Relationships between Project Interdependencies, Knowledge Creation and Knowledge Transfer

An explanotory study of the visual management tools in European companies

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Abstract

The number of project-based organizations is increasing every year; this increase indicates the need to understand the complexities and ascertain the best ways of managing them. In these organizations, where the multi-project complex environment is dominant, one of the main challenges is dealing with project interdependencies. Interdependency relationships among the projects can be better understood and managed if appropriate tools and techniques are used efficiently. Thus, the ultimate goal of this study is to investigate and evaluate the best methods practiced by project-based organizations to effectively manage the interdependencies among the projects and suggest a new approach to view and understand those relationships better. A number of past researches have emphasized that effective project interdependency management results in an increase of the project and portfolio success.

This research examines and explains the impacts of knowledge creation and knowledge transfer on interdependency management and vice-versa, by reviewing the existing literature and collecting data through multi-method qualitative study. In addition, the role of visual interdependency management and visual knowledge management tools are analyzed and compared, with the purpose of filling the gaps in the currently available literature, and investigating their moderating effects on interdependency management. Previous studies have found supporting evidence for the impacts of project interdependency management, knowledge creation and knowledge transfer on project success and organizational performance. However, there is no research targeted on how project interdependencies interact with knowledge creation and knowledge transfer. In order to investigate these interactions four project-based organizations from IT, multinational event management and consulting areas are involved in the semi-structured interviews. Additionally, as a part of qualitative study, questionnaires were undertaken to get access to valuable insights into the project and portfolio managers' experience in dealing with interdependencies among the projects in the selected cases. The study is explanatory, cross- sectional in nature and takes a mixed approach to theory.

The findings showed the presence of mutual impacts between knowledge creation, knowledge transfer processes and project interdependencies. The results revealed that the visual knowledge management tools, which are employed for the knowledge management, are beneficial in terms of project interdependency management as well. The visual interdependency management tools that are separately discussed in the existing literature, were found to be suitable for the knowledge management practices. Thus, it was found reasonable to integrate the visual interdependency management tools into the knowledge management area. As a result, these tools altogether serve to the efficient project interdependency management and lead to more successful project outcomes, which affect the organization's performance as well.

Keywords: *portfolio management, project interdependency management, knowledge integration, knowledge transfer, knowledge creation, visualization tools*

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List of Abbreviations

IPMA	International Project Management Association
KC	Knowledge Creation
KI	Knowledge Integration
KM	Knowledge Management
KMS	Knowledge Management System
KT	Knowledge Transfer
PI	Project Interdependency
PM	Project Management
PMBoK	Project Management Body of Knowledge
PMI	Project Management Institute
PPM	Project Portfolio Management
SPM	Single Project Management
VIM	Visual Interdependency Management
VKM	Visual Knowledge Management

1 Introduction

1.1 Choice of Subject

Complex multi-project environments lead to a number of challenges and issues, including the interdependency relationships among projects. Previous employment in both oil and gas, and education sectors have enabled us to acknowledge the difficulties in terms of interdependency. When talking about this issue, we realized that project interdependency (PI) is a common challenge in project-based organizations. Even though there were attempts to deal with the complications arising from the PIs, to ensure the effective sharing of the same information, technology, and human resources in our organizations, it was not possible to solve the issue completely. When the current literature was reviewed with the hope to find guidance to the suggested tools, techniques and methods that could help to manage the interdependencies, we came across some gaps that caught our immediate attention and later developed into an idea for a thesis research. We approached the PIs from different aspects, and eventually decided to investigate this topic through the lens of knowledge management in our thesis, to be able to learn more about the ways of dealing with interdependencies, the skills and tools needed to minimize the challenges and to contribute to the existing research in this field of study.

Knowledge management (KM) was chosen because it is considered as one of the most promising and diverse areas of business management to investigate, and has a presence throughout the complete life-cycle of the project. In addition, there are evidences of direct relationships between KM and PI in the existing literature. Although, different tools for managing PIs have been studied by previous researchers, there is a need to broaden the perspectives, to find new aspects of integrating different methods and practices to come up with the most suitable ways that will contribute to the practical and theoretical usage of these tools and methods. In this thesis, knowledge management, specifically knowledge creation (KC) and knowledge transfer (KT), and visual tools, which are used to enhance organization's ability to manage links and dependencies among projects, are analyzed. Thus, the present study aims to identify and explain the impacts of using visual tools in portfolio management and investigate its perspective to be considered within KM practices, which will be done by constructing a new model of relationships between PIs, KC and KT.

1.2 Theoretical Background

In the modern business world, organizations are widely implementing their operations through projects (Blomquist and Müller, 2006, p. 52; Reyck et al., 2005, p. 524; Newell et al., 2008, p. 34; Midler, 1995, p.172). As Artto et al. (2007, p. 144) point out, today, the management of a single project is not enough. Organizations should be able to manage several projects simultaneously as one entity, therefore, the Project Portfolio Management (PPM) plays a critical role in the contemporary business environment.

PPM is defined by Thiry and Deguire (2007, p.653) as a method used for selecting the right projects and for managing them by using the resources efficiently. Also, in contrast to single projects, PPM requires more holistic and strategic view. This usually combines previous experience, current simultaneous projects and future goals. The activities of PPM, excluding the selection of projects, typically include their continuous evaluation from the perspective of alignment with the corporate strategy (Cooper et al. 2001, p.362). PPM plays a central role in

implementing strategic management processes, as it involves the decisions about the activities taken to deliver organizational strategy through projects (Blichfeldt and Eskerod, 2008, p. 358-362; Artto et al., 2007, p.144; Dietrich and Lehtonen, 2005, p.388; Turner, 2009, p.39). There is a growing body of literature which recognizes that portfolios are accompanied with a complexity evolved from the multi-project environment, where the projects are dependent from each other on different levels and kinds (Aritua et al. 2009, p.34; Reyck et al., 2005, p.525; Collyer and Warren 2009, p.56). In light of recent studies on PPM, it is becoming difficult to ignore a significant role of Project Interdependency Management (PIM) in regulating interrelationships and adjusting the complexity arising from dependencies, which is why we consider PIM as a primary focus of our study. Effective PIM contributes to PPM and increases both project and portfolio's success rate (Teller et al., 2012, p. 597). Literature suggests that there are a number of tools and methods used to successfully manage project portfolios by developing a centralized view of the interdependent projects, analyzing the relationships among them and making decisions accordingly (Cooper et al., 2001, p.366; Reyck et al. 2005, p.525). Earlier studies on PPM mainly discussed the tools, frameworks and techniques for project evaluation, selection, prioritization, knowledge sharing and transfer between projects, as well as resource allocation (Martinsuo and Lehtonen 2007, p.56). While Thiry and Deguire (2007, p.653) describe PPM as a method used for selecting the right projects and managing them, Dye and Pennypacker (1999, p.141) define it as "the art and science of applying a set of knowledge, skills, tools, and techniques to a collection of projects to meet or exceed the needs and expectations of an organization's investment strategy". Killen and Kjaer (2012, p.555) took it further by studing the ways to enhance organization's understanding of interdependencies within a project portfolio and thus, achieve better strategic portfolio decision making. Cooper et al. (2001, p. 362) have conducted a study with the aim to identify best practices in portfolio management and investigate the best portfolio methods. From this perspective, Rungi's (2010a, p.4) study suggests that Visual Interdependency Management (VIM) tools can be considered as one the most effective and widely used techniques to deal with the interdependencies in project portfolios. The researches to date have discovered that PIs are treated and considered by practitioners in different levels (Rungi, 2010a, p.120; Ward et al.,2007, p. 7; Canonico and Söderlund, 2010, p. 803) and if PIM is not implemented for various reasons such as lack of time and guidelines, it may result in project delays, resource shortage or competition for the common resources (Formentini and Romano, 2011, p. 546; Rungi and Hilmola, 2011, p. 156).

So far the introduction has focused on project portfolio and PIs. The following part will discuss the knowledge integration processes in project-based organizations, represented by KC and KT, which have certain impacts on PIs. After reviewing the current literature, it was recognized that the integration of knowledge inventory of the company has a proximate effect on project activities (Skyrme, 2001, cited in Durant-Low, p.61; Styhre and Gluch, 2009, p.108). Knowledge integration can be encountered as a condition for the competitive advantage of the organization (Love et al., 2005, p.22). Throughout this paper, the term knowledge integration will refer to the efficient use of knowledge inventory by a project-based organization. In the pages that follow, it will be argued that knowledge integration can be best viewed through KC and KT processes (Styhre and Gluch, 2009, p.108; Pemsel and Wiewiora, 2013, p.41; Müller et al., 2013, pp.14-15), which are essential when project-based organizations develop complex projects with interdependencies within portfolios (Andersen and Hanstad, 2013, p. 236; Formentini and Romano, 2011, p.546; Lindner and Wald 2011, p. 877). The project-based organizations need to see the "big picture", understand the links and interactions among

projects, identify the existing gaps and recognize the needs for the transfer and development of new knowledge to be used in the future projects and operations. However, such organizations frequently fail with KC and KT practices (Andersen and Hanstad, 2013, p. 239; Lindner and Wald 2011, p. 877; Love et al. 2005, p. 12; Lindner and Wald 2011, p. 878), which are part of knowledge management (KM). The KM is commonly understood as a practice involving the four basic processes such as creating, capturing, transferring and reusing knowledge (Owen & Burstein, 2005, p. 138-153). Current literature highlights the importance of KC and KT to organizations, which operate in complex multi-project environment and have heterogeneous knowledge domains (Berggren et al., 2011; cited in Anderson and Hanstad, 2013, p.238). A number of authors emphasize that the temporary nature of projects leads to a decrease of the capability to periodically reflect upon experiences, learn, identify gaps, develop knowledge and efficiently transfer it to other projects (Andersen and Hanstad, 2013, p. 239). Likewise, Danilovic and Sandkull (2005, p.193) holds the view that project-based organizations face with challenges, such as knowledge exchange and getting a deep understanding about relationships among projects. The reason of the fail is usually related to the regular changes of project requirements and content, re-organization of project team, implementation of projects in different locations, resulting in spreading of personnel, which leads to the fragmentation and loss of the individual and organizational knowledge (Prencipe and Tell, 2001, p.1377; Lindner and Wald 2011, p. 878). Thus, the second focus of this paper will be drawn to KC, KT processes and their relationships to portfolio.

With respect to KT in project-based organizations, it is considered as an important process, where knowledge is "displaced" to a specific locations, where it is useful and important, driven by giving and receiving communication processes and information flows (Alavi and Leidner, 2001, p.119; Love et al., 2005, p.57; Matzler et al. 2008, p.303). In order to be able to transfer the required knowledge, it is necessary to cope with such obstacles as lack of time, trust, capabilities and prior knowledge, resource constraints, uncertainty and complexity of the organizational structure, low motivation of PMO members, shortage of formal and informal spaces, and technological obstructions (Riege, 2005, p. 18-31; Javernick-Will, 2013, p.25; Müller et al., 2013, p.14; Formentini and Romano, 2011, p. 545; Love et al., 2005, p.59).

Having defined what is meant by KT, we will move on to discuss what is the KC, in this thesis. Any project-based organization, which is aiming to be competitive in the long-term perspective, needs to continuously create knowledge, in order to adapt to the fast changing world (Yang, Fang and Lin, 2010, p. 231; Love et al., 2005, p. 42). KC can be achieved by building new content or by replacing existing content (Pentland, 1995, p.7) through social, collaborative or individual thinking processes (Nonaka, 1994, p.19).

It is also worth noting that the selection of appropriate knowledge management activities and tools for the knowledge transfer and creation processes are essential for the success of the firm, which is argued by Andersen and Hanstad (2013, p. 236) in his study of the Vancouver Olympic Winter Games. To manage organizational knowledge, the IT-based knowledge management tools are largely used in modern organizations (Alavi and Leidner, 2001, pp.114-115). Currently, KM tools are extensively represented by a new promising technique such as visualization tools. These tools can help to deal with multi-tasks of organizations to coordinate individuals, to keep an attention, to improve remembrance of knowledge and enhance a motivation (Burkhard and Meier, 2005, p.474; Burkhard and Eppler, 2007, p.119; Cañas et al.

2005, p.205). Hence, we decided to consider the visual management tools as a last focus of this study.

1.3. Research Gaps

The current study aims to fill the gaps identified during the comprehensive literature review in Chapter 3 and briefly described in this part. Although, the importance of PIM is acknowledged by Project Management Body of Knowledge (PMBoK Guide, Project Management Institute, 2013, p.6) and ISO 10006 Quality Management Systems (Rungi, 2010, p.117), it still remains as a weakly covered, briefly defined and underexplored area of PPM (Elonen and Artto, 2003, p.397; Rungi, 2010a, p.117; Rungi and Himola, 2011, p. 158; Killen and Kjaer, 2012, p. 555; Staudenmayer, 1997, p. 27). The current state of PIM does not fully investigate practical and potential application of comprehensive methods and tools, which can be broadly used in various sectors of business (Killen, 2012, p.805; Söderlund, 2004, p. 659; Collyer and Warren, 2009, p. 359). ***Therefore, PIM will be presented as a first concept to be explored in this research.***

To cope with the challenges emerging from complexities within multi-project environments, the KC and KT processes are considered essential (Styhre and Gluch, 2009, p.108; Danilovic and Sandkull, 2005, p.193; Thiry and Deguire 2007, p. 649; Andersen and Hanstad, 2013, p. 239; Love et al. 2005, p. 12; Lindner and Wald 2011, p. 878) as a part of knowledge integration activities. So far, however, there has been little discussion about the theoretical models, management techniques and tools, which can support the implementation of KC and KT processes in the context of project-based organizations (Hong, 2012, p.211; Love et al., 2005, p. 43; Du Chatenier et al., 2009, p.371; Todorović et al., 2014, p.773; Formentini and Romano, 2011, p.546; Lindner and Wald 2011, p. 877; Massingham, 2014, p. 1098). We recognize that much more effort and consideration is required to better understand and manage these processes (Durant-Low, 2012, p.76), as the current literature does not fully serve the existing need. Moreover, we recognize that complexities arisen from multi-project environments include the difficulties related to PIs, and if KC and KT can help to solve challenges of such environments, they can also positively influence PIM in the organizations. Even though, more recently researchers have mentioned connections between complex multi-project environments and KC, KT processes (Andersen and Hanstad, 2013, p.239; Danilovic and Sandkull, 2005, p.193), little to nothing is known on how to review this processes holistically from the perspective of PIs. Therefore, ***KC and KT processes within knowledge integration will be our second target of investigation, in order to shed light on their interaction with the PIs in project portfolios. Eventually, it leads to the assignment of relationships between PIs, KC and KT processes in portfolios as a unit of our analysis.***

It was found that few numbers of academic papers investigate new forms of visual knowledge representation, and understanding of their advantages and limitations (Burkard and Meier, 2005, p.480; Eppler and Burkhard, 2007, p.112-113). On the other hand, the current theories of KM do not sufficiently present the potential usage of visual representations for the creation and transfer of knowledge (Burkhard, 2005, p.138) in multi-project environments. New techniques and tools are required to better understand and manage relationships among projects represented by knowledge artefacts, people relationships or other interdependencies (Durant-Low, 2012, p.76), because traditional tools can not serve these purposes (Burkhard and Meier, 2005, p.475). There is absence of study which considers knowledge visualization tools as an instrument to manage interdependencies between projects, thus to better manage project portfolio. ***In***

addition to above-mentioned gaps, this thesis also attempts to investigate the potential application of visual knowledge management (VKM) tools and their ability to deal with project interdependencies (PIs), and to organize effective KC and KT processes in project-based organizations.

We are planning to investigate and explain the relationships between above-mentioned notions based on qualitative research design and through multiple-case study to collect data grounded on subjective perspectives. The rationale behind this decision is also connected with the paucity of evidences in the previous researches that mainly consider the objective perspectives to the knowledge and social entities (Nonaka and Peltokorpi, 2006, p.81). Multiple-case study, on the other hand, will contribute to the current study by providing rich information on the topic in diverse sectors to achieve the illustration of relationships from different stances. The explanatory multi-method approach and constructive nature of this study will shed new light on the PIM and KI areas of business management and will fill the gaps in the current literature.

To sum up, it has been pointed out that the previous studies recognize the main challenges that project-based organizations encounter because of PIs, although there are tools and techniques that can be efficient in dealing with those issues. It was also mentioned that the existing studies show the importance of KT and KC in terms of managing PIs, and a couple of attempts have been found in the literature suggesting that also knowledge integration processes can get affected from the existence of complexities and interdependencies in the project portfolio. Moreover, in this introduction the VIM and VKM tools have been emphasized as a means of balancing and managing PIs and knowledge integration among the projects respectively. However, no previous study has investigated the possibility of integrating and merging these two types of visual tools within KM area.

