauge_System
51	TT-Governing_Law
52	TT-Handling_of_Contaminated_Disposal
53	TT-Hauling_Alongside
54	TT-HulladÃ©k_megelÅ‘zÃ©s_Ã©s_kezelÃ©s
55	TT-Human_Resources
56	TT-ISO_Standards
57	TT-International_Freight_Forwarding
58	TT-Inventory_Level
59	TT-Inventory_Management
60	TT-Inventory_Planning
61	TT-Inventory_Replenishment_Systems
62	TT-Invoice
63	TT-Law
64	TT-Loading_Gantry
65	TT-Loading_Procedure
66	TT-Logistic_Controlling
67	TT-Logistic_Plan
68	TT-Logistics
69	TT-Logistics_Cost_and_Performance_Monitoring
70	TT-Logistics_Scope
71	TT-Logistics_System
72	TT-Loss_Regulation
73	TT-Maritime_Transport
74	TT-Metrological_Authority
75	TT-Metrological_Inspection
76	TT-Minimum_Delivery_Quantity
77	TT-Mode_of_Transportation
78	TT-Net_Quantity
79	TT-Non_Excise_Duty_Licensed_Trading
80	TT-Operation_and_Logistics
81	TT-Order_Management
82	TT-Order_Picking_and_Packing
83	TT-Performance_based_Evaluation_Measures
84	TT-Planned_Sampling
85	TT-Problem
86	TT-Project_team
87	TT-Pump_Stock_Level
88	TT-Purchase_Order
89	TT-Rail_Transport
90	TT-Rail_and_Intermodal_Transport
91	TT-Railway_Service
92	TT-Railway_Tank_Car
93	TT-Replenishment_Level
94	TT-Road_Freight_Routing_and_Scheduling

#	Concept
95	TT-Road_Freight_Transport
96	TT-Road_Weighing_Bridge
97	TT-Sales_Process
98	TT-Sample_Collection
99	TT-Sampling
100	TT-Sampling_Method
101	TT-Sampling_Process
102	TT-Sampling_Technique
103	TT-Scheduling_in_SCM
104	TT-Selective_Sampling
105	TT-Shipment
106	TT-Shipping_Document
107	TT-Strategic_Performance_Indicator
108	TT-Supply_Source
109	TT-Takeover_Handover_Procedure
110	TT-Tank
111	TT-Tank_Bottom_Loading
112	TT-Tank_Bottom_Residue
113	TT-Tank_Compartment
114	TT-Tare_Weight
115	TT-Tax_Warehouse
116	TT-Transfer
117	TT-Transport_Regulations
118	TT-Transportation
119	TT-Travel_and_tourism_law
120	TT-Travel_document
121	TT-Visual_Inspection
122	TT-Wagon
123	TT-Waste_Management_Investment
124	TT-Weighing_Bridge
125	TT-project_reporting

f. AR: Activity Roles

AR	Business operation	Dispatcher / shift supervisor	Local Logistics person responsible for transportation	Local Retail	Local Sales	Local product storage management	Maintenance management	Operator	Quality Control	SSC	Scheduler	Technical execution	Terminal manager
100. Metrology	FALSE	FALSE	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
110.1.a Administrative return goods	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	TRUE
110.1.b Physical Return goods handling	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	TRUE
110.2. Off-spec product management	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	TRUE
120. Reporting	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	TRUE
Acceptance/transfer in tank	FALSE	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
Calculating necessary transportation capacity	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
Checking loading conditions - Train	FALSE	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
Checking loading conditions - Barge	FALSE	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
Checking loading conditions - Road	FALSE	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
Controlling the quality	FALSE	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
Controlling the quantity - Barge	FALSE	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
Controlling the quantity - Pipeline	FALSE	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
Controlling the quantity - RTC	FALSE	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
Controlling the quantity - RoTC	FALSE	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
Create transportation plan for next day/shift	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE
Defining optimal (target) replenishment inventory level	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
Ensure available capacity	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
Execution â€“ autonomous maintenance	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
Execution â€“ routine maintenance	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	TRUE	FALSE
Inspecting the vehicle	FALSE	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
Inventory checking (FS & VMI accounts)	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE
Inventory checking - managing data quality	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE
Issuing the transport documents - Barge	FALSE	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
Issuing the transport documents - Train	FALSE	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
Issuing the transport documents-Road	FALSE	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
Loading the transport means - Train	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE

AR	Business operation	Dispatcher / shift supervisor	Local Logistics person responsible for transportation	Local Retail	Local Sales	Local product storage management	Maintenance management	Operator	Quality Control	SSC	Scheduler	Technical execution	Terminal manager
Loading the transport means - Barge	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE
Loading the transport means -Road	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE
Making preparations for product reception, reviewing the transport documents	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	TRUE
Monitor FS (VMI) turnover	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
Notification	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
Order generation for filling stations (VMI accounts)	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE
Plan-Fact evaluation, controlling	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
Planning and Scheduling	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE
Quality control - Barge	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE	FALSE
Quality control - Train	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE	FALSE
Quality control- Road	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE	FALSE
Receiving Retail business plans, forecasted delivery volumes	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
Receiving Wholesale business plans, forecasted delivery volumes	FALSE	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
Receiving actual information about delivery fulfillment from haulers	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE
Receiving customer orders, forwarding to R&S	FALSE	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
Receiving daily inventory and sales reports from FSs (and other VMI accounts)	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
Receiving the transport means - Barge	FALSE	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
Receiving the transport means - Train	FALSE	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
Receiving the transport means-Road	FALSE	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
Record keeping and registration in inventory	FALSE	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
Sales forecasting	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE
Sending confirmation about scheduled delivery time to local Sales organisation and/or customers and/or FS	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE

AR	Business operation	Dispatcher / shift supervisor	Local Logistics person responsible for transportation	Local Retail	Local Sales	Local product storage management	Maintenance management	Operator	Quality Control	SSC	Scheduler	Technical execution	Terminal manager
Sending information about transportation plans to haulers and/or terminals	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE
Transferring the risk of product, registering the discharge - Train	FALSE	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
Transferring the risk of product, registering the discharge - Barge	FALSE	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
Transferring the risk of product, registering the discharge- Road	FALSE	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
Unloading	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE
Verification	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
Work order selection (RBWS)	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE

g. RP: Roles Positions

RP	Dispatcher	Maintenance Manager	Retail Manager	Terminal Manager	Transportation Manager	Wholesale Manager
Business operation	FALSE	FALSE	TRUE	TRUE	TRUE	TRUE
Dispatcher / shift supervisor	TRUE	FALSE	FALSE	FALSE	TRUE	FALSE
Local Logistics person responsible for transportation	FALSE	FALSE	FALSE	FALSE	TRUE	FALSE
Local Retail	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE
Local Sales	FALSE	FALSE	FALSE	FALSE	FALSE	TRUE
Local product storage management	FALSE	TRUE	FALSE	TRUE	FALSE	FALSE
Maintenance management	FALSE	TRUE	FALSE	FALSE	FALSE	FALSE
Operator	FALSE	TRUE	FALSE	TRUE	FALSE	FALSE
Quality Control	FALSE	TRUE	FALSE	TRUE	FALSE	FALSE
SSC	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
Scheduler	TRUE	FALSE	FALSE	FALSE	TRUE	FALSE
Technical execution	FALSE	TRUE	FALSE	TRUE	FALSE	FALSE
Terminal manager	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE

h. IP: Individuals Positions

IP	Dispatcher	Maintenance Manager	Retail Manager	Terminal Manager	Transportation Manager	Wholesale Manager
MAINTEINANCE2	FALSE	TRUE	FALSE	FALSE	FALSE	FALSE
Dispatcher2	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE

IP	Dispatcher	Maintenance Manager	Retail Manager	Terminal Manager	Transportation Manager	Wholesale Manager
Terminal3	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE
Transportation2	FALSE	FALSE	FALSE	FALSE	TRUE	FALSE
Transportation1	FALSE	FALSE	FALSE	FALSE	TRUE	FALSE
Terminal1	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE
Terminal2	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE
Retail1	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE
Wholesale1	FALSE	FALSE	FALSE	FALSE	FALSE	TRUE
Dispatcher1	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE
Mainteinance1	FALSE	TRUE	FALSE	FALSE	FALSE	FALSE