1.4 Purpose of the Study

This study sets out to investigate the relationships between KC, KT and PI, in an attempt to examine how and to what extent they impact each other. Moreover, this research provides an important opportunity to advance the understanding of challenges of project-based organizations in terms of impact of KI, encompassing KC and KT processes, on interdependencies among projects. This work presents new insights into the investigation of tools and techniques to identify, collect and transfer knowledge. Furthermore, the present research views and connects, the VKM and VIM tools by distinguishing two sides to attain differences and common features. Therefore, present study is expected to make significant contributions to the research on PIM, KM and application of visual tools on both of them. For this purpose, four organizations representing three areas, which are IT, consultancy and mega-event management, will be investigated within this study to gain an overview from diverse industry categories. All the cases that are involved in the research are project-based organizations with interrelationships among projects and the study will be conducted in multi-method qualitative way, for which both semi-structured interviews and questionnaires are employed.

The main purpose of this thesis is to investigate and identify the relationships between PI, and KC and KT, and to build a coherent model to illustrate the interplay between these phenomena. Moreover, this study systematically reviews the selected concepts and intends to explain the impacts of using VIM tools and their potential to be considered within the KM practices, that are also included in the model. At the end, it is aimed to examine and reveal whether the developed model will influence project outcomes.

1.5 Research Questions

Based on the above-mentioned reasons and discussions, a necessity of investigating the relational links among PI, KC and KT builds a foundation for the present study which is designed to answer the following research questions:

Why and how do the KT and KC processes impact the interdependencies among projects in the project-based organizations?

Why should visual interdependency management tools be used as part of knowledge management practices?

1.6 Objectives

By answering the research questions presented above, the present study aims to fulfill the following objectives:

- To explore the impacts of KC and KT processes on the project interdependencies;
- To investigate why the visual knowledge management tools can be used to deal with the interdependencies among projects;
- To identify the reasons of integrating the visual interdependency management tools into the knowledge management are.

According to objectives, this study is focused on relationships between PI and KI, encompassed by the KC and KT, as illustrated in Figure 1. Moreover, this model displays the links from two types of tools, which are visual interdependency management and visual knowledge management tools, leading to the areas they are directed to, namely PI and KI. The understanding of the concepts mentioned in the model is based upon the current literature, described in the literature review (chapter 3). KI is differentiated in 2 counterparts: KC and KT. In order to investigate and understand whether the relationships between the chosen phenomena exist in practice, we will thoroughly review the literature and conduct qualitative study following these steps:

- Data will be collected from the selected four companies that represent three sectors, through semi-structured interviews and questionnaires;
- The empirical findings will be analyzed qualitatively following the cross-case strategy, which includes case-by-case analysis and their summary;
- The results of the data analysis will be compared with the theoretical data gained from the literature review. Hence, the benefits and drawbacks of PIs, KI, as well as the functions and features of VIM and VKM tools collected from the literature and practice will be paralleled in order to investigate the relationships between two main phenomena (PIs and KI), to understand the usability of VKM tools for PIs and to identify the potential integration of VIM into KM;
- Conclusions will be drawn based on the results of this discussion.

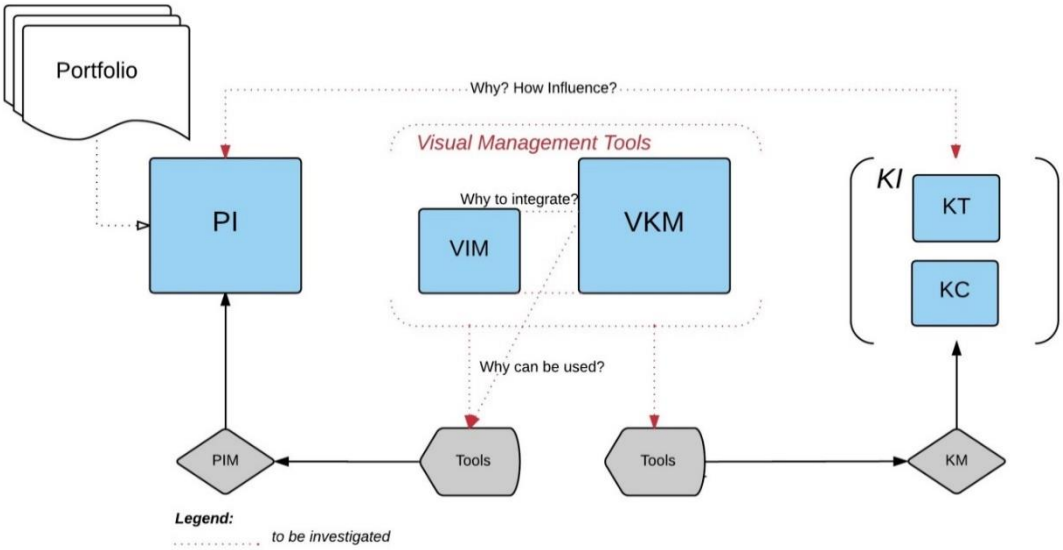


Figure 1. Model on the relationships between PI and KC, KT based on the research questions and objectives

1.7 The Structure of the Study

This paper begins with Section 1, Introduction, which provides an overview of the current study, describing the theoretical background and research gaps that it aim to fill by following the guidance established by research questions and identified objectives. Thus, this section aims to familiarize the reader with the subject of study and its significance.

Section 2, Research Methodology, begins by laying out the philosophical dimensions and assumptions that had an impact on the methodological choices. The section gives a brief overview of the research strategy, research design and approaches by describing them and explaining the methods selected for the present study.

Next part, Section 3, Literature Review, is organized according to the topics that build a frame for the theories that have been covered in the current literature. While the first parts present the project management, PPM and PIM, next parts discuss the KM concepts, namely knowledge integration, which consists of KT and KC processes and their challenges. The concluding part of the section proceeds with the visual interdependency and knowledge management tools, outlines the similarities, differences and merges the two previously unconnected types of tools which leads to the formulation of the model that illustrates all the relationships among the notions described in the section. Thus, as an outcome, a graphic display is presented at the end of the Literature Review Section.

Section 4, Empirical method, addresses the case selection criteria, respondents selection and semi-structured interview design and procedure followed by a questionnaire procedures and design, data analysis procedure, truth criteria and ethical considerations that guided the current research study.

Section 5, Data analysis, introduces the empirical data collected through multi-method qualitative study and analyzed based on the categories derived from the templates. The analysis

consists of the following steps: case-by-case analysis of both interview and questionnaire results, according to the themes and categories, and cross-case analysis.

Section 6, Discussion, is concerned with the findings from the results of empirical data analyzes and comparison of these findings with the theoretical framework discussed in the literature review section.

Section 7, Conclusions and recommendations part is divided into four sections: main conclusions, theoretical implications, managerial implications, limitations and future studies. Thus, this section lays out the contributions of the current thesis by summarizing the answers to each research question, mentions the strengths and in addition highlights the specific recommendations for future research derived from the limitations of the study.

2. Research Methodology

In this chapter, methodological considerations and assumptions that direct the current research in terms of Chapter 3, literature review, Chapter 4, empirical method, Chapter 5, data analysis and Chapter 6, discussion, are explained. In order to answer the research questions and achieve the research objectives, constructivism is deemed as the most appropriate ontological philosophy, whilst critical realism and "mixed" approach are employed to conduct qualitative study. Moreover, multiple-case and explanatory study methods are adopted to obtain rounded and in-depth understanding of the phenomena.

2.1 Research Philosophy

The definition of the philosophical views that have been adopted for this study is the starting point, which provides the guidelines for the research. According to Creswell (2013, p.16), research philosophy refers to the author's philosophical beliefs, assumptions and knowledge of ontology, epistemology and axiology. It is an important stage where the decisions on how the research will be conducted and assumptions on how we view the world are presented (Saunders et al., 2012, p.128).

According to Long et al. (2000, p.190), ontology refers to assumptions concerned with the nature of social reality, which contains objective and subjective reality. While objectivism implies that social entities exist in reality external to social actors, which can influence them, subjectivism presents a standpoint that social phenomena are socially constructed. Each individual may develop a subjective meaning of the reality (Bryman and Bell, 2011, p.21). The ontological standpoints influence further choices of research methods (Evans and Hardy, 2010, p. 18).

Epistemology, on the other hand, concerns the basis of acceptable knowledge and how it can be transferred to others (Long et al., 2000, p.190). Saunders et al. (2012, pp.134-137) distinguishes three major philosophical stances within epistemology: positivism, realism and interpretivism. Positivism is a philosophical position that supports the application of natural science methods and views reality to be external and objective, which usually leads to a law-like generalization as an end-product of statistical analysis (Saunders et al., 2012, p.134). In positivism, knowledge develops by examining and observing the objective reality (Blumberg et al., 2011, p.20). Realism has two major forms – empirical realism and critical realism, also shares a similar view to the external reality (Bryman and Bell, 2011, p.17). It is a position based on the philosophy that "objects have an existence independent of the human mind" (Saunders et al., 2012, p.136). Interpretivism, however, holds the view that reality is socially constructed and subjective, therefore, it is important to differentiate the role of humans as "social actors" (Saunders et al., 2012, p.137). Interpretivist philosophy is constituted upon the view that the knowledge about the complex world cannot be generalized and thus, the social roles of others should be interpreted by giving the subjective meaning to their actions and "making sense" of the world around us (Saunders et al., 2012, p.137, Bryman and Bell, 2011, p. 17).

Considering the undertaken research, our stance is ***constructionism (subjectivism)***, because it represents the belief that people interact with their environment and each other, and hence, they construct social reality through this interaction (Creswell, 2014, p.8). Moreover, the purpose of this study relies on the understanding of ***subjective*** meanings based on participants' views of the social world and thus, their ability to generate a model of relationships between PIs and KT,

as well as KC processes in an organization. According to this ontological position, the meanings and types of social phenomena are generated by social actors as a result of the social interaction, which is constantly revised in accordance with this ontological position (Bryman and Bell, 2012, p. 32). We aim to capture these meanings (David andSutton, 2011, p. 78) and as a result, to have a holistic picture about relationships among individuals and its associated issues. As subjectivism will be helpful to learn about the individual approaches, experiences and opinions of managers, it is exploited as an ontological position for the current study. Upon reviewing the existing literature, it was determined that the majority of scholars present an objective perspective of knowledge and social entities; there are few works with subjective perspectives (Nonaka and Peltokorpi, 2006, p.81). This is another reason to review the topic in subjective perspective.

We recognized the importance of deep and multilevel study of the ever-changing social world. Thus, it leads to rationally investigate a topic of project interdependency within portfolios, by gaining an understanding of the situation, the tools and techniques that are used or can be used to manage it, through the lenses of realism. This will once again serve the main purpose of the study, which is to create a ***model of relationships in project portfolios***. Thus, this study holds the standpoint of ***critical realism*** (Saunders et al., 2012, pp. 136-137).

According to Bhaskar (2011, p.2), reality can be understood only if the structures and actors creating it are identified through the practical and theoretical approaches of the social sciences. Realism is the stance between two extremes, which perfectly reflects our epistemological relativism perspective and fits the research questions, that intend to explain the topic of visual tools from interdependency and KM aspects. For this reason, a balance between positivism and interpretivism should be preserved and critical realism is a choice, which is viewed as an alternative to positivism and idealism (Sayer, 2004, p.6). Three philosophical views of critical realism are distinguished by Patenkamp and Botterill (2013, p.112): differentiated ontology, epistemic relativism and judgmental rationality.

Critical realism is a relatively new approach (Easton, 2010, p.119) and it is claimed to be ontologically least limiting and epistemologically most "heuristically suggestive" perspective (Bhaskar and Danermark, 2006, p.295). This perspective suits the aims of the current study, which include providing an explanation to relationships between interdependency and KM processes. In the same vein, Easton points (2010, p.119) out that explanation is "the most fundamental aim of critical realism". Critical realists believe in a socially constructed world, but from a "realist" perspective, complexities do exist in different situations. For example, the researchers can break down stories sometimes, to be able to see a clearer picture (Easton, 2010, p.199). As per Sayer's (1992, pp.3-6) view on realism, social phenomena must be critically evaluated in order to achieve a better understanding these phenomena. Furthermore, we are also in favor of the critical realism, because it helps the researcher to describe and explain the real world in causal language and a performative way, thoughtfully reflecting the realities connected to the project managers' daily lives (Easton, p.119).

2.2 Research Approaches

Predominantly, there are two research approaches that determine the steps to construct a research study: deductive and inductive (Bryman and Bell, 2011, p.11). When hypotheses are deduced to develop a theory and test them through propositions leading to a confirmation or rejection, a deductive approach is being followed (Saunders et al., 2012, p.145). Inductive

approach, as opposed to deduction, entails collection of data based on observations and findings to build a theory (Bryman and Bell, 2011, p.13). Thereby, theory is the starting point for the deductive approach and the outcome of the inductive approach. According to Saunders et al. (2012, p.145), the key feature of the deductive approach is structured methodology in order to ensure reliability, an ability to measure the facts quantitatively and a reduction of problems to the simplest elements and generalization all of which require a careful selection and sufficient sample size.

Presently, several studies address the problem of KM in project-based organizations through case studies and qualitative research (Lindner and Wald 2011, p. 877) based on an inductive approach. However, it does not mean that the deductive approach should be neglected for the investigation of the subjects in qualitative studies (Hyde, 2000, p. 85). Gummesson (2007, p.229) in his research study, highlights that case studies mainly provide an inductive approach to the study, but can also be deductive or a mix of the two. This research is based on general principles and existing theories. By analyzing them, conclusions about individual phenomena will be drawn and an inductive approach will be used to understand and explain the interaction of social actors that create that phenomena. Based on the above-mentioned, it can be stated that the current work employs a ***"mixed" approach***, in essence a deductive approach is employed with some elements of inductive approach. This will help to identify research gaps in the literature, establish a frame by which research questions are fulfilled, and contribute to the existing theory by conducting multiple-case studies, and eventually analyzing the findings.

2.3 Research Strategy

Saunders et al. (2012, p.680) describes research strategy as a plan to help and define the methods that will lead to the answers of the research question. It can be viewed as a general orientation to the overall research and making a decision between the qualitative or quantitative strategies for data collection to conduct a research. By taking ***constructivism*** as the ontological stance and seeing the ***reality as subjective*** and constructed by the individuals (Long et al., 2000, p.190), the topic of this research is also viewed from the ***managers subjective perspective and individual perceptions***. Although, we initially planned to collect data through quantitative surveys alone, later, when an in-depth literature review was done it became obvious that each individuals' opinion should be collected through interviews and thus, a qualitative analysis needed to be performed (Ghauri and Grønhaug, 2010, p. 103). Consequently, it was decided that both questionnaire and interviews would be employed for the qualitative data collection and analysis. Another reason for the change from quantitative to qualitative study, was a need to "get as close to the subject of interest as possible" (Bromley, 1986, p.23). It is presumed that the research topic has not been well covered in the current literature and there is a necessity to fully understand and explain the phenomena that may lead to the development of the existing theory. Therefore, qualitative research is the best fit for this study (Edmondson and McManus, 2007, p.1155).

Having a constructivist position with critical realism approach, and identifying the value of subjective perspectives in terms of research objectives, preference was given to the qualitative nature of research (Long et al., 2000, p.191, Bryman and Bell, 2007, p.402). Sayer (1992, pp.3-6) suggests that qualitative methods of explaining the relations are more effective than quantitative ways of "assessing regularities", as realism substitutes the regularity in social sciences. The qualitative research is performed in a basic and interpretive way because

researcher drives the study when using the quantitative method (Bryman and Bell, 2007, p.425; Merriam, 2009, p.22).

2.3.1 Qualitative Study

The choice of engaging in a multi-method qualitative study using various techniques to collect the data, including both structured interviews (questionnaires) and semi-structured interviews holding the cross-sectional research strategy is in line with the epistemological stance of the study (Eisenhardt, 1989; Saunders et al., 2012, p. 165).

The qualitative methods provide an examination of the subject through the project team members' eyes (Bryman and Bell, 2011, p. 627). The chosen method is also particularly useful for the investigation of the phenomena that have not been covered in the literature before (Barker et al., 2002, p. 74) and to recognize patterns in participants' responses (Silverman, 2011, p. 16). To be able to recognize new phenomena we developed our "theoretical sensitivity" by reviewing the existing state of the literature and past experiences of practitioners to build a theoretical frame for the study (Strauss, 1987, p. 11). Also, we established an open conversation with the interviewees to create a platform where respondents can freely express themselves (Barker et al., 2002, p. 74). By doing so, we were able to see how people expound their experiences, the type of meaning they impute into it, and how they form their environments (Merriam, 2009, p.23). During the interview transcribing process the attention to the non-verbal signals was not fully documented (Silverman, 2011, p. 20), as it is not within the scope of this study. Altogether, this qualitative research comprises the "collection, organization and interpretation" (Malterud, 2001, p. 483) of semi-structured interviews and questionnaires for extracting the empirical data. The unit of analysis (phenomena) in this study is the relationships between PIs, KC and KT processes in project-based organizations.

2.4 Research Types

Research can also be distinguished in terms of research types, which are often categorized as: exploratory, descriptive and explanatory (Saunders et al., 2012, pp.170-172). Being adaptable and flexible, exploratory studies usually involve a clarification of the understandings of the problem and seek new insights by conducting mainly unstructured in-depth interviews to collect and analysis data (Saunders et al., 2012, p.171). In the other hand, descriptive studies are set up to profile and categorize the data, which requires having a clear picture of the topic. Explanatory research is normally concentrated on the relationship between variables and often aims to get a clear view of the situation or interactions by using both quantitative and qualitative data.

As discussed above, the objectives of this thesis are to explore the impacts of the KC and KT processes on the project interdependencies, to determine why the visual knowledge management tools can be used to deal with the interdependencies among projects, investigate and explain the reasons of integrating the visual interdependency management tools into the knowledge management area. For this reason, this research can be described as an ***explanatory study***. While the current literature has discussed the main phenomena of the studies previously, the perspective and approach to it is different and we believe that closer attention needs to be paid to this area of research. Hence, it can be stated that the choice of explanatory research is the most suited to the study (Edmonsdson and McManud, 2007, p.1177). Moreover, the choice

of explanatory study fits our critical realism position, as "the most fundamental aim" of this epistemological stance is explanation (Easton, 2010, p.119).

2.5 Research Design

The research design aims to create a framework or structure for the collection of data and its analysis (Bryman and Bell, 2011, p.69, Creswell, 2013, p.49). According to Bryman and Bell (2011, p.68) there are five research designs in business research, which are: experimental, cross-sectional, longitudinal, case study and comparative. Saunders et al. (2012, pp.173-191) on the other hand, distinguishes archival research, case study, ethnography, action research, grounded theory and narrative inquiry as research strategies; there are linked to a qualitative research design. Cross-sectional and longitudinal studies are defined separately as two types of research design divided based on time criteria. The choice of the strategy for this research is coherently linked to the research question and objectives of the study. Further, time is also considered a large constraining factor. Thus, having a requirement to conduct the study within the framework of a particular period of time, this research is considered ***cross-sectional*** (Saunders et al., 2012, p.190). As such, it is possible to perform the study as a cross-sectional study, with either a large or smaller sample. Since, this study is explanatory, the second option was chosen.

The ***case study*** approach is considered appropriate for the current study because this method focuses on the diverse contexts (Eisenhardt and Graebner, 2007, p. 25), which cannot be changed by the researchers. They explore this context to understand them better (Yin, 2013, p. 14; Merriam, 2009, p.39). Case studies allow studying complexity, context and ambiguity, thus providing a holistic and systemic approach (Gummesson, 2007, p.229) within the inductive part of mixed-method study (Merriam, 2009, p.39). Chosen bounded systems or cases, which are instances of a particular issue, can be distinguished by their heuristic features, where we aim to investigate the phenomena and capture a sophisticated picture of the environment (Merriam, 2009, pp.41-44). According to Yin (2003, p.5), case studies can be divided as single or multiple, and exploratory, descriptive or explanatory. The present research is identified as an explanatory multiple case study.

2.5.1 Multiple Case Study

To minimize bias and incomplete data, and to increase the research's generalizability (Remenyi et al., 1998, p. 168), we decided to perform a ***multiple case study.*** This fits the research purpose better than single case study. By employing this research design, deep empirical investigation of the chosen phenomena can be performed (Saunders et al., p.179), because multiple cases can provide better variance and more demonstrative investigation (Merriam, 2009, p.49). According to Flyvbjerg (2006, pp.219-245) case studies should not be considered a limitation to the generalizability or a constraint to the summarization of propositions and theories from findings, because the difficulty in summarizing empirical data is related to the context of the study, not to the type.

Multiple case studies enable us to use a triangulation method for data collection, which then combines the application of semi-structured interview and questionnaires to get more valuable insights from multiple sources. Focusing on the perceptions and experiences of project, portfolio and program managers from different sectors, as well as involving an expert would be

beneficial in terms of enlarging the capacity and increasing the reliability of the study. In addition, according to Easton (2010, p.199), using case studies is very suitable to the critical realist approach. However, it should be used to study complex phenomena, such as organizations, for example, rather than individuals' behavior. In this study, discovering the answers to the "how" and "why" questions by explaining the interdependencies and knowledge management in organizations through multiple sources of data are key. In the end, this research process creates a holistic view of the social situation in the real world (Easton, 2010, p.199). Sayer (2000, p.19) describes case study as an intensive research method that perfectly matches the critical realist ontology. The case study reviews the perspectives of individual agents in a certain context and includes causal explanation by analyzing data collected through qualitative methods, such as interviews. It is attempt to obtain a deep understanding of the impacts and relationships between PIs and KM as a whole. In addition, we want to achieve the overall view of how KM impacts interdependencies in project portfolio. As a result, a multi-method qualitative research and multiple cases studies will fit the aim to collect data by using more than one qualitative technique and analyzing different cases.

2.6 Literature Selection Methodology

In order to find relevant articles on the topics of ***project portfolio, project interdependency management, knowledge management*** *and* ***visual management tools*** both the Umeå University and Heriot-Watt libraries' electronic sources and hardcopies were used. The libraries' search engines, Google Scholar, DiVa system and EBSCO provided an access to reliable sources, where academic articles of business journals can be found. Thus, full access to Emerald Insight, Sage Journals Online, Elsevier ScienceDirect Journals, International Journal in Project Management, Project Management Journal and Journal of Knowledge Management, was gained. Additional to journals, conference papers and PhD dissertations were also used, in order to obtain a wide range of relevant knowledge from previous studies on the subject of current research. Although using secondary citation have always been avoided, sometimes it was not possible to find primary sources of the literature due to the reason that they were not available from any of the above-mentioned sources. During the theoretical framework, we tried to take broad view on the existing literature and cover various aspects of the topic. As a result, several key search words and their combinations were used, such as: ***project interdependency, visual interdependency management, knowledge management in project-based organizations, impacts of knowledge management on the project success, visual tools in knowledge management.***

In this regard, project portfolio, project interdependency management, knowledge, knowledge management are considered as general areas of relevance, whereas, visual knowledge management tools and visual interdependency management tools are part of specific aspects of interest. Moreover, the different combinations of key words enabled us to focus on the literature that may not be directly related to the topic, but could be considered important for the investigation of other contexts.

3. Literature Review

In this chapter, where the significance of the study is demonstrated by using existing literature, concepts and theories that are relevant and applicable to the investigation will be established. The chapter includes the presentation of the current knowledge base and the reasoning behind the conceptual model of the study, which is presented in three parts. It begins with a review of the project and portfolio management, interdependency among projects and interdependency management practices. Next, the chapter represents the importance of knowledge integration in project-based organizations, encompassed by KC and KT processes. Moreover, we will discuss knowledge management, by highlighting the knowledge management tools and techniques, which are used to control such processes. The chapter ends with the important insights into the visual representation literatures to simultaneously review visual interdependency management and visual knowledge management tools and build a coherent model. The main findings summarized in the chapter and identified research gaps will be discussed further and compared with empirical findings in the sections 6 and 7.

3.1 Project and Portfolio

As a business process, both on strategic and operational levels, project management has become very valuable for many organizations. Consequently, the number of supporters of the assumption that project management will take over general management is constantly increasing (Perminova et al. 2008, p. 73). It is important to distinguish the terms project and project management as two different phenomena. Archer and Ghasemzade (1999, p.208) define project as a complex effort with a specific aim, budget and timeframe. There are other definitions of a project as well. For example, Turner (2009, p.2) suggests that a project is "a temporary organization", whereas PMBOK (Project Management Institute, 2013, p.1) defines it as a "temporary endeavor undertaken to create a unique product, service, or result". On the other hand, project management can be defined as "the process of controlling the achievement of the project objectives", which involves the application of specific tools and techniques (Munns and Bjeirmi 1996, p.81).

Project objectives determine the success of projects; the Project Management Institute (2013, p.35) suggests to measure a project's success after its completion in terms of time, cost, quality, scope, resources and risks "as approved between the project managers and senior management". Turner (2009, p.114) adds more criteria to that, suggesting that stakeholders' satisfaction should be taken into consideration, evaluating whether the end product achieves the goals and if performance targets are met.

Projects cannot exist as an island; they are not isolated from time and space factors (Engwall, 2003, p.790). According to Müller et al. (2008, p. 28) "projects influence and are influenced by the complex and uncertain character of their context", which is set by the project portfolio where the project is a part of. Archer and Ghasemzade (1999, p.208) define portfolio as a group of projects, also reporting that there is a competition for resources available among the projects in portfolio. Moreover, there is an interrelationship and interdependency between projects (Staudenmayer, 1997, p. 31), which is considered in PM. Whilst compared with Single Project Management (SPM), which can be characterized by standard tools, techniques and defined procedures (Dietrich and Lehtonen, 2005, p.385; Nidomolu, 1996, cited in Teller et al., 2012, p.598), PPM is more complex by nature, and gives more importance to effectiveness in addition to efficient execution (Teller et al., 2012, p. 596). Turner (2009, p.325) differentiates projects and programs from a portfolio, highlighting that projects within portfolio have a shared goal,

which also leads to a competition for the common resources. The term portfolio is used synonymously with the term project portfolio in this study.

3.2 Project Portfolio Management

Although, Martinsuo and Lehtonen (2007, pp.56-63) identifies that success factors of a single project are positively correlated with the portfolio efficiency in general; managing single projects effectively is not the main goal of modern organizations. It became more important to be able to manage several projects simultaneously as one entity, which is why PPM plays a significant role in today's business world. PPM is central for organizations from a strategic and competitiveness point of view, as innovation and change, that require large amounts of investments, are done mainly through projects (Killen et al., 2009, p.1). The activities of PPM, besides the selection of projects, typically include continuous evaluation, from the perspective of alignment with corporate strategy (Cooper et al., 2001; p.362). Blichfeldt and Eskerod support this claim (2008, p. 358-362) by noting that PPM plays a central role in implementing strategic management processes, mainly because it involves the decisions about the activities taken to deliver organizational strategy through projects (Elonen and Artto, 2002, p.395; Dietrich and Lehtonen, 2005, p.388; Teller et al., 2012, p.598; Levine, 2005, cited in Rungi, 2009c, p.1508; Turner, 2009, p.39). Literature suggests that there are a number of tools and methods used to successfully manage project portfolios (Cooper et al., 2001; 374). Hence, a range of studies state that PPM has an important strategic role that helps to choose right projects, and thus, deliver and shape the strategy. Moreover, its objectives include maximizing the value of the portfolio and balancing the portfolio (Cooper et al., 1999, pp.334-335). It depends on the organization to weight the importance of each factor and balance them in a relationship to risks, market and short, long-term goals. According to Cooper et al. (2001, 365) is important not only to achieve focus, balance, financial goals, efficient allocation of scarce resources, to gain market share and increase sales, to ensure the strategic alignment, to better communicate the objectives (vertically and horizontally within the organization), but also to provide better objectivity within the project selection. It does not come as a surprise that majority of the early researchers focused on the project selection and prioritization. Archer and Ghasimzadeh (1999, p.208) reported the significance of the usage of techniques and project parameters considering the inter-project interactions and interdependency while making decisions on project selection. Later, Reyck et al. (2005, p.525) summarized that PPM was developed to have a centralised view of all the projects, modelling relationships, and including the interdependencies between them, which will enable a risk and financial analysis of the project thus, "ensuring the accountability and governance at the portfolio level". This can be possible by applying new visual tools and techniques along with the traditional ones, that enable the project manager to illustrate and explain, also understand the above-mentioned factors.

Unlike SPM, which is mainly seen as "doing the project right" (PMBOK, 2013, p.1), PPM is seen as "doing the right projects" (Cooper et al. 2001, p.363). If the PPM practices are adopted and implemented efficiently, a number of benefits can be achieved, including timely delivery, customer satisfaction with the final product, availability of resources and effective communication and coordination between the projects, and team members (Müller et al. 2008, p.29; Reyck et al. 2005, p. 526). PPM has both strategic and financial goals (Turner, 2007, p.48). Successful PPM may boost the organization's returns on project investments and maximize its profits (Killen et al., 2009, p.1), as it has the primary role of project selection and prioritization. When this process is carried out effectively, in other words, the limited resources

have been allocated to those projects that increase "the monetary value of the overall portfolio of assets", it means the PPM has achieved its objectives (Turner, 2007, p.48).

3.3 Project Interdependency and Project Interdependency Management

Interdependency has been found to be a "very difficult concept to define both theoretically and operationally" (Staudenmayer, 1997, p. 24). Even though PIM is not theoretically a well-established discipline, it has been researched as a side factor not a primary research subject since the 1960s (Thompson, 2003, p.24). According to Reyck et al. (2005), it is widely used in practice. Rungi (2010a, p.117) defines it as a "portfolio level strategic issue", since PIM is usually a part of project selection, which has an important strategic role in PPM. He also agrees with Thompson's (2003, p.23) definition of interdependency, which is a "contingent relationship between projects" (Rungi, 2010a, p.117). While the importance of understanding interdependency and its effective management has been underlined by several researches (Teller et al., 2012, p. 597; Reyck et al., 2005, p. 525), it is still an area that has not been paid the deserved attention (Teller et al., 2012, p. 597; Elonen and Artto, 2003, p. 398).

There is a consistent approach among the researchers that managing project portfolios encompasses complexities and uncertainties, which also takes its roots from the presence of interdependencies between projects (Perminova et al. 2008, p.265; Collyer and Warren 2009, p.56; Aritua et al. 2009, p.34). Projects are not only affected by the external factors, but also the uncertainties related to the other projects within the same portfolio as well (Hossain and Ruwanpura, 2008, p.2421). Eventually, effective PPM has to be practiced to deal with such kinds of uncertainties that arise in a turbulent, complex from PIs (Killen, 2013, p.804; Verma andSinha, 2002, p. 463; Reyck et al., 2005, p.525). According to Collyer and Warren (2009, p.358) if projects are conducted in dynamic environment, due to "the highly integrated nature of the environment, combined with high rates of change" makes it challenging to realize forward planning. Therefore, it is vital to practice effective PIM, which involves the understanding and analyzing project complexities and leads to high quality portfolio management, which in turn has a positive impact on portfolio outcomes and success (Teller et al., 2012, p. 597). Rungi (2010b, p.94) highlights the significance of the systematical PIM, which results in the increase of the project's success rate and decrease of resource consumption, since it is effective for more careful project selection and process review.

According to Patanakul and Milosevic (2008, p.124) PIM is about managing interdependencies and interactions between projects. PIM is highly recommended for the development of complex products or services requiring the implementation of several projects, be it simultaneously or in different times (Newell et al., 2008, p.34). Other researchers agree with the point that PIs are not managed only within the multiple projects occurring in parallel (De Maio et al., 1994, p. 183; Verma and Sinha, 2002, p. 452). Especially in a multi-project environment, where the projects run with scarce resources, overlap or concur, it is crucial to explore and manage the uncertainty through the information exchange and get a deeper understanding of the situation and relationships between projects (Danilovic and Sandkull, 2005, p.193). Such organizations often fail to develop and transfer knowledge from one project to another and properly perform KM in an attempt to overcome new challenges. Usually, the reason is either lack of time, incapability to identify issues and reflect upon past projects, to see the "big picture", to recognize the existing gaps and to see the need for the development of new knowledge to be used in future projects and operations (Andersen and Hanstad, 2013, p. 239). Learning-based

interdependencies between projects are especially hard to manage because it is a challenging process to codify the knowledge belonging to one project and transfer it to another one (Killen et al., 2009, p.2). KT and the tools for ensuring the effectiveness of this process play a huge role in large multi-project organizations, where the existence of well-organized KM is critical (Formentini and Romano, 2011, p.545-546). Since there is lack of literature on the implementation of knowledge transfer and creation practices in the complex multi-project environment, it presents a real challenge and underlines a need to determine the tools, methods and procedures to create, develop and transfer knowledge.

Scholars have recognized multiple types of interdependencies based on nature, which are resource (Santhanam and Kyparisis, 1996, p. 382; Teller et al., 2012, p.600; Blau et al., 2004, p. 233; Verma and Sinha, 2002, p. 451; Schmidt, 1993, p. 404), technology (Santhanam and Kyparisis, 1996, p. 382; Verma and Sinha, 2002, p. 452), knowledge (Rungi, 2010b, p. 96; Teller et al., 2012, p.600), outcome (Teller et al., 2012, p.600; Blau et al., 2004, p. 233; Schmidt, 1993, p. 404), benefit (Zuluaga et al., 2007, p. 2; Santhanam and Kyparisis, 1996, p.382; Schmidt, 1993, p. 404) and market interdependencies (Verma and Sinha, 2002, p. 451; Rungi, 2010b, p. 102). The present study will focus on PIs from the resource, knowledge and outcome perspectives. By this, the availability and sharing of resources, knowledge, information and technology considering the time constraints and also dependency of one project on the results of another one, is meant (Teller et al.,2012, p.600).

The importance of PIM is also acknowledged by PMBOK (2013, p.6) and ISO 10006 Quality Management Systems (Rungi, 2010a, p.117). Nevertheless, there is still a need to conduct further research to explore more and to clearly define PIs (Rungi, 2010a, p.117; Rungi and Himola, 2011, p. 158; Killen and Kjaer, 2012, p. 555; Staudenmayer, 1997, p. 27), and identify the tools and techniques used in practice (Söderlund, 2004, p. 659; Collyer and Warren, 2009, p. 359). Kjølle et al. (2012, p. 81) state that, there have been studies investigating PIs in the construction sector but not from the project management perspective. Although it has been explored within the PPM context, PIM still remains weekly covered area of PPM (Elonen and Artto, 2003, p.397). There is a gap in the current literature on the more comprehensive tools and methods that can be broadly applied in various sectors to manage PIs. Also, a view of projects isolated from each other (Killen, 2012, p.805) should be changed to be able to contribute to PPM, considering the increase of complexity and interdependency in organizations.