i. IT: Individuals Tested

IT	AF-Actual_Performance	AF-Adat	AF-Availability	AF-Contamination	AF-Delivery	AF-Guideline	AF-KockÃ¡zat	AF-Performance	AF-Purchase	AF-Quality_of_the_Sample	AF-Risk_Assessment	AF-Szervezet	AF-pm_cost	TT-Acceptance_Procedure
MAINTEINANCE2	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	FALSE	TRUE
Dispatcher2	TRUE	TRUE	TRUE	TRUE	TRUE	FALSE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	FALSE	TRUE
Terminal3	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	FALSE	TRUE
Transportation2	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	FALSE	TRUE
Transportation1	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	FALSE	TRUE
Terminal1	TRUE	TRUE	TRUE	TRUE	TRUE	FALSE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	FALSE	TRUE
Terminal2	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE
Retail1	TRUE	TRUE	TRUE	TRUE	TRUE	FALSE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE
Wholesale1	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE
Dispatcher1	TRUE	TRUE	TRUE	TRUE	TRUE	FALSE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	FALSE	TRUE
Mainteinance1	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	FALSE	TRUE

(extract: the full table is available on request)

j. AP: Activity Positions

AP	Dispatcher	Maintenance Manager	Retail Manager	Terminal Manager	Transportation Manager	Wholesale Manager
100. Metrology	FALSE	TRUE	FALSE	TRUE	FALSE	FALSE
110.1.a Administrative return goods	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE
110.1.b Physical Return goods handling	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE
110.2. Off-spec product management	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE
120. Reporting	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE
Acceptance/transfer in tank	TRUE	FALSE	FALSE	FALSE	TRUE	FALSE
Calculating necessary transportation capacity	FALSE	FALSE	FALSE	FALSE	TRUE	FALSE
Checking loading conditions - Train	TRUE	FALSE	FALSE	FALSE	TRUE	FALSE
Checking loading conditions - Barge	TRUE	FALSE	FALSE	FALSE	TRUE	FALSE
Checking loading conditions - Road	TRUE	FALSE	FALSE	FALSE	TRUE	FALSE
Controlling the quality	TRUE	FALSE	FALSE	FALSE	TRUE	FALSE
Controlling the quantity - Barge	TRUE	FALSE	FALSE	FALSE	TRUE	FALSE
Controlling the quantity - Pipeline	TRUE	FALSE	FALSE	FALSE	TRUE	FALSE
Controlling the quantity - RTC	TRUE	FALSE	FALSE	FALSE	TRUE	FALSE
Controlling the quantity - RoTC	TRUE	FALSE	FALSE	FALSE	TRUE	FALSE
Create transportation plan for next day/shift	TRUE	FALSE	FALSE	FALSE	TRUE	FALSE
Defining optimal (target) replenishment inventory level	FALSE	FALSE	FALSE	FALSE	TRUE	FALSE
Ensure available capacity	FALSE	FALSE	FALSE	FALSE	TRUE	FALSE
Execution â€“ autonomous maintenance	FALSE	FALSE	TRUE	TRUE	TRUE	TRUE
Execution â€“ routine maintenance	FALSE	TRUE	FALSE	TRUE	FALSE	FALSE
Inspecting the vehicle	TRUE	FALSE	FALSE	FALSE	TRUE	FALSE
Inventory checking (FS & VMI accounts)	TRUE	FALSE	FALSE	FALSE	TRUE	FALSE
Inventory checking - managing data quality	TRUE	FALSE	FALSE	FALSE	TRUE	FALSE
Issuing the transport documents - Barge	TRUE	FALSE	FALSE	FALSE	TRUE	FALSE
Issuing the transport documents - Train	TRUE	FALSE	FALSE	FALSE	TRUE	FALSE
Issuing the transport documents-Road	TRUE	FALSE	FALSE	FALSE	TRUE	FALSE
Loading the transport means - Train	FALSE	TRUE	FALSE	TRUE	FALSE	FALSE
Loading the transport means - Barge	FALSE	TRUE	FALSE	TRUE	FALSE	FALSE
Loading the transport means -Road	FALSE	TRUE	FALSE	TRUE	FALSE	FALSE
Making preparations for product reception, reviewing the transport documents	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE
Monitor FS (VMI) turnover	FALSE	FALSE	FALSE	FALSE	TRUE	FALSE
Notification	FALSE	TRUE	FALSE	FALSE	FALSE	FALSE
Order generation for filling stations (VMI accounts)	TRUE	FALSE	FALSE	FALSE	TRUE	FALSE
Plan-Fact evaluation, controlling	FALSE	FALSE	FALSE	FALSE	TRUE	FALSE
Planning and Scheduling	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE

AP	Dispatcher	Maintenance Manager	Retail Manager	Terminal Manager	Transportation Manager	Wholesale Manager
Quality control - Barge	FALSE	TRUE	FALSE	TRUE	FALSE	FALSE
Quality control - Train	FALSE	TRUE	FALSE	TRUE	FALSE	FALSE
Quality control- Road	FALSE	TRUE	FALSE	TRUE	FALSE	FALSE
Receiving Retail business plans, forecasted delivery volumes	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE
Receiving Wholesale business plans, forecasted delivery volumes	FALSE	FALSE	FALSE	FALSE	FALSE	TRUE
Receiving actual information about delivery fulfillment from haulers	TRUE	FALSE	FALSE	FALSE	TRUE	FALSE
Receiving customer orders, forwarding to R&S	FALSE	FALSE	FALSE	FALSE	FALSE	TRUE
Receiving daily inventory and sales reports from FSs (and other VMI accounts)	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE
Receiving the transport means - Barge	TRUE	FALSE	FALSE	FALSE	TRUE	FALSE
Receiving the transport means - Train	TRUE	FALSE	FALSE	FALSE	TRUE	FALSE
Receiving the transport means-Road	TRUE	FALSE	FALSE	FALSE	TRUE	FALSE
Record keeping and registration in inventory	TRUE	FALSE	FALSE	FALSE	TRUE	FALSE
Sales forecasting	TRUE	FALSE	FALSE	FALSE	TRUE	FALSE
Sending confirmation about scheduled delivery time to local Sales organisation and/or customers and/or FS	TRUE	FALSE	FALSE	FALSE	TRUE	FALSE
Sending information about transportation plans to haulers and/or terminals	TRUE	FALSE	FALSE	FALSE	TRUE	FALSE
Transferring the risk of product, registering the discharge - Train	TRUE	FALSE	FALSE	FALSE	TRUE	FALSE
Transferring the risk of product, registering the discharge - Barge	TRUE	FALSE	FALSE	FALSE	TRUE	FALSE
Transferring the risk of product, registering the discharge- Road	TRUE	FALSE	FALSE	FALSE	TRUE	FALSE
Unloading	FALSE	TRUE	FALSE	TRUE	FALSE	FALSE
Verification	FALSE	TRUE	FALSE	FALSE	FALSE	FALSE
Work order selection (RBWS)	FALSE	TRUE	FALSE	FALSE	FALSE	FALSE

k. AK: Knowledge Required for the Activity

AK	AF-Actual_Performance	AF-Adat	AF-Availability	AF-Contamination	AF-Delivery	AF-Guideline	AF-KockÃ¡zat	AF-Performance	AF-Purchase	AF-Quality_of_the_Sample	AF-Risk_Assessment	AF-Szervezet	AF-pm_cost
100. Metrology	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
110.1.a Administrative return goods	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
110.1.b Physical Return goods handling	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
110.2. Off-spec product management	FALSE	FALSE	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
120. Reporting	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
Acceptance/transfer in tank	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE

AK	AF-Actual_Performance	AF-Adat	AF-Availability	AF-Contamination	AF-Delivery	AF-Guideline	AF-KockÃ¡zat	AF-Performance	AF-Purchase	AF-Quality_of_the_Sample	AF-Risk_Assessment	AF-Szervezet	AF-pm_cost
Calculating necessary transportation capacity	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
Checking loading conditions - Train	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
Checking loading conditions - Barge	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
Checking loading conditions - Road	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	TRUE	FALSE
Controlling the quality	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
Controlling the quantity - Barge	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
Controlling the quantity - Pipeline	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
Controlling the quantity - RTC	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
Controlling the quantity - RoTC	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
Create transportation plan for next day/shift	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
Defining optimal (target) replenishment inventory level	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
Ensure available capacity	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
Execution â€“ autonomous maintenance	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
Execution â€“ routine maintenance	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	TRUE
Inspecting the vehicle	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
Inventory checking (FS & VMI accounts)	FALSE	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
Inventory checking - managing data quality	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
Issuing the transport documents - Barge	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE

AK	AF-Actual_Performance	AF-Adat	AF-Availability	AF-Contamination	AF-Delivery	AF-Guideline	AF-KockÃ¡zat	AF-Performance	AF-Purchase	AF-Quality_of_the_Sample	AF-Risk_Assessment	AF-Szervezet	AF-pm_cost
Issuing the transport documents - Train	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE

(extract: the full table is available on request)

l. RK: Knowledge Required for the Role

RK	AF-Actual_Performance-13	AF-Actual_Performance-14	AF-Adat-143	AF-Adat-144	AF-Availability-44	AF-Availability-45	AF-Contamination-27	AF-Contamination-28
Business operation	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
Dispatcher / shift supervisor	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	TRUE	FALSE
Local Logistics person responsible for transportation	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
Local Retail	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
Local Sales	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
Local product storage management	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
Maintenance management	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
Operator	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
Quality Control	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
SSC	FALSE	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE
Scheduler	FALSE	FALSE	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE
Technical execution	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
Terminal manager	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE

(extract: the full table is available on request)

m. PK: Knowledge required for the Position

PK	AF-Actual_Performance	AF-Adat	AF-Availability	AF-Contamination	AF-Delivery	AF-Guideline	AF-KockÃ¡zat	AF-Performance	AF-Purchase	AF-Quality_of_the_Sample
Dispatcher	FALSE	TRUE	FALSE	TRUE	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE
Maintenance Manager	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	TRUE	TRUE	FALSE	TRUE
Retail Manager	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
Terminal Manager	FALSE	FALSE	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE	TRUE	TRUE
Transportation Manager	FALSE	TRUE	FALSE	TRUE	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE
Wholesale Manager	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE

(extract: the full table is available on request)

n. IK: Knowledge required by the Individuals

IK	AF-Actual_Performance	AF-Adat	AF-Availability	AF-Contamination	AF-Delivery	AF-Guideline	AF-KockÃ¡zat	AF-Performance
MAINTEINANCE2	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	TRUE	TRUE
Dispatcher2	FALSE	TRUE	FALSE	TRUE	TRUE	FALSE	FALSE	FALSE
Terminal3	FALSE	FALSE	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE
Transportation2	FALSE	TRUE	FALSE	TRUE	TRUE	FALSE	FALSE	FALSE
Transportation1	FALSE	TRUE	FALSE	TRUE	TRUE	FALSE	FALSE	FALSE
Terminal1	FALSE	FALSE	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE
Terminal2	FALSE	FALSE	FALSE	FALSE	FALSE	TRUE	FALSE	FALSE
Retail1	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
Wholesale1	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE	FALSE
Dispatcher1	FALSE	TRUE	FALSE	TRUE	TRUE	FALSE	FALSE	FALSE
Mainteinance1	TRUE	FALSE	FALSE	FALSE	FALSE	FALSE	TRUE	TRUE

(extract: the full table is available on request)

o. IFit: Fit at the Individuals level

IFit	AF-Actual_Performance	AF-Adat	AF-Availability	AF-Contamination	AF-Delivery	AF-Guideline	AF-KockÃ¡zat	AF-Performance	AF-Purchase
MAINTEINANCE2	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE
Dispatcher2	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE
Terminal3	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE
Transportation2	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE
Transportation1	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE
Terminal1	TRUE	TRUE	TRUE	TRUE	TRUE	FALSE	TRUE	TRUE	TRUE
Terminal2	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE
Retail1	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE
Wholesale1	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE
Dispatcher1	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE
Mainteinance1	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE	TRUE

(extract: the full table is available on request)

p. PFit: Fit at the Position Level

PFit	AF-Szervezet	AF-pm_cost	TT-Acceptance_Procedure	TT-Ad_hoc_Sampling	TT-Asset	TT-Automatic_Tanker_Loading_Station	TT-Barge	TT-Barge_Gauging
Dispatcher	1	1	1	1	1	1	0	0
Maintenance Manager	1	0	1	0	1	1	1	1
Retail Manager	1	1	1	1	1	1	1	1
Terminal Manager	1	0.333333333	1	0.666666667	1	1	1	1
Transportation Manager	1	1	1	1	1	1	0.5	0
Wholesale Manager	1	1	1	1	1	1	1	1