Recent studies prove the importance and criticality of using visual tools for decision making within the portfolios and managing the interdependencies between separate projects. As Tergan and Keller (2005, p.241) states, most decisions regarding PPM are based on human judgement and experience. As such, when complex team decisions are made on a portfolio level, cognitive thinking and skills of each individual of the diverse environment affect the decisions. In addition, time constraints, limited knowledge and people factor increase the pressure in the situation and make this process more challenging. Visual representation, however, increase the individual's' ability to identify and understand complicated relationships between projects. "While humans have limited ability to recognize interdependencies", visualisation is a solution to overcome the limitations in working memories, suggest the scholars (Tergan and Keller, 2005).

3.4 Integration of Knowledge in Project-based Organizations

Through the first part of this section we have set the basis of the current study by defining a project and portfolio concepts and their management. Moreover, complex environment and interdependencies within portfolios were discussed. The purpose of this chapter is to review knowledge integration process of project-based organisations through the lens of KC and KT, because project-based organizations that employ multiple projects often face with difficulties regarding effectual use of their knowledge inventory (Thiry and Deguire 2007, p. 649). In this part, we will describe in detail the challenges of efficient knowledge inventory employment. Also, we will briefly present why an appropriate KC and KT processes are important for utilization of knowledge.

There are different challenges that project-based organizations encounter because of the presence of the assigned timescales, continuous change of client's requirements, unique design, fragmented project processes which constrain KC and KT, as well as building a proper KM culture (Love et al., 2005, p. 106). PPM can be best viewed as a logical framework of organization's knowledge inventory (Skyrme, 2001; cited in Durant-Low, p.61). Due to the highly interrelated nature of multi-project environment, the process of innovation, development and sharing of new ideas are also dependent on each other. However, the "self-contained" and isolated nature of projects create assorted streams of resources from one project to another, which leads to the issues with distributing knowledge across organization and capturing learning processes (Love et al., 2005, p.83). Hence, researchers concur with the opinion that challenges of project-based organizations can be in some sense encountered as difficulties of knowledge integration or effective use of knowledge inventory by organization. The knowledge inventory from this perspective is considered as a key asset of the organization (Styhre and Gluch, 2009, p.108). An appropriate management of knowledge can minimize localized learning and "stickiness of knowledge" to facilitate its creation and diffusion among projects (Love et al., 2005, p.85). Below, the challenges of efficient knowledge inventory employment in project-based organizations will be discussed.

In contrast to the permanent organizations, where several departments act as one knowledge force, temporary organizations face with an "organizational amnesia" or loss of organizational routine and memory (Todorović et al. 2014, p.773; Lindner and Wald 2011, p. 877; Dooley et al., 2005, p.477; Love et al. 2005, p.105). This happens because of changing work conditions and project characteristics, assorted project team organization, geographical dispersion of personnel, which then leads to the fragmentation and loss of individual and organizational knowledge (Prencipe and Tell, 2001, p.1377; Lindner and Wald 2011, p. 878). Hence, the temporary nature of projects results in a decrease of the capability to periodically reflect upon experiences, learn, identify gaps, develop knowledge and efficiently transfer it to other projects (Andersen and Hanstad, 2013, p. 239). Also, project-based organizations encounter the challenges such as knowledge exchange and getting a deep understanding about relationships among projects (Danilovic and Sandkull, 2005, p.193). Thus, as researchers state, "projects do not support any natural transfer mechanisms", and "deliberation management" takes a critical role in the KC and KT processes (Love et al. 2005, p. 12; Lindner and Wald 2011, p. 878).

In addition, project team members often face with the issues such as "reparative activities", "leaking of project knowledge", and "reworks", which are significant problems in project-based

organizations (Love et al. 2003, p.13; Sokhanvar et al., 2014, p. 1826). Studies done by Pemsel and Wiewiora (2013, p.41) and Müller et al. (2013, p.14-15) highlight that Project Management Office (PMO) members make very poor knowledge exchange among themselves because exchange across the PM community fully depends on the individuals' motivation to share knowledge. PMOs sometimes do not understand the necessity to do that beyond their cluster. These authors highlight the importance of top-down communication by stating that top managers shall facilitate this process by increasing awareness about existing tacit and explicit knowledge through physical meetings and IT techniques, tailoring policies and practices to share knowledge within clusters, synchronization of all practices with corporate and project governance. To successfully perform communication , managers shall rely on existing tools and databases to identify collaborative relationships between clusters. The support by management is critical in "paving the way" for KM (Love et al, 2005, p.12). Thus, it can be summarized that project-based organizations frequently fail with knowledge development and knowledge transfer practices that are required to fill the gap between today's scarcity and forthcoming difficulty (Andersen and Hanstad, 2013, p. 239; Lindner and Wald 2011, p. 877).

This chapter has demonstrated the challenges of efficient knowledge inventory employment and the role of KC and KT processes in them. It is now necessary to explain KT and KC separately by reviewing the constraints for this processes that occur in the project-based organisations.

3.4.1 Knowledge Transfer in Project-based Organizations

Hereby, KT is described as an integral part of knowledge integration. Transfer of knowledge to specific locations is an important process of KM in organizational settings. KT is, driven by the communication process (namely, giving and receiving) and information flows (Alavi and Leidner, 2001, p.119; Love et al., 2005, p.57; Matzler et al. 2008, p.303). On the other hand, Wang and Noe (2010, p.123) claim that KT is used only to provide knowledge, not receive it, thereby they state that knowledge receiving is a distinct part of knowledge exchange processes.

KT can be performed from individuals to explicit sources, from individuals to groups, between groups, across groups, and from the group to the organization (Alavi and Leidner, 2001, p.119). In this research, all the above-mentioned types of the flow is indirectly examined during the empirical data analyzes. In terms of the way of conceptualization of KT flows, Gupta and Govindarajan (2000, cited in Alavi and Leidner, 2001, p.119-120) differentiated them as per five elements: value of the source, motivational disposition of the source, existence of transmission channels, motivational disposition of the receiving unit and absorptive capacity. For the purpose of this research, KT will also be considered with giving and receiving capabilities. As for KT channels, they can be formal or informal, personal or impersonal (Alavi and Leidner, 2001, p.121; Cabrera and Cabrera, 2002, p. 690). Matzler et al. (2008, p. 303) and Lindner and Wald (2011, p.879) highlighted that different forms of the knowledge affect the way how knowledge is transferred, captured and retained. Several typologies of knowledge can be distinguished, such as tacit and explicit, in the way of the articulation, and individual or collective, in terms of their aggregation. Typologies such as "knowledge as solution", "knowledge as experience" and "knowledge as socially created" depending on its purpose are also represented in the literature (Cabrera and Cabrera, 2002, p. 690; Snider and Nissen, 2003, p. 7), which are taken into account in the current study.

According to the Javernick-Will (2013, p.25) and Love et al. (2005, p.63-72) organization type and working field in the project based organizations considerably influence the method of KT and management. Studies have identified that contracting firms use a combination of socialization methods and formal methods to transfer explicit knowledge, and engineering consulting firms, generally rely on the formal KM strategies with the application of interactive online platforms to transfer the knowledge. Moreover, the results of the study done by Reich et al. (2014, p.599) show that IT-enabled business projects are knowledge-intensive, because they need to have an access to large quantities of knowledge. Which is why, the area, where organization does its business (e.c. construction, IT, oil and gas, manufacturing, consultancy), has a considerable impact on the method of assortment of suitable knowledge management processes and practices.

3.4.2 The challenges of Knowledge Transfer in Project-based Organizations

There are several reasons of facing with difficulties during the KT processes. Szulanski (2003, p.680-681) categorized them into five groups of "stickiness" such as: initiation stickiness, the difficulty in recognizing opportunities, implementation stickiness, ramp-up stickiness and integration stickiness. Further, Riege (2005, p. 18-31) identified "three domains" of knowledge sharing obstacles. At the individual level the obstacle of transmitting the knowledge is related to lack of time, lack of trust in the accuracy and credibility of knowledge. The complications at the organizational level, are concerned with a shortage of formal and informal spaces to share, reflect and generate knowledge. As for last domain, they are mainly associated with technological obstructions, such as limited integration of IT systems and processes, reluctance to use IT systems due to the lack of familiarity and experience with them. Alternatively, Hall and Sapsed (2005, cited in Love et al., 2005, p.59) categorized four types of challenges related to KT in project-based organizations. Firstly, it is resource constraints, where competition leads to the conflict between long and short term pressures, which is also mentioned by Lindner and Wald (2011, p. 878). Secondly, the difficulties raised from capabilities and prior knowledge. In addition, Formentini and Romano (2011, p. 545) distinguished that an effective understanding of the underlying mechanisms is missing in the project-based organizations, due to the uncertainty and complexity of the organizational structure. Thirdly, Hall and Sapsed assumed that another source of issue is the nature of knowledge and working conditions, where firm operates. This topic is broadly covered in the recent research done by Javernick-Will (2013, p.25). Last source of knowledge constraint is motivational factors and incentives of PMO members, which are analyzed in details by Müller et al. (2013, p.14). According to him, individuals' prior collaboration is the main factor which affects PMO members' desire to share and transfer knowledge. Hence, the knowledge governance structures should support the natural knowledge exchange patterns (Lord and Ranft, 2000, p.574).

IT can support all forms of the KT in projects and organization. By taxonomies or organizational knowledge maps, users can easily identify the essential knowledge or the individual who has the required knowledge (Offsey 1997, cited in Alavi and Leidner, 2001, p.121). Also, Lindner and Wald (2011, p. 887) in their study identified a number of success factors of the KT in the temporary organizations. They showed the importance of the effective support of communication by IT mechanisms and systems providing a convenient sharing, storage and retrieval platform available to everyone in the project environment, which are also suggested by Riege (2005, p. 31) in his study. Researchers emphasize that the critical attention shall be given to the quality and usefulness of the system. It should be clear and user friendly.

Also, another major factor of success of KM transfer is the role and setup of the PMO (Pemsel and Wiewiora, 2013, p.41; Müller et al., 2013, p.14-15), and their effort to motivate people to share the knowledge (Riege, 2005, p. 31). Moreover, companies need to group project program and portfolio with individuals keen to add value to the firm's knowledge stock by their abilities and behaviors (Ajmal, 2009, p.16). In addition, several other factors, such as the adequate organization of the project KM system in the firm, can have a positive impact on the effectiveness of KT, which will be considered in the following parts of this chapter.

3.4.3 The Knowledge Creation in Project-based Organizations

Any organization that is eager about being competitive in the long-term perspective, needs to adapt to the dynamic working tempo and have a willing to continuously create knowledge (Yang et al., 2010, p. 231). Especially, this applies to the project-based organizations, where each project is a unique endeavor (Love et al., 2005, p. 42). The KC can be achieved through a creation of new content or by replacing existing one within the organization's tacit and explicit knowledge (Pentland, 1995, p.7) and by social, collaborative or individual thinking processes (Nonaka, 1994, p.19). According to Nonaka and Takeuchi's (1995, p.62) knowledge-creation theory, organizational KC is continuous flow between the tacit and explicit dimensions of knowledge from individual to organizational levels. Their model has following forms: socialization, externalization, combination and internalization, where each configuration is "highly interdependent and intertwined" (Alavi and Leidner, 2001, p.116). Lately, to describe KC in the context, specific "ba" idea, which is the "place where information is interpreted to become knowledge", is added (Nonaka et al., 2000, p. 14). Currently, this model is widely used in its primary or modified versions (Fischer, 2001, cited in Balestrin et al., 2008), because it is one of the rare KC theories that examines the interrelationship between tacit and explicit knowledge, even if the distinction between them is problematic (Lindner and Wald 2011, p. 878; Love et al., 2005, p.44). Lindner and Wald (2011, p. 878) note that transfer of tacit knowledge into explicit one is quite unmanageable step in the organizational knowledge process, because only explicit knowledge can be a part of the organizational knowledge base. Love et al. (2005, p. 46) proposes modified KC model with added social construction and communication elements. This model has following processes: KC, knowledge sharing, knowledge generation, knowledge integration and collective project learning.

3.4.4 The Challenges of Knowledge Creation in Project-based Organizations

The KM literature seems to be scarce in providing sufficient information about KC processes at the project and organization team levels (Hong, 2012, p.211; Love et al., 2005, p. 43), especially it has limited analysis about challenges of the KC in the project-based organizations (Du Chatenier et al., 2009, p.371). However, several criticisms were found to the Nonaka and Takeuchi's (1995, p.56) knowledge-creation theory. Tuomi (1999, cited in Love et al., 2005, p.45) highlights that this model took a culture as a granted, which is not reasonable, because even cultural values and behaviors of individuals affect the frame of the organizational and inter-cultural dynamics (Hong, 2012, pp.210-211). The members have a distinct cultural values and assumptions, which require an understanding, because they act within a frame of team as a principal agents of learning (Hong, 2012, p.211). Moreover, it is not clear what would happen when the knowledge would be created outside the organization (Tuomi, 1999, cited in Love, p.45). As per some authors, benefits of the interorganizational learning is two-fold. The KC in "open innovation teams" may reduce risk or increase uncertainties of the project, but mostly it

has a high failure rate and expands the problems related to the stakeholders (Du Chatenier et al., 2009, p.371). On the other hand, Love et al. (2005, p.47) state that the knowledge integration within a company is fruitful. In both cases, acquisition of knowledge through the process of KC or outside the organization require clear understanding of KC processes and techniques (Yang et al., 2010, p. 231). Additionally, as was identified in the first part of the literature review, that the cooperation between project and portfolio members is crucial to create a new knowledge, but currently knowledge management toolkits do not support this process (Massingham, 2014, p. 1098).

As a result of the above-mentioned, it was affirmed that project-based organizations encounter problems with the "integration of knowledge", and this process is critical when large multi-project-based firms develop complex products and systems. Moreover, influence of the simultaneous management of several projects cause interdependencies among them. Unfortunately, the current literature does not present theoretical models or tools supporting the implementation of KT and KC practices in the portfolio and program levels (Formentini and Romano, 2011, p.546; Lindner and Wald 2011, p. 877).

In this research study, we are aiming to analyze mechanisms for KC and KT in the mega-event, consulting and IT companies, in relation to the critical settings of its implementation. Mega event organization is specifically interesting case, because, as per Andersen and Hanstad (2013, p. 236), it represents an enterprise with complex outcome, where the requirements to meet the "iron triangle" of the project cannot be modified or prolonged. In this case, the ability to mobilize, use and develop new knowledge, which is carried out by individuals, is even more vital than in regular settings. Having discussed KT and KC processes, the next section of this paper addresses why the selection of appropriate knowledge management mechanisms for knowledge transfer and creation is essential for the organization's success and how to perform it.

3.5 Knowledge Management

The presence of proper project KM is one of the main success factors in the project-based organizations. The absence of the project KM can negatively affect project outcome and lead to the failure (Desouza and Evaristo, 2004, p.87-91). Generally, research about KM in organizations is being performed since 1980s, whereas, the investigation of KM in the project environment was started only 15 years ago (Sokhanvar et al. 2014, p. 1826; Chen and Chen, 2005, p. 32). The understanding of KM processes evolved several perspectives (Chen and Chen, 2005, p.18) since last decade and is demonstrated in the Figure 2.

As was stated by Alavi and Leidner (2001, p.114) and Lindner and Wald (2011, p. 878), a KM is commonly understood as a process involving at least four basic processes, such as creation, storage or retrieval, transfer and application of knowledge. This view of knowledge system organization represents cognitive and social nature of organizational knowledge, the representation of the individual (thinking and doing) and group (practices and culture) perspectives respectively (Alavi and Leidner, 2001, p. 115). Alternatively, Owen and Burstein (2005, p. 138-153) developed another model from their standpoint with the following processes: creating, capturing, transferring or sharing, and reusing. The analysis of the current academic papers with the various project management contexts showed the validity of this framework to the project-based organizations (Morales-Arroyo et al., 2010, p.63). It is remarkable that

creation and transfer of knowledge in projects are mostly emphasized in the firms, which operate with complex technological systems and have diverse knowledge domains (Berggren et al., 2011, cited in Andersen and Hanstad, 2013, p.238).

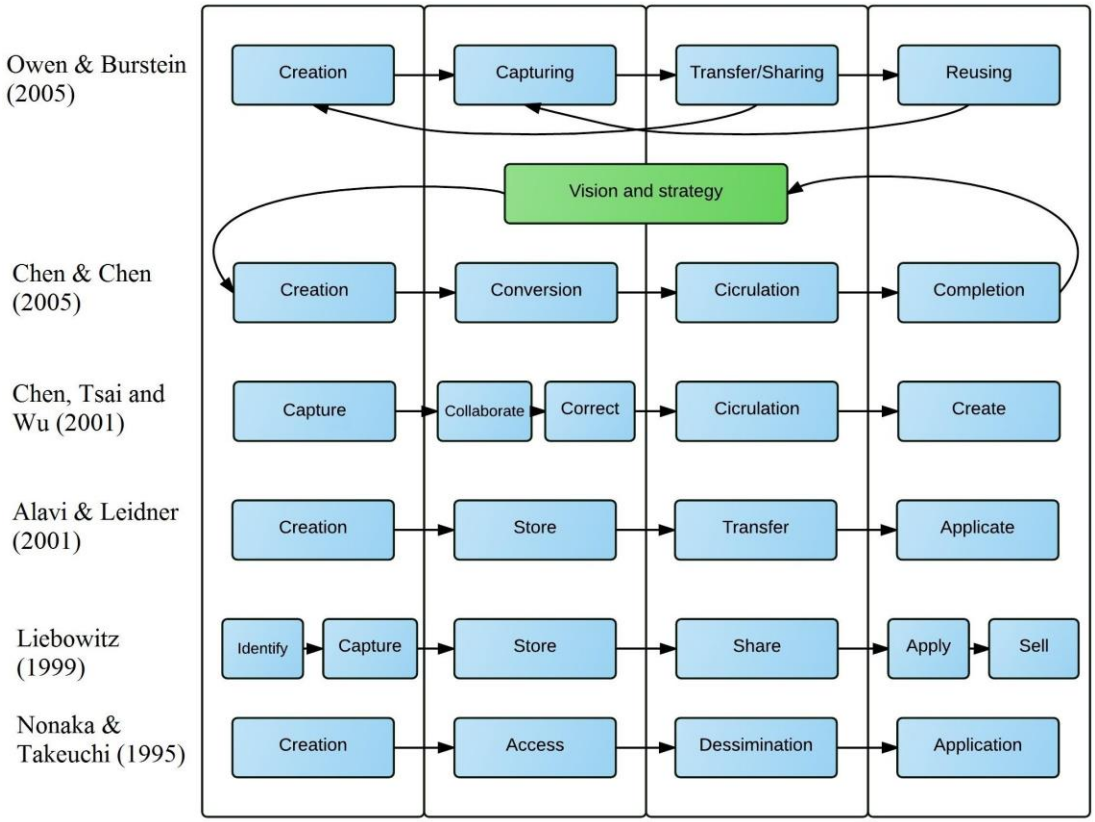


Figure 2. Knowledge Management processes adopted from Chen and Chen (2005, p.18)

KM includes information, communication, human resources and intellectual capital, where people, technology and process are main working aggregates (Quintas et al., 1997, p.385; Sokhanvar et al., 2014, p. 1826). The literature recognizes several definitions of KM including the systemic process, which is qualified by organization to receive, organize and deliever both tacit and explicit knowledge of employees (Alavi and Leidner, 2001, p.110; Sokhanvar et al., 2014, p. 1826), and the coherent approach to effectually employ knowledge in order to be competitive (Arkell, 2007, p.14; Gasik, 2011, p.24). As categorized by Gasik (2011, p.24) in his empirical study of the project-based organizations, above-mentioned definitions of KM comprise two types of approaches, firstly, to explain process of mono knowledge element and functions of its life cycle. Second group of definitions explains all knowledge of organization and the advantages to use them. Correspondingly, both of them are considered in the current study to have a holistic view of the phenomena (Gasik, 2011, p.40). Generally, KM was born from the mix and influence of the several subjects as philosophy, computer science and economics (Nonaka and Peltokorpi, 2006, p. 73).

As per Model of Project-based Knowledge Management developed by Reich et al. (2014, p.593), main KM goals are achieving the project's business value by technological and organizational solutions and reach a common understanding across all individuals and stakeholders, with an idea of what the project needs to achieve for the business. In the same vein, Love et al. (2005, p.85) in their book note that KM is utilized to overcome mainly two

types of perspectives, namely “the community model” with tacit dimensions of knowledge to achieve joint identity of project group and “cognitive model” driven by the enlargement of availability of information by several tools. From our perspective, all of the identified goals in the literature share the same idea and complement each other.

As per research study done by APM (2015, p. 15-20) on the project-based organizations to analyze current bad and good practices of KM, it is noted that in many organizations people share knowledge between projects only at the handover and closure stages (APM, 2015, p.21). Nonetheless, Owen and Burstein (2005, p. 138-153) suggest that knowledge management activities should be undertaken at the initiation, planning, execution and monitoring phases. With regards to knowledge capturing, it is advised to perform it at the project closure stage. Todorović et al. (2014, p.773) in their recent study draw an inference that there is a need to conduct further research about the KM in the project environment.

3.5.1 Impacts of Knowledge Management on Project Performance and Project success

KM has been recognized as a critical factor for both organizational performance and project success (Chen and Chen, 2005, p. 32; Sokhanvar et al., 2014, p. 1826). As it is mentioned by Todorović et al. (2014, p.782), previous studies have examined the influence of KM in project environment on project performances. According to the five years large-scale longitudinal change study done by Massingham (2014, p. 1098), KM has direct and indirect, financial and non-financial impacts on the firm’s performance. However, measurement of the entire organization’s KM performance is very difficult from process, leadership, culture or technology perspectives (Chen and Chen, 2005, p. 32). Traditionally, performance has been thought of in terms of whether it meets key constraints such as its pre-set budget, planned schedule and agreed scope (Todorović et al. 2014, p.782). Nonetheless, as per study done by Reich et al. (2014, p. 599), the proper KM can be beneficial for the achievement of business value from the project, whereas knowledge alignment does not have any effect on the schedule and budget. The KM has a business value when it involves processing widespread and large-scale knowledge and combination of different specialist knowledges and mutual understanding among them, which infers communication. Same perspective is presented by Søderlund et al. (2008, p. 518), the study emphasizes that successful project-based knowledge development and transfer requires organizational support for three main mechanisms: “relating different competences”; “reflecting upon experiences”; and “routinizing lessons learned”. Moreover, another study by Andersen and Hanstad (2014, p. 246) espouse same idea by assuming that personal knowledge and problem solving capacities and the nature of social relationships are the key to success. Thus, the KM have a business value and presumable effect to the project performance, if different competences of specialists were incorporated and company achieved common understanding of projects. Having defined how knowledge management influence project performance and success, we will now move on to discuss knowledge management tools which are employed as a part of knowledge management practicies.

3.5.2 Knowledge Management Tools

Paying attention to the individualities and knowledge intensity of the multiple project environments (Burkhard and Meier, 2005, p.474; Burkhard et al. 2005, p.76; Burkhard and Eppler, 2007, p.119; Coldrick et al., 2005, cited in Durant-Low, 2012, p.75), it is distinguished that the vast majority of tools and methods have not been successful in KM, due to the

complexity nature of program and portfolio. Therefore, project portfolio and program management require multivariable data (Durant-Low, 2012, p.63). Common project management approaches as the PMBOK® Guide and PRINCE2™ are not able to identify either knowledge artefacts or people relationships (Morris 2006, cited in Durant-Low, 2012, p.76). For instance, the Gantt Chart provides comprehensive and precise information, besides people generally consider this tool as demotivating and too detailed. Whereas, motivation is an essential factor for the PPM success, as it was mentioned above. Especially, when group work is required, it is hard to see the big picture and interdependencies between projects. There is a necessity to establish a "new visual format that complements traditional Gantt Charts and that concentrates on the motivation of employees and tries to initiate a mutual story" (Burkhard and Meier, 2005, p.475). Some authors stress that relationships are the corner stone of success and shows that complexity of project work signify presence of social and technical relationships. Henceforth, new techniques are required to better understand and manage relationships (Durant-Low, 2012, p.76). Nowadays, authors recognize visualization tools as one of the promising new KM techniques, which can effectively cope with knowledge-intensive tasks (Burkhard and Meier, 2005, p.474; Burkhard and Eppler, 2007, p.119; Cañas et al. 2005, p.205) in project-based organizations. In this perspective we decided to investigate potential of knowledge visualization tools, because the current literature of KM does not sufficiently present the opportunity of visual representations for the transfer and creation of knowledge (Burkhard, 2005, p.138), so it is indispensably needed for the relationship identification (Andersen and Hanstad, 2013, p. 239; Lindner and Wald 2011, p. 877) in multi-project environments The next chapter describe synthesis and evaluation of knowledge visualization to the KC and KT processes.

3.6 Knowledge Visualization: Enhancement of Knowledge Creation and Knowledge Transfer Processes

The question ***"does the visualization really enhance knowledge creation and transfer processes, and thus help to successfully perform PPM?"*** was interesting to us and therefore, the current literature was reviewed in order to find answers to it. Klein (2005, p.75) mentions that companies can meet the requirements of internal and external communication by the employment of visualization tools. In the complex environment, the growing efficiency constraint sources for communication are the quality of information, the proficiency to share experiences across several contexts derived from different cultures, professional backgrounds and hierarchical levels. Burkhard and Meier (2005, p.476) identically argue that organizations often face with information overload and it is vital to support individuals' ability to filter, analyze and prioritize information by interfunctional communication, where contents presented to the different stakeholders should not be contradictory. Correspondingly, Styhre and Gluch, (2009, p.108) say that visual representations can be used for the variety of purposes, but its main strength is the enhancement of communication between personal to inter-organizational and societal levels (Burkhard and Eppler, 2007, pp.112-113). The research in psychology and communication done by Dansereau and Simpson, (2009, p.104) demonstrated the cost-effectiveness of visual displays in comparison with traditional methods. They argue that visualisation strengthens the communication among clients and stakeholders, because it shows comprehensible representation of interdependencies among ideas, emotions, and actions. Also, visual representations can be successfully used for KM processes such as knowledge identification, transfer, creation, and application in knowledge-intensive tasks (Burkhard andMeier, 2005, p.474; Burkhard et al. 2005, p.76; Burkhard and Eppler, 2007, p.119).

It is critical to underscore that the transfer of knowledge is fundamental process interfering with several issues and criticalities as: information profundity and conditions that need to be communicated; limited time, attention, and capabilities of the recipients; different backgrounds and contexts; relevance of information to different stakeholders (Burkhard et al., 2005, p.76; Burkhard and Eppler, 2007, p.119). All the above-mentioned issues can be solved by the usage of the visual knowledge management (VKM) tools (Cañas et al. 2005, p.205). Knowledge visualization offers a systematic approach to the transfer of "insights, experiences, attitudes, values, expectations, perspectives, opinions, and predictions" among various levels (Alavi and Leidner, 2001, p.119; Burkhard and Eppler, 2007, p.119; Burkhard, 2005, p.133). To efficiently perform this task, knowledge must be reconstructed in the mind of the receiver (Burkhard and Eppler, 2007, p.112-119; Burkhard and Meier, 2005, p.474), which depends on the recipient's cognitive capabilities. Hence, consideration of KT with receiving and giving capabilities (Alavi and Leidner, 2001, p.119; Love et al., 2005, p.57; Matzler et al. 2008, p.303) are defended and required in this study. Hence, the person responsible for the transfer of knowledge not only needs to pass the relevant knowledge at the right time and place, but also needs to understand appropriate context. Meanwhile, knowledge visualization provides supporting techniques for the creative power of imagery and for the capture of "implicit aspects of personal knowledge". It helps people to create new knowledge. Unlike text, graphic formats can be easily modified and improved, which is also beneficial in terms of time constraints (Polanyi, 1958, cited in Burkhard and Eppler, 2007, p.120). Obviously, after the literature review the first part of the question can be answered as ***"yes, the visualization can enhance KC and KT processes"***. To justify whether ***"the visualization really enhance knowledge creation and transfer processes, and thus help to successfully perform PPM"***, we came to a determination that the further investigation of this phenomena is required by cross-sectional studies. Because, the current state of the academic research can not reply to that.

3.6.1 The Knowledge Visualization Framework

In general, according to the communicating strategies developed by Burkhard et al. (2005b, p.1) there are following six "functions" of visual representations to visualize the "big picture" and have social, emotional, and cognitive benefits (Burkard and Meier, 2005, p.480; Burkhard and Eppler, 2005, p.491) to the organization: "coordination" of individuals in the communication process (e.g., knowledge maps, heuristic sketches); keeping an "attention" and representation of emotions by identifying patterns, outliers, and trends; improving "recall" and remembrance of knowledge, because human brains think in images (e.g., visual metaphor, conceptual diagram); "motivation" and inspiration of viewers (e.g., knowledge maps, instructive diagrams); "elaboration" of knowledge in teams by using physical models and sketches; "new insights" by inserting details in specific working contexts and illustrating relationships between objects. Altogether, it can be summarized that knowledge visualization has tremendous appropriateness for KC and for KT processes (Eppler and Burkhard, 2007, p.120). It also designates all graphic means that can be used to build, analyze, measure, transfer or use knowledge (Eppler and Burkhard, 2007, pp.112-113).

Knowledge visualization aims to justify a creation and transfer of knowledge among people by giving more capabilities to represent experiences, insights, instructions and assumptions (Burkhard, 2005, p.134; Cañas et al. 2005, p.205; Burkhard, 2005, pp.134-136). In terms of recipient, knowledge visualization is concentrated on supporting KC and KT processes in

collaborative settings by enriching knowledge-intensive communication between individuals utilizing visual formats. The VKM tools consider declarative (know-what), procedural (know-how), experimental (know-why), orientational (know-where), and individual (know-who) types of knowledge (Burkard et al., 2005, p.76). The KM framework is summarized in the Figure 3 based on the above-mentioned (Burkhard and Meier (2005, p.479).

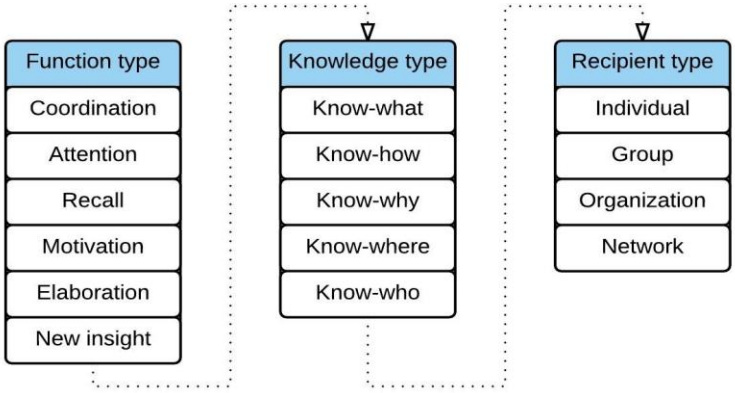


Figure 3. The Knowledge Visualization framework adopted from Burkhard and Meier (2005, p.479)

Eppler and Burkhard (2007, pp. 112-118) differentiated six formats of the knowledge visualization: heuristic sketches, conceptual diagrams, visual metaphors, knowledge animations, knowledge maps and domain structures inspired by visualization types detected in the architecture (Burkhard, 2004, pp.521–523). Additionally, today some researchers accomplished studies to develop mixed-mode visualizations that combine the concept maps, mind maps, conceptual diagrams, and visual metaphors methods in order to investigate advantages of new hybrid methods. However, in reality such formats were limited in terms of their application (Eppler, 2006, p.210). Consequently, this research study will not focus on mixed-mode formats and will investigate tools used in the practice to see their applicability to interdependency and portfolio management.

3.6.2 The Drawbacks of Knowledge Visualization Tools

Before proceeding to the further analyzes of VKM tools and their usefulness, limitations are reviewed in this part. Five drawbacks of VKM tools are discussed by Burkard and Meier (2005, p. 491): confusion of presented information content, overload or oversimplification, misrepresentation, manipulation, ambiguity of meanings (Burkard and Meier, 2005, p. 491). It is important to realize that the miscommunication and misunderstanding can happen when visual representations are wrongly programmed by the author or wrongly understood by the recipient, since the role of designer becomes a crucial and communicative (Burkhard, 2005, p.133). Also, Klein (2005, p.74) and Burkhard et al. (2005b, p.9) in their works identified particularly identical challenges for knowledge visualization in the current corporate communication. Both of them paid an attention to the contextual complexity and the diversity of communication networks in terms of professional backgrounds, personal experiences and working positions. To allow receiver to re-create the knowledge, the contents shall be integrated into the context of the recipients to have task-oriented action, which is difficult to maintain. The above-mentioned can be solved by the technical mediation, which requires time and cost for professional visualizations. Therefore, organization shall be familiar with the cost-benefit ratio

or whether is feasible to spend time and budget for the creation and modification of visual tools (Burkhard, 2005, p.133).

To sum up, during the literature review was ascertained that there are few numbers of academic papers which investigate new forms of visual knowledge representation and understanding of their advantages and limitations (Burkard and Meier, 2005, p.480; Eppler and Burkhard, 2007, p.112-113). In addition, there is absence of study which considers VKM tools as an instrument to manage interdependencies between projects, thus to better manage project portfolio.

3.7 Relationships between Visual Knowledge Management Tools and Visual Interdependency Management Tools

3.7.1 Visual Interdependency Management Tools

Having discussed the knowledge visualization framework, the final section of the literature review addresses investigations of relationships between VKM tool and VIM tools. Before proceeding with comparison analysis of these tools, we decided to start discussion with the explanation of VIM tools.

Generally, VIM tools are considered and studied within the portfolio management in the current literature, more precisely, as part of project portfolio selection methods (Rungi, 2010b, p.101). While searching for the relevant tools, it was observed that there is only a couple of studies fully dedicated to these tools and only one paper by Rungi (2009b, pp.111-136) presenting a compact overview of mostly researched techniques. Visual tools and techniques that are addressed the most in the literature to manage the interdependencies within a portfolio have been summarized by Rungi (2009b, pp.111-136). Some of the most popular visual and non-visual interdependency management tools are presented in the table below:

Table 1. Interdependency management tools

Informal Techniques - Meetings	Main aspects to be considered in meetings: 1) Time Management 2)Agenda Use 3)Ensuring results, follow-ups 4)Group facilitation-engaging participants 5)Maintaining focus and direction (Ravn, 2014, pp.75-76). There are several studies proving the role of visual tools in increasing the effectiveness and productivity of meetings, as well as having an impact on creativity of personnel. By adding interactivity and helping to map the ideas, visual tools achieve the followings: more engaged and motivated participants; ability to see "a big picture" with the logical links and relationships between the objects illustrated through the idea mappings; increasing the group memory (Sibbet, 2010, p.14).
Dependency Matrix	This tool presented as a simple way of documenting and mathematically quantifying the interdependency between projects by inputting numerical financial data (Dickinson et al., 2001, pp. 523-527).
Dependency Structure Matrix	The researchers believe that this tool is useful to focus on the dynamics of product development, because it enables both managers and engineers to see the real situation, links between domains, and provide a transformation of information between domains, which leads to a need of communicating and exchanging the knowledge. At the end, it reduces the uncertainty, because both sides are able to deal with complexity and have clear picture of the relationships in the whole system. They make a conclusion on the importance of learning throughout the process, which involves "communicating, reflecting, understanding and acting" (Danilovic andSandkull, 2005, pp.193-202).
Networking mappings	The scholars investigate network mapping as a visual tool for capturing, displaying and updating information on dependencies between projects in a portfolio. This tool is also presented as a method to facilitate group decision -making for PPM, thus contribute to the strengthening of PPM process. It discloses the interdepency more clear than verbal communication or matrix displays, because it represents the "web" nature of inter-project relationships (Killen et al., 2009, pp.2-6).

It is reported by Rungi (2009a, p. 150) revealed not having enough time for the implementation, lack of knowledge and limitations of each tool in terms of the number of relationships as the main problems of these techniques. Tools were ranked according to their impact of project success rate and mathematical and visual methods along with dependency matrix came out as the best ones. Despite the fact that the informal methods are used the most in practice, their results were the worse.

3.7.2 Usability of the Visual Knowledge Management Tools for the Interdependency Management

We assume that the benefits of VKM tools also may be considered and applied for the purposes of managing interdependencies between projects. The table below presents both the interdependency drawbacks and benefits of VKM tools (see Table 2). It is summarized from the current literature that the interdependency between projects has certain drawbacks and negative effects on the project and portfolio performance (Rungi, 2010, p.150). Drawbacks such as project delays, cannibalization of existing resources or knowledge diffusion across the projects can be eliminated both by visual interdependency and knowledge management tools. As VKM tools have benefits that help managers to illustrate the relations between projects, to present and provide better understanding of "a big picture" and the details, as well as to coordinate, engage and motivate people to interact and transfer knowledge to each other, it can also solve the interdependency issues if viewed and considered that way.

Table 2. Identification of particular benefits of VIM tools for PIM

Interdependency drawbacks	**Visual knowledge management tools benefits**
● Delays ● not being able to start a project ● cannibalization of existing resources ● conflicts in resource sharing ● modularization ● knowledge diffusion across projects ● budget overrun or shortage ● conflicts between the managers ● competition for the resources (Rungi, 2009a, p.150)	● to address emotions ● illustrate relations ● discover trends, patterns, outliers ● to get and keep the attention of recipients ● to support remembrance and recall ● to present both an overview and details ● to facilitate learning ● to coordinate individuals ● to motivate people and establish a mutual story ● to energize people and initiate actions by illustrating options to act (Burkhard et al. 2005b, p.3)

3.7.3 Usability of the Interdependency Management Tools for the Knowledge Management

After the review of the interdependency management tools, we revealed the connection and potential linkage between the VIM tools and VKM tools, as well as common functions were discovered from both sides. They are presented below (see Table 3).

Table 3. Comparison of functions of visual interdependency and knowledge management tools

Functions of visual interdependency management tools	**Functions of visual knowledge management tools**

● more engaged and motivated participants; ● ability to see "a big picture" with the logical links and relationships between the objects ● idea mappings increasing the group memory ● documenting and mathematically quantifying the interdependency between projects ● represents the "web" nature of inter-project relationships ● reduces the uncertainty and complexity ● capturing, displaying and updating information on dependencies between projects (Danilovic and Sandkull, 2005, pp.193-202; Sibbet, 2010, p.14; Dickinson et al., 2001, pp. 523-527; Killen et al., 2009, pp.2-6; Rungi, 2010b, p.113-120)	● "coordination" of individuals in the communication process ● keeping an "attention" and representation of emotions by identifying patterns, outliers, and trends ● improving "recall" and remembrance of knowledge, because human brains think in images ● "motivation" and inspiration of viewers ● "elaboration" of knowledge in teams by the use of physical models and sketches ● "new insights" by insertion details in specific working contexts and illustrating relationships between objects (Burkard and Meier, 2005, p.480; Burkhard and Eppler, 2005, p.491)

The functions listed in the left column are the functions of VIM tools that are presented in the current literature. The right side column, on the other hand, are the functions of the VKM tools. Both sides include mostly similar features regarding the visual illustration of general view, helping users to see the links, patterns and relationships between the objects and projects, thus motivating and inspiring them to elaborate the knowledge within and among the teams. However, left side is naturally more interdependency oriented, whereas, right column covers broader functions and is a result of a more comprehensive approach. Therefore, by analyzing this table of functions of two types of visual tools, the need to include these more detailed and interdependency focused tools in the broader context of KM is determined. VIM tools and their functions can be viewed and implemented as a part of general KM area, as they are already matching some of the features and meeting the requirements of VKM tools.

3.8 Research Model

This Literature Review section gives an overview of the main concepts related to the current study and research questions addressed in the previous section. In order to visually summarize the outputs of this section, we developed the following model. This model puts various strands and notions explained above in a logical order and illustrates the links between them as displayed in the Figure 4 below:

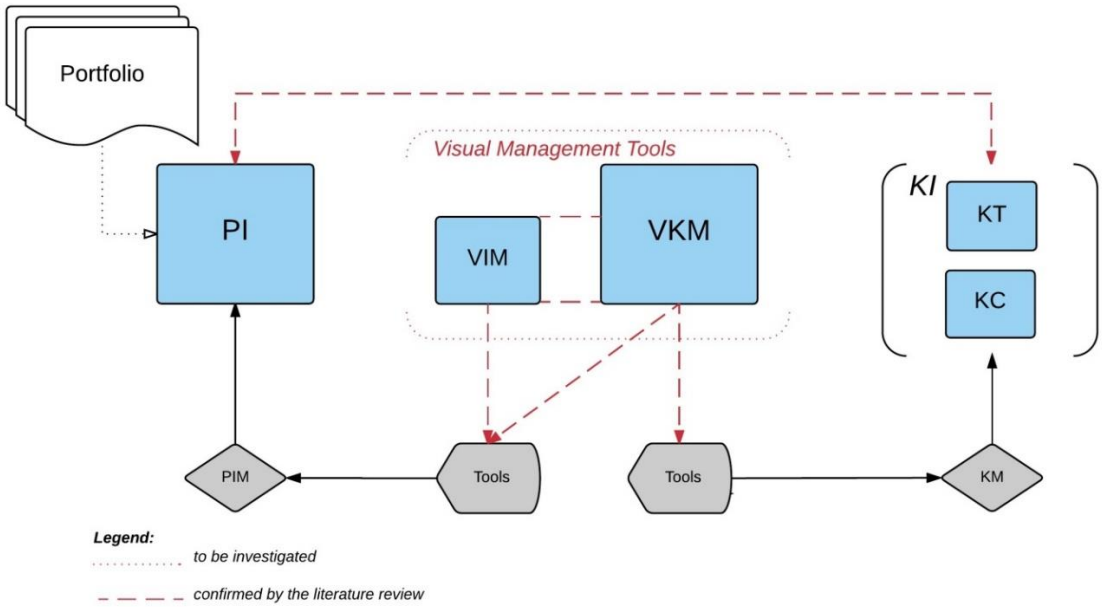


Figure 4. Research Model developed from the literature review of the authors

As discussed before, this model includes Project Portfolio where PIs are observed, resulting from multi-project and complex environment. This environment in the organization is affected by Knowledge Transfer (KT) and Knowledge Creation (KC) processes, which are part of Knowledge Integration (KI). VIM tools are employed for the management of PIs in portfolios. Separately, VKM tools are implemented for the KT and KC within the same portfolios. We are looking for links and relationships between these two types of visual management tools and suggest to integrate them to deal with interdependencies in a portfolio level.

4. Empirical Method

This chapter outlines the research design for this study, which can be understood as a functional diagram to guide from the research question to the conclusion (Yin, 2009, p. 26). It consists of the case selection criteria, respondent selection, interview design and procedure, questionnaire procedures and design. The chapter is brought to a close by describing the truth criteria and ethical considerations ensured within this study.

4.1 Case Selection Criteria

As was highlighted before in the methodology part, case study is suggested to investigate complex phenomena to answer "how" and "why" questions by qualitative research strategy to explain the interdependencies and knowledge management practices in organizations. According to many researchers in the field, the units of analysis in qualitative study are advised to be sampled by nonprobabilistic or purposeful strategy, because generalization in terms of the statistics is not an objective of the qualitative research (Merriam, 2009, p.77). Patton (2002, p.230) considers that the main strength of the purposeful sampling is information-richness of cases to express the problems of the research topic. In addition, according to Merriam (2009, p.49) to have convincing and empirical interpretation of results, the enlargement of the number of cases and the better variance among them might need to be achieved.

This qualitative study aims to generate a model of relationships in project portfolios including interdependencies and KT and KC among the projects. Particularly, during the current study it is intended to proof the following propositions formulated as a result of comprehensive literature review. It is argued that usually the interdependencies among the projects and difficulties related with knowledge integration cause problems for the project-based organizations, which is important for the achievement of the higher business value and effective project performance in general. The KC and KT, which are integral parts of the KM processes in portfolios, and have an impact on PIs, can be enhanced by the VKM tools. The VKM tools are beneficial to deal with the PIs in portfolios too. By integrating the VIM tools into KM practices, the needed solution to both challenges can be attained. Thus, it is planned to investigate whether the findings are replicated in diverse contexts, such as the mega-event, consultancy and IT companies.

In the present study, multiple case design is used to predict similar results by literal replication, because the evidence gained from such types of the design would be more convincing and carefully specified (Yin, 2003, p.46). If in all cases of mega-event, consulting and IT companies the results would be the same, demonstrative and argumentative support for the above-mentioned propositions and theoretical framework would be achieved. As was highlighted by Yin (2003, p.48), it is important to differentiate the replication and sampling logics of surveys, because, surveys are aimed to investigate specific subpopulation of respondents, which can represent entire pool for the evaluation of the occurrence of concepts. In contrast, the qualitative research in this research is aimed not only to study the phenomena, but also to consider several contexts and variables in order to verify duplication of outcomes (Yin, 2003, pp.51-52). The present study targets to investigate only one unit of analysis, which is about ***the relationships between project interdependencies and knowledge creation and transfer processes in project-based organizations.*** Thus, this study is considered as a holistic multiple case study.

To have relevant cases to proof propositions mentioned above, a ***two-level purposeful selection,*** with ***maximum variation sampling strategy*** is done (Bryman and Bell, 2009, p. 442; Merriam, 2009, p.266) to select informative cases, without taking into account the statistical representation of population (Saunders et al, 2012, p.287). The maximum variation sampling strategy is first identified by Glaser and Strauss (1967, cited in Merriam, 2009, p. 78), this type of purposeful and judgemental selection of respondents with heterogeneous characteristics aims to capture the common and key patterns sourced from the maximum possible variation (Patton, 2002, p.234; Saunders et al, 2012, p.287). Even if the sample would be characterized with the small number of diverse cases, Patton (2002, p.243; Saunders et al, 2012, p.288) highlights that it would not be a limitation for the identification of the phenomena.

At first, the analyzed case is selected, and then the sampling within the case is performed before the data from the interview and the survey was collected (Merriam, 2009, p.81). The organizations were chosen according to the criterion-based selection, which allows to capture same pattern in diverse characteristics of sample (Merriam, 2009, p.77; Saunders et al., 2012, p.288) to replicate the logic of the theory (Yin, 2009, p.55). The following lists of attributes were essential during the identification of appropriate diverse cases to reflect the purpose of the study and contribute to the elaboration of insights of the phenomena:

1. project-based organization with interrelationships among projects;
2. knowledge-intensive organizations;
3. dissonant industry categories to have multi-perspective illustration of visual management techniques in different settings (mega-event, consulting and IT companies).

Consequently, it can be concluded that, now, phenomena, which is planned to study would have maximum variation of characteristics in different settings to adjust the replication of findings. Thus, this study corresponds to the multiple case design.

As a result of shortlisting of suitable heterogeneous type of organizations, preference was given to the mega-event with multidisciplinary project team settings, major international management consultancy firm with numerous business sectors and knowledge-intensive IT-companies (Reich et al., 2014, p.599). Firstly, the mega event company is chosen, due to the high complexity of organizational setting, where each detail has a critical impact on the result and negative outcomes, delays or cost-overruns are not rational (Andersen and Hanstad, 2013, pp. 236-237) and acceptable. The management consultancy was selected due to the reason that the level of knowledge for such organizations is described to be their competitive advantage and business success criteria (Love et al., 2007, p. 71). Lastly, IT-companies were picked, for the reason that they are associated with high level of knowledge intensity (Reich et al., 2014, p.599), and project employment, despite the fact that it is relatively new field (Martinsson, 2010, p.65). In addition, it is crucial for these organizations to understand the underlying mechanisms, to obtain the ability to manage risks, mobilize, use and develop new knowledge in order to operate successfully. To sum up, all firms considered for the case study and described above are project-based organizations, which operate in the complex environment and experience interrelationships among projects.

During this qualitative study, we are trying to investigate individual's perspectives in the selected organizational context. It is believed that selected cases would help the reader to evaluate the arguments of the research analysis (Merriam, 2009, p.258). Having discussed how

the organizations are selected for the case study, the next part will address the respondent sampling methodology.

4.2 Respondents Selection

From the previous discussion, it can be seen that purposive sampling in this thesis is applied in two-levels. The respondents selection is done in critical way to assure that all significant parameters are included (Silverman, 2011, p. 388) and interview participants determined to design a case study that will enable us to answer the research questions through the justification of underlying theory (Yin, 2003, p.47).

The study done by Reich et al. (2014, p.599), which developed theory and tested the relationships between KM and various aspects of performance in IT-enabled business projects, had several limitations. The most prominent one is the involvement of a project manager as a single informant. In contrast, the current study's primary inclusion criterion to the respondents is the presence of multiple sources of information, such as from the project, portfolio and program managers.

Once the two-level purposeful selection criteria is justified, possible interview or survey partner companies are identified using online search engines such a google or yandex. In some cases, it was possible to find full information in the website, about the company and their employees. With regards to the contact information of the project, portfolio or program managers, in the vast majority of cases, it was not possible to get this data directly from the company's web site, because only general contact information was presented there. The information of only 15 companies' employees were available from their website. To facilitate contacting process, LinkedIn social network's search engine was used to send enquires directly to the individuals, after the identification of the targeted organization. If both cases were not possible or resultative, a general e-mail was sent to the company asking for it to be forwarded to the employee who is familiar with the topic. All communication was in English to minimize any bias interpretation of information by both parts. However, the barrier associated with language can be encountered; even though it was not the case in this study, because all respondents have good level of English.

The e-mail sent to companies included general information and the purpose of the study, as well as the request to participate in the research. In addition, the message contained the acknowledgement about the confidentiality of the data to be collected and its usage solely for the research purposes. Project and portfolio managers, with a direct involvement in multi-project environment, were invited to the semi-structured interviews and provided with the interview guide prior to the interview time ("Interview guide" in an Appendix 1). In order to increase the validity of the information, self-administered online questionnaires ("Survey questions" in an Appendix 2) were sent to the other project managers from the same companies, who were willing and interested to participate in the research study, however, were too busy to be involved in the interviews. It should be mentioned that mostly project managers agreed to voluntarily participate in the current research study. The initial probes showed that the self-administered questionnaires do not take more than 15 minutes, which was stated in the message sent to potential respondents. Depending on the positive or negative response to the first correspondence, the link to the online survey or the interview guide was sent. Thus, communication process had two steps: confirmation of participation and sending interview

guide or survey link. It is believed that using such multiple case study design by focused interview (Yin,s 2009, p.107) and questionnaire to gain qualitative data allows cross-case comparability and having wider amount of information for the purpose of triangulation (Bryman and Bell, 2011, p. 467). Being a form of verbal reports, the responses collected through interviews might be a subject to "bias, poor recall or inaccurate articulation" (Yin, 2009, p.108). For this reason, interview data is corroborated with questionnaire, to organize more insightful research study.

Totally, 99 requests to participate in the study were sent out via e-mail and 111 were sent by LinkedIn messenger. As a result, five people agreed to participate in the interview and scheduled it by themselves at the beginning of December, and seventeen respondents participated in the survey with response rate 10.48%. Regarding the rejection rate, twenty respondents canceled their participation in the questionnaire due to the limited time or privacy policy in their companies and two organizations agreed firstly, and then did not reply to the second message. Unfortunately, a majority of requests were not answered at all, even after a reminder. A possible explanation for this can be the fact that the research was undertaken at the end of the year, when companies need to close their operations and prepare annual reports in the period of holidays. Some denials and non-responses can be caused by lack of understanding of the topic or considering the study not suitable for the company's field of operations. Although it has been highlighted during the communication with the potential respondents that their privacy will be protected and explaining the purpose of the study, according to Fink (2013, p.17), some people feel suspicious and uncomfortable about the questionnaire, having a fear of the inappropriate usage of the information provided by them.

Taking into account the acquired amount of responses to the interview and questionnaires, we believe that the samples are multi-various enough to contribute to the research question (Ritchie et al., 2003, p. 83). The following parts are dedicated to the preparation, construction and execution of the interview process, as well as the follow-up analysis, truth criteria, and the research ethics.

4.3 Semi-structured Interview Design and Procedure

As DeMarrais (2004, p.55) points out, an interview is the conversation between respondent and researcher, in order to get answers to the research questions. This research provides an explanatory element to the research questions through the provision of intensive case studies with limited numbers of selected respondents, therefore, it is most suitable to conduct non-standardised semi-structured interviews (Merriam, 2009, p.88). Depending on the structure of the interview, highly structured, semi-structured or informal types of interviews can be exploited (Merriam, 2009, p.89). This research is required to ask a large number of complex questions with some probing and follow-up questions to receive in-depth understanding and explanation of the phenomena by cross-case comparability, which is in-line with the inductive approach. Therefore, the semi-structured interviewing is applied for the research purposes (Saunders, 2012, p.374; Bryman and Bell, 2011, p. 467). The flexibility of interview questions can not be achieved by structured and permanent interviews, whereas in-depth interviews can be too non-directive in regard to the theoretical framework of the study (Saunders et al. 2009, p. 375). It was decided to keep balanced approach during the interview (Bryman and Bell, 2011, p. 475).

The key process of semi-structured interview is asking right and relevant questions. Patton (2002, pp.350-365) in his study recognizes six types of questions that can be asked in the interview: ***experience and behavior, values and opinion, feeling, knowledge, sensory and background questions.*** It is decided to ask most of the above-mentioned types of questions to receive descriptive and full answers about the phenomena. These questions are inquired in open, closed and probing manner in the current study (Saunders, 2012, p.391). We also tried to avoid multiple, leading or yes and no questions to minimize poor answers (Merriam, 2009, p.100).

After considering the types of questions that can possibly be asked or avoided in the interview, we concentrated on our purpose and theoretical framework to develop an interview guide, to be sent to the respondents prior to interviews. This thesis has an deductive approach, even though some inductive constituent parts are recognized. The themes for the interview guide are particular illustration of the deductive element, because they were developed by considering the theoretical approaches generated from the literature review. After completing the formulation of the interview guide, pilot test of interview was executed, as recommended by Kvale (2007, p 79). Project director of the company, where one of us has been working before, participated in the pilot test, which gave a straightforward feedback about weaknesses of the interview questions. It is important to highlight that, the respondent of this pilot interview was fully suitable to criteria of the study (project manager, who experience interrelationships among projects). As a result of this, we decided to eliminate some questions, as well as specific terms and expressions of the project and KM research areas, to increase the clarity and transparency of the questions (Bryman and Bell, 2011, p. 475).

The interview guide helped to feel confident about the order of questions, to clarify underlying logic, save time to think and answer to the open-ended questions. During the first interview, researchers were asking questions according to the interview guide, later questions were asked with natural flow. We were aware that the interview guide should not restrict them, instead, they should aim for "an unbroken discussion" with the respondents and get prepared to ask all the needed questions to get substantial data (Easterby-Smith et al., 2012, p. 127). The interview guide is structured by the following five themes: ***Introduction and General questions; Project Interdependencies; Visual Management Tools; Knowledge Management and Project Outcomes.***

Prior to data collection, the interviewers started with the self-introduction; brief explanation of the research; ensuring the respondents that all the information and material from the interview will be respectfully used for the research process only. Moreover, interviews were recorded only after getting a permission of the respondents, and their anonymity was kept in case it is requested. This introductory step is helped to establish credibility, minimize uncertainties from the respondents' viewpoint and hence, to increase the reliability of the results (Bryman and Bell, 2011, p. 477; Merriam, 2009, p.103). After this stage, background and experience questions about respondents, their values, opinions, approaches and knowledge about the phenomena of interest were gained to have an access to the subject, as presented in the interview guide plan in the Appendix 3.

The majority of interviews were conducted through voiceover internet protocol such as Skype, due to the different geographic location of interviewees, and two sessions were done face-to-face. According to some researchers, Skype electronic synchronous interviews have limitations related to the obtaining spontaneous communication, because of the "transmit of social cues"

and "narrow bandwidth" (Saunders, 2012, p.406). Another limitation can be driven by difficulty to set a personal contact and observing the body language of the respondents to establish open transfer of information (Bryman and Bell, 2011, p. 489). Even so, the chance to build a mutual understanding between both parts by this type of the electronic interview was conceivable during the study. As for the face-to face interviews, they were done in convenient and quiet place in the office environment. It was done to build comfortable atmosphere for the respondents and facilitate open interaction (Saunders, 2012, p.387). This also gave us an opportunity to see the real circumstances where the managers are working and get familiar with the tools and techniques presented by them. In general, most interviewees allocated between 45 and 80 minutes of their time for each interview. It can be concluded that each respondent provided comprehensive answers contributing to the research questions in a satisfactory way and ensured respectful, non-judgemental, non-threatening environment played a key role in achieving these results.

All the respondents were very open and gave their authorization to use the provided data. The anonymity was kept depending on the respondents' request. To record the interview, including contextual data hand-written notes and audio-recording were applied. The main advantage of audio-recording is associated with guaranteeing the accessibility of the word-by-word responses afterwards. This was done with the purpose that in case notes are not sufficient to refer to the exact quotations, everything said can be used exactly as they are, by keeping them "preserved for analysis", accurate, permanent for others and without any bias (Saunders et al, 2012, p.396). With regards to the notes, they can record interviewer's reactions to the answers and highlight important quotes to refer to them later (Merriam, 2009, p.109). Thus, a combination of both types of recordings provide a complete understanding of respondent's rationales and minimization of bias perceptions (Eisenhardt and Graebner, 2007, p. 25). After the first implemented interview, the interviewers checked the recordings again to revise questions, the method of conducting the interview and to improve the process for the next interviews within the study (Merriam, 2009, p.109). The following table summarizes the information about respondents by date when the interview was conducted. More information on the companies and respondents is available in Appendix 4. All the information was affirmatively authorized for indication by respondents:

Table 4. Demographic profile of participants in the interview

Respondent	Function	Company	Operating field	Work Experience	Interview date	Duration	Language
Luca Cavoni	Project Manager	JMAC Italy	Consultancy firm	5 years	02.12.2015, at 9.10h	1:07:47	English
Anonymous	Project Manager	Company X	Mega event	3 years	02.12.2015, at 11.00h	0:43:54	Russian
Niclas Holmberg	Project Manager	Cinnober	IT company	2 years	08.12.2015, at 9.25h	1:08:35	English
Magnus Larsson	Project Manager	Cinnober	IT company	1 year	08.12.2015, at 10.40h	0:57:24	English
Liljana Krstanoska	Project Manager	Seavus	IT company	5 years	11.12.2015, at 14.00h	1:00:57	English

Holding interviews in pairs was a very convenient experience, as one interviewer could take detailed notes, while the other one was asking questions. Interviewers were switching the roles each time. Questions were addressed mainly according to the interview guideline by adding

follow-up questions depending on the emerging topics and circumstances that would happen in a balanced and similar manner (Bryman and Bell, 2011, pp. 205, 467). As for respondents, all answers were given fluently with confidence, detailed description of the situations and examples were provided to support their arguments. Nonetheless, it is understandable that for the interviewees it would be much more comfortable to answer to the questions and express their opinions in the mother tongue (Italian, Swedish, Kazakh, and Russian languages). In case if any confusion or misinterpretation would occur, the interviewers would clarify them for the respondents. Directly after interviews, it is decided to transcribe the records to justify them by respondents, because researchers understood that the verbatim transcription provides the key information for the research analysis (Merriam, 2009, p.110).

4.4 Questionnaire Procedures and Design

After setting the case and respondent criteria, an interview guide and questionnaire were formalized in accordance to the theoretical framework. The main reason why researchers decided to have multiple sources of data is to have cross-case comparability and obtaining wider amount of information to perform a triangulation and increase the validity of findings (Creswell, 2013, p.251; Creswell, 2014, p 201; Bryman and Bell, 205, p.403) for the IT, consultancy and mega-event cases. In this study, the findings from the questionnaire will be used to reinforce the results of the semi-structured interview.

Questionnaires are one of the methods of obtaining information to describe, explain or compare the individual's or group's knowledge, values, perceptions and approaches, feeling and behavior (Fink, 2013, p.2). There are different types of questionnaires, including self-administered that is filled out by respondents themselves or with assistance, paper or online, completed privately or in a central location (Fink, 2013, p.2). For the present study self-administered online questionnaire type was chosen. The following list of advantages presented by Bryman and Bell's (2015, p.240) can be helpful to understand the reasons why self-administered questionnaires were preferred instead of other possible methods of qualitative study: less expensive, the absence of interviewer's influence, convenience for respondents to fulfill the questionnaire, the information is obtained immediately, easier to process data as responses can be downloaded as a spreadsheet. It is important to state that while ***online semi-structured interviews*** provide relational anonymity and more open responses (Saunders, 2012, p.406; Bryman and Bell, 2015, p. 467), ***questionnaires,*** have the same layout of questions during the whole process and involve a limited interaction between parties, which make them more structured type of the interview. In other words, the questions asked in the questionnaire seem to be structured, with limited range of specific answers. Most of the researchers employ structured interviews as a quantitative type of the study (Saunders et al., 2012, p.377; Bryman and Bell, 2015, p.366-367). Nevertheless, a decision to use internet-mediated questionnaire to conduct a qualitative study was made within the current research.

These are the main reasons for this decision:

1. Questionnaires are used to collect opinion, behavior and attributes of the respondents in closed (like risk, category, ranking) and open nature of questions. Mixing closed and open questions in the interviews are also common during the qualitative study (Saunders et al., 2012, p. 432; Bryman and Bell, 2015, p.257). Hereby, employing a prominent number of open questions in questionnaire can guarantee a variation in answers to receive subjective and socially constructed meanings presented by the phenomena (Saunders, 2012, p.16). The

sufficient number of open questions is also applied in the present study as their results will be interpreted and have a contribution to the qualitative analysis (Fink, 2013, p. 131). An example of open questions is presented below in Figure 5.

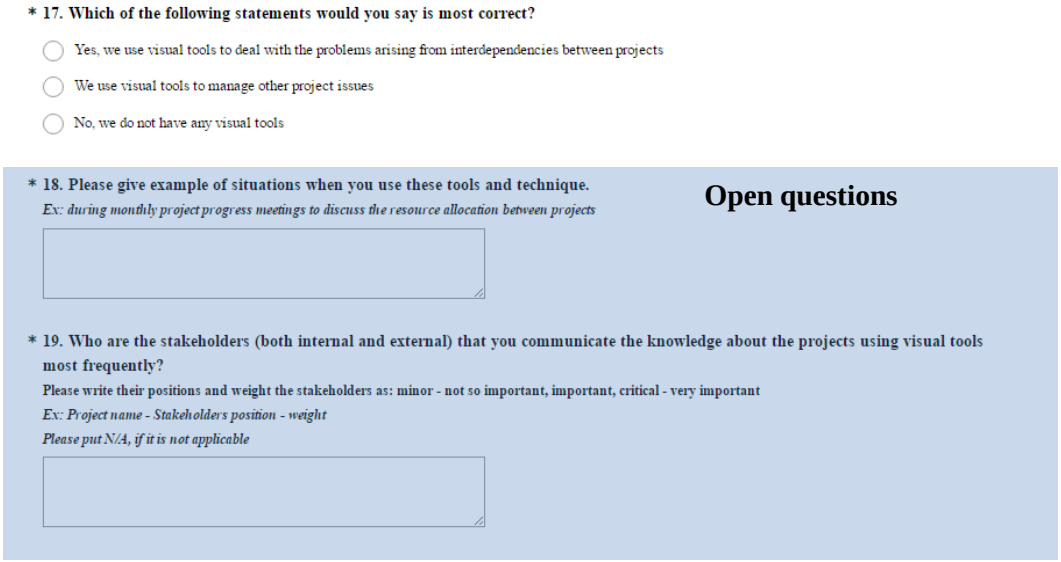


Figure 5. Sample of self-administered internet-mediated questionnaires performed in Surveymonkey™

2. Some researchers (Merriam, 2009, p.90) have used structured questionnaires in qualitative research with an attempt to receive socio-demographic data and a confirmation to particular statement, or to specify an idea of the formed framework as in this questionnaire;

3. The explanatory nature of the questions in this questionnaire help to understand relationships between PIs and KT and KC among projects, previously conceptualized in the theoretical framework in the Figure 4. As Saunders et al. (2012, p.163) emphasize in some studies "inductive inferences are developed and deductive ones are tested iteratively throughout the research". As a result, it is possible to say that questionnaire is used to test the relationships within the mixed approach of the current study.

Thus, the questionnaires in this study are used within a research strategy to understand relationships among variables, to confirm assumptions of researchers in order to have in-depth investigation of socially constructed meanings expressed by the project, portfolio and program managers, and not to focus on quantifiable data.

Table 5. The profile of participants in the questionnaire

Company	Operating field	Number of respondents	Number of project managers	Number of portfolio managers	Number of program managers
JMAC Italy	Consultancy firm	**1**	1	-	-
Seavus	IT company	**7**	6	-	-
Company X	Mega-event	**9**	7	1	1

According to the Table 5, seventeen answers to the questionnaire are received from the respondents with relatively diverse range of positions and from different companies. The

structuring of questions in the survey was done either by developing totally new set of questions referring to the literature review or adopting previously used questions. These questions were partly adopted from the existing studies in the field of KM, VKM and VIM tools and PIM. Particularly, while designing questionnaires, researchers referred to the methodology parts of studies done by Durant-Low (2012, p.101), Landaeta (2008, pp.31-33), Killen and Kjaer (2012, p.561), Kotnour (1999, pp.32-28), Rungi and Hilmola (2011, p.156), and Rungi (2009b, pp.111-114). The questionnaire was a mix of closed and open questions, with parts as: Introduction; General questions; Project Interdependencies management; Understanding of interdependencies within portfolios by visual knowledge management tools; The impact and features of visual knowledge management tools on the project performance and portfolio management as a whole. In order to achieve subjective and broad social perspectives of the respondents, less guiding, short and clear questions were aimed to be designed.

4.5 Data Analysis Procedure

The data received from the case studies are rich (Saunders et al., 2009, p. 482), and sometimes present diverse, inconsistent and opposite information. Therefore, the data management process is extremely critical and challenging (Merriam, 2009, pp.203-204; Bryman&Bell, 2015, p.579) in a way of its standardization and categorization. As Bryman and Bell (2015, p.579) emphasize, there is a limited number of common procedures for the analysis of qualitative data. The review of the current state of the papers and books about the data analysis strategies showed that authors mainly cover the following types of the strategies for the analysis of qualitative data: content analysis, discourse analysis, grounded theory, narrative analysis (Hardy and Bryman, 2004, pp.547-625; Creswell, 2013, p.190; Adams et al., 2007, 161; Saunders et al., 2012, p. 548; Bryman and Bell, 2015, p.580).

Saunders et al. (2012, p.548) distinguish two types of approaches, depending whether a research process starts with the theory or it is built at the end of the qualitative study: deductive methods, such as the pattern matching, explanation building; or inductive methods, such as grounded theory, template analysis, analytic induction, narrative and discourse analysis. While paying attention to inductive strategies, it can be recognized that such approaches as grounded theory, analytic induction, narrative analysis and discourse analysis may involve some deductive aspects during the analysis of the data. In contrast, template analysis incorporates deductive elements at the beginning, and then concentrates on inductive aspects, as it is done in the present paper. In terms of the interviewing process, Bryman and Bell (2015, p.581) emphasize that during the empirical data collection process, there is always a possibility to observe new topics, which have not been covered in the literature review. The process of reviewing existing literature (deductive element), including academic papers and books, can also affect the choice of data collection methods in inductive study. This leads to the fact that there is a little number of research studies, which are totally inductive (Bryman and Bell, 2015, p.581). Due to the reason that the current study uses a "mixed" approach, where theoretical framework is generated using a deductive approach to identify research gaps in the literature and establish a frame by which research questions are analyzed; and inductive approach is employed to understand and explain the interaction of social actors that create the social phenomena, we find ***template analysis*** in-line with the strategy of the research. Template analysis is additionally associated with the following advantages: flexibility of the approach which can be regulated as per requirements of the particular study; operation with prior identified codes aligned with theoretical framework of the work; presence of defined structure (King, 2004, cited in Smith,

2011, p. 236). However, this type of the research was not well covered in the literature, and there are only limited number of papers about it.

Template analysis is conducted in several stages within a research process of the study (see Appendix 5). Prior to the analysis, a predefined, generally descriptive template with the list of the concept-driven codes or categories is created, which are obtained from the theoretical framework to facilitate analysis of the qualitative data (Saunders et. al., 2012, p. 558). It is widely agreed that to start "intensive" stage of data analysis, all results of each case shall be accumulated into one specific database (Patton, 2002, p.449; Merriam, 2009, p.203). The analysis of multiple case studies consist of two stages: within the case and cross-case analysis. It means that firstly, the investigation of a single unit should be performed in order to understand its contextual variables, and then abstraction among cases is needed to build combined disclosure (Merriam, 2009, p.204; Yin, 2009, p.57). After the creation of transcript for each case, the predefined template is updated as per received data to have hierarchically well-organized logic among the categories. According to Creswell (2013, p.184), the coding process itself is "aggregating data into small categories, seeking evidence for the code from different databases, and then assigning a label", whereas categories represent a combination of codes, which serve the same idea. During the revision of the transcripts, some categories can show occurrence or non-occurrence. Depending on this fact, researchers insert a new code, delete the code that is not required anymore, combine codes and change the hierarchical level and scope of the code by updating higher-level category (King, 2012, cited in Saunders et al, 2012, p.573). Generally, the updating process can be finished only when authors are sure about the accurateness of codes, patterns and correspondence between categories (King, 2012, cited in Saunders et al, 2012, p.573).

After finishing the review of a particular case, cross-case synthesis will be applied as a part of analytic technique to enhance strength of the results (Yin, 2009, pp.156-160). By addressing this analytic technique, it is planned to test whether the same similarity is shared by different cases to be considered as one "general case" or not. This synthesis reflects argumentative interpretation with no numeric features. It is important to pay an explicit attention to the development of arguments based findings (Yin, 2009, pp.156-160). At the last stage of data analysis, conceptual framework of the study will be justified or updated according to the results, to represent all relationships and topics identified in the data analysis phase (Saunders et al., 2012, p.574; Creswell, 2014, p.199).

4.6 Truth Criteria

Although, in the current literature, the list of criteria for judging the quality of the research design is not defined in an exactly same way, the most discussed criteria used for the qualitative study include validity (external and internal), reliability (external and internal), credibility, transferability, dependability, confirmability, authenticity, transparency and coherence (Yin, 2003, p.33; Bryman&Bell, 2011, p.395; Saunders et al., 2012, p.192). Some of these criteria are also common for the case study approach, however, in case studies, a continuous "tactics" and methods should be used along the process, not just in the beginning (Yin, 2003, p.35).

In the qualitative study validity is concerned to which degree the undertaken research measures what is supposed to be measured. It is viewed from Yin's perspective that is suitable for the

case study method. Thus, internal validity, external validity and construct validity is used to test the quality of the current study.

Construct validity is about building proper operational measures by avoiding subjective approaches while collecting data (Saunders et al., 2012, p.193). Using multiple sources of data for triangulation serves the aim of collecting, comparing and choosing different information and checking if they corroborate or not. Thereby, we want to eliminate the possible threats and increase the chances of receiving more accurate and realistic information by reducing the possibility to make conclusions based on a single source of data.

Internal validity refers to the founding of causal relationships between the variables and can be applied in explanatory studies only (Saunders et al., 2012, p.193). To deal with internal validity, special attention is paid to data analysis, where the "tactics" might occur. For this purpose, pattern matching technique is used in data analysis stage, where the results of the first case will be augmented by other cases to make literal replications across the cases (Yin, 2003, p.117).

External validity is established to deal with the generalizability of the study's findings. Although, statistical generalizability is not the main focus of the current study, we considered this criteria by conducting multiple-case study and multi-method qualitative research. As a result, findings from each case can be used in other organizations with the same features and in the same industry.

Along with validity, reliability is also a most commonly used criteria in qualitative research. ***Reliability*** aims to make sure that if the research is conducted all over again by other researchers, or if the same cases in the present study will be studied again, they will get the same results and it will lead to the same findings (Yin, 2003, p.37). It is believed that the results of the current study might be different after some time passes, because business management, tools and techniques used in managers' daily-life are changing over the time. Nonetheless, to ensure the reliability and consistency of the current study, we made efforts to make as many operational steps as needed to record and document the research process in a detailed and transparent way, as described above in this chapter. Besides the detailed explanation of the research procedure, all the documents that were confirmed by the supervisor and used within the study, are presented in the appendixes. This was done with the logic to carry out a research meeting the high quality requirements, therefore, possible threats and biases from both ours and participants' side have been considered in advance (Saunders et al., 2012, p.192).

Confirmability is a criteria according to which the researchers objectivity can be measured in a certain extent (Saunders et al., 2012, p.398). We tried to maintain confirmability towards the study during the whole process by sustaining balance between two individual's objective approaches. Being equally involved in every step of the study and contributing to the literature review, data collection and analysis in the same level, as well as feeling the same about the undertaken research without allowing subjective perspectives to interfere, was very helpful for the conduction of objective inquiry.

4.7 Ethical Considerations

Ethics is one of the main concerns of any research (Merriam, 2009, p. 234), because it indicates the credibility of the researcher and contains very important qualities of the study, such as

validity and reliability in itself (Patton, 2002, p.552). Therefore, it was ensured in the current study that the ethical considerations are taken into account. The ethics of business and management research, as well as policies and regulations stated by the Umeå Business School and Umeå University were followed from the very beginning of the research. In order to avoid any ethical issues throughout the thesis work, namely while formulating the research topic, conducting the research, collecting the data, reporting and summarizing the findings (Creswell, 2013, p.174; Merriam, 2009, p. 234; Bryman and Bell, 2015, pp.129-143), shortly in each step ethical manners were carefully considered.

We selected the topic of our interest without any external influences from mentors or sponsors. The companies and participants were also picked according to their background and relevance to the chosen topic. While communicating the purpose of the study and sending the information about the short description of the process, all the participants were addressed the choice of mentioning their name or keeping the anonymity. The respondents were involved in the research according to the mutual consent and they were informed about the safety and confidentiality of the information provided by them. Their participation in the interviews was not harmful either, since it was one time contribution, mainly through web applications, and the time and duration of the interviews were agreed with the respondents in advance. Meanwhile, the interview guides were sent to the interviewees prior to the meeting (both online and face-to-face) to save their time and give them a chance to get familiarized with the content of the questions. Moreover, respondents were aware of the fact that the results of the research will be published and made publicly available. Prior to the interview, it was made clear whether the respondent gives a permission to the interview being recorded or not, and none of the interviewees was against that. In addition, in case there was a request from the individuals about the anonymity of their results, this was maintained accordingly in later stages. Thus, data collected through the semi-structured interviews and questionnaires were recorded and stored only for the thesis research purposes. All the participants and their employers were addressed messages of gratefulness for their time and contribution to the current research study afterwards. Those who requested, are provided with a copy of the final thesis document.

5. Data Analysis

This chapter presents an introduction to the sources of data which are four different companies and five respondents (see Appendix 4 for "Introduction to Companies"). The data collected according to research methodology (chapter 2) and empirical method (chapter 4) is analysed based on the themes, categories of codes and cases. A case-based analysis was produced in the first level, after the empirical findings from the semi-structured interviews are described, compared and supported by the quotations. Then the chapter examines the results obtained from the questionnaires that are also set out case-by-case in the second level of the analysis. Lastly, cross-case evaluation is reported upon each theme to summarize the results revealed from each case.

5.1 Results Analysis and Display

In order to deal with the large quantity of data, template analysis method was deployed in the current study. The chosen structured, at the same time flexible way of analyzing qualitative data allows the interpretation of findings from critical realism perspective, considering the areas discussed in the literature review and derived from the interview guide. This was achieved by using a new model (see the Figure 4) that was developed within the theoretical framework, and to verify whether different contexts duplicate the studied phenomena.

Data analysis started with the interview transcription and the coding of the results. According to the template analysis method, firstly, an initial template was developed (see Appendix 6). This initial version of the template included the themes covered by the theoretical research within the current study. Later, interview guide was reviewed and this lead to the development and elaboration of the new categories. Thus, in connection to our research, the findings are organized in the following identified areas: ***Project Interdependencies; Visual Management Tools; Knowledge Management; Impacts of Visual Management Tools on Project Outcomes.***

Each area of the template consist of categories and each category includes the abbreviations or codes, which help to interpret the large texts of interview transcripts as it is displayed in the fragment at the Table 6 below.

Table 6. A fragment of Initial template

2	**Visual tools**	**VT**
2.1	**Benefits of applying visual interdependency management tools**	**BVIM**
2.1.1	Illustrating relationships	ILL REL
2.1.2	Document interdependency	DOC INT
2.1.3	Quantification of interdependency	QUANTI INT
2.1.4	Ability to see big picture	BIGPIC
2.1.5	Idea mapping	ID MAP
2.1.6	Reducing uncertainty	RED UN
2.1.7	Reducing complexity	RED COM

After the initial template was revised and updated according to the empirical data collected through the semi-structured interviews, new codes and categories were created based on subjective interpretation and added to the existing categories. Some of the codes from the initial template were removed, because they did not appear to be effective compared to the interview

results (see Appendix 7). The revised version of the table (see a fragment at the Table 7) displays the crossed out codes that were eliminated and new codes are distinguished with comment.

Table 7. A fragment of revised template

2	Visual Tools	VT	Status
2.1	**Benefits of applying visual interdependency management tools**	**BVIM**	
2.1.1	Planning	PLAN	new
2.1.2	Progress status	PROG STAT	new
2.1.3	Illustrating relationships	ILL REL	
2.1.4	Getting immeadiate information	IM INFO	new
2.1.5	Document interdependency	DOC INT	
2.1.6	Quantification of interdependency	QUANTI INT	
2.1.7	Ability to see big picture	BIG PIC	
2.1.8	Idea mapping	ID MAP	
2.1.9	Reducing uncertainty	RED UN	
2.1.10	Seeing workload and skills of people	WORKL	new

Hence, the final version of the table demonstrates the codes that will be discussed, commented and explained by categories and cases in the following part of the chapter. If the initial template contained of 15 categories, the final table includes 14 categories (see Appendix 8), since "the drawbacks of visual knowledge management tools" was eliminated after the revision. The analysis of the findings is presented in two levels: within and across the cases.

In addition to the interviews, the questionnaires that were sent to project managers from JMAC Europe (1 person), Seavus (7 persons) and Mega event company (9 persons), revealed supplementary data that are analyzed qualitatively case-by-case and presented in this chapter. Data is presented anonymously, according to the request of the majority of respondents. Questionnaire included both open and multiple-choice questions.

5.2 Project Interdependencies

5.2.1 Resource Selection

In hereby, the analysis of the results are presented about the resource selection category, which was added to the initial template after the comparison with the empirical data.

Table 8. Resource selection

Respondents	JMAC Italy	Mega event	Cinnober		Seavus
Codes	**R1**	**R2**	**R3**	**R4**	**R5**
KNOW				x	
PPL	x	x	x	x	x
RES SELEC	new				
COMP	new	x	x	x	x
AVAIL	new	x		x	x
NEGOT	new			x	x

When asked about the most important resource for managing the projects successfully, all the respondents answered that people in the team and organization are the most valuable resources. While running more than one project at the same time, interviewees have faced with some challenges to get the resources they need. **Respondent 1** from a consultancy company mentions the importance of human resources in their job and explains the factors that influence the resource selection process by saying *"in order to select the resources, there are two main points to consider: competencies, the capabilities of the people to be involved, the availability, maybe that person is already booked for another project".* He also adds that *"...in the end, it is a combination of capacity and capability, availability"*, because he has to consider other projects, their needs and negotiate for the resources. **Respondent 2** from the mega event company highlights the criticality of human resources in her projects, as she is working in a Participants Division and their activities mainly consist of *"participants, diplomacy, interaction and communication".* Further, she clarifies that since in mega event that she is involved in *"the funding is based on governmental budget"*, they can not use it *"freely for the involvement of extra employees or services"*, and when there is a need, they work overtime to not end up with overbudget. Respondent 3 and 4 from IT company Cinnober also consider the human resource as the most essential resource. **Respondent 3** comments on the people by defining that *"the skills and personalities"* they have in their team is *"a key, absolutely key"* and **Respondent 4** elaborates this idea further, he adds that people *"are the ones who make things done"* and have the knowledge to do that. In Cinnober, they have a *"project office",* a *"group of people who are responsible for the resource allocation"* among the teams. Usually, through the checking of the availability and negotiations the resources needed for the project can be obtained and as Respondent 3 mentions they need to be *"proactive"* and they *"need to talk"* to get the people with the required skills, as according to the Respondent 4, the resources are *"prioritized"* based on the needs. **Respondent 5** from Seavus talks about the *"resource planning tool"* that is used for the *"resource allocation"* or in case that is not possible, *"switching of people"* internally. All this processes are done only through the *"discussions with the division manager".* In addition, if they practice an overlap or interdependency in terms of skilled resources between other projects, they involve *"technical leads and technology line managers as mentors"* to help less experienced personal when they *"bump into a problem"* or need to handle a complex situation.

From the responses, it was identified that the most important resource that all the companies identified as human resources, because of the competencies they have, may not always be available. This is a strong evidence of the dependence from other projects, which requires the project and portfolio managers to compete, to negotiate and convince the ones who are in charge of resource allocation explaining whom, why and for how long they need those skilled and experienced people.

5.2.2 Types of Interdependencies

From the interviews, it was acknowledged that in all the studied cases, there are usually interdependencies occurring among the projects on portfolio or organizational levels.

Table 9. Types of interdependencies

Respondents	**JMAC Italy**	**Mega exent**	**Cinnober**		**Seavus**
Codes	**R1**	**R2**	**R3**	**R4**	**R5**
CUST	new				x

TOP	new	x		x	x
KNOW	x	x	x	x	x
OUT	x	x	x	x	
BEN	x			x	
TME	x	x	x	x	
RES	x	x	x	x	x

As it is shown in the table 9, most of the respondents have experienced resource, knowledge, outcome, time as types of interdependency they need to manage among the projects. Only a two respondents have mentioned benefit, customer and topic as types of interdependencies, and the last two codes were added while reviewing the transcript of the interview with the **Respondent1** from the consultancy company. According to him, *"running more than one project for the same customer at the same time"* and *"having same topic"* are the most frequently occurring interpedencies in his experience. **Respondent 2** from the mega event states that *"closer you get to the actual event, the more critical the interdependency among the projects are"*, and there are many types of interdependencies in this kind of big organizations. She explains it by giving an example of ensuring countries' participation in the event is a minor project itself, however without having the exact number of participants the other divisions can not continue their work, since the budget, design, construction, marketing and PR are all dependent on it. In Cinnober, however, the most frequently, interdependencies are about how to *"communicate different projects in terms of data transferring, back and force*", says **Respondent 3**.
Respondent 4 explains the software offering pyramid that they have in Cinnober, and this

> ***Respondent 3****: "It is all about what kind of people you have within the team. It is so important, you can not have just a group of very specialized developers, you need to have good behaviors. You need to have someone who is good with customer relationships and all that testing. You need to have a team that has a good understanding on what to build, to have good experience. You do not always get that, but you need to balance team. That is the absolute most important thing."*

pyramid consists of 3 layers *"platform layer, ...distance layer, and customization layer"* from bottom to top. The layers of the pyramid usually depend on each others' *"deliverables"* and outcomes, on the other hand, other teams *"working in business functionalities in parallel"* also have the interdependency realtionships among the projects, therefore, Respondent 4 recognizes it as *"both vertical and horizontal dependencies"*. **Respondent 5** mentions that usually instead of projects, they "are having a lot of interdependencies between the tasks that need to be performed" this happens when there are *"shared people, shared resources, and sometimes shared knowledge"*. She adds that when the project is about *"a development within the company"*, or for the same customer and in the same topic, then the other types of interdependencies are also common. Other project managers from Seavus who took part in the research through ***questionnaire*** also support Respondent 5, as they mention that *"knowledge"* and *"resources"* are the most common types of interdependency among the projects.

5.2.3 Benefits of Managing Project Interdependencies

As it is demonstrated in the Table 10 below, all the respondents find PIM beneficial for different reasons, but the most common aim is that it helps them to see a *"big picture"*. Some of the codes were added, because they were suggested by the respondents, in addition to the existing ones.

Table 10. Benefits of managing project interdependencies