(extract: the full table is available on request)

q. RFit: Fit at Role Level

RFit	TT-Discharging_Procedure	TT-Dispatcher	TT-Document	TT-Document_type	TT-Electronic_Dip_Stick	TT-Emptiness_Check	TT-European_Union_s_Transport_Regulations	TT-Excise_Duty_Licence
Business operation	1	1	1	1	1	1	1	1
Dispatcher / shift supervisor	1	0	1	1	0	0.5	1	0.25
Local Logistics person responsible for transportation	1	1	1	1	1	1	1	1
Local Retail	1	1	1	1	1	1	1	1
Local Sales	1	1	1	1	1	1	1	1
Local product storage management	1	1	1	1	1	1	1	1
Maintenance management	1	1	1	1	1	1	1	1
Operator	1	1	1	1	1	1	1	1
Quality Control	0.4	1	1	1	1	1	1	1
SSC	1	1	1	1	1	1	1	1
Scheduler	1	1	1	1	1	1	1	1
Technical execution	1	1	1	1	1	1	1	1
Terminal manager	1	1	1	1	1	1	1	1

(extract: the full table is available on request)

r. AFit: Fit at Activity level

AFit	AF-Adat	AF-Availability	AF-Contamination	AF-Delivery	TT-Acceptance_Procedure	TT-Ad_hoc_Sampling	TT-Asset	TT-Barge	TT-Barge_Gauging	TT-Chargeable_Loss
Order generation for filling stations (VMI accounts)	1	1	1	1	1	1	1	1	1	1

AFit	AF-Adat	AF-Availability	AF-Contamination	AF-Delivery	TT-Acceptance_Procedure	TT-Ad_hoc_Sampling	TT-Asset	TT-Barge	TT-Barge_Gauging	TT-Chargeable_Loss
Plan-Fact evaluation, controlling	1	1	1	1	1	1	1	1	1	1
Planning and Scheduling	1	0	1	1	1	1	1	1	1	1
Quality control - Barge	1	1	1	1	1	1	1	1	1	1
Quality control - Train	1	1	1	1	1	0.4	1	1	1	1
Quality control- Road	1	1	1	1	1	1	1	1	1	1
Receiving Retail business plans, forecasted delivery volumes	1	1	1	1	1	1	1	1	1	1
Receiving Wholesale business plans, forecasted delivery volumes	1	1	1	1	1	1	1	1	1	1
Receiving actual information about delivery fulfillment from haulers	1	1	1	1	1	1	1	1	1	1
Receiving customer orders, forwarding to R&S	1	1	1	1	1	1	1	1	1	1
Receiving daily inventory and sales reports from FSs (and other VMI accounts)	1	1	1	1	1	1	1	1	1	1
Receiving the transport means - Barge	1	1	1	1	1	1	1	1	1	1
Receiving the transport means - Train	1	1	1	1	1	1	1	1	1	1
Receiving the transport means-Road	1	1	1	1	1	1	1	1	1	1
Record keeping and registration in inventory	1	1	1	1	1	1	1	1	1	0
Sales forecasting	1	1	1	1	1	1	1	1	1	1
Sending confirmation about scheduled delivery time to local Sales organisation and/or customers and/or FS	1	1	1	1	1	1	1	1	1	1
Sending information about transportation plans to haulers and/or terminals	1	1	1	1	1	1	1	1	1	1
Transferring the risk of product, registering the discharge - Train	1	1	1	1	1	1	1	1	1	1
Transferring the risk of product, registering the discharge - Barge	1	1	1	1	1	1	1	0.25	1	1
Transferring the risk of product, registering the discharge- Road	1	1	1	1	1	1	1	1	1	1
Unloading	1	1	1	1	1	1	1	1	1	1
Verification	1	1	1	1	1	1	1	1	1	1
Work order selection (RBWS)	1	1	1	1	1	1	1	1	1	1

(extract: the full table is available on request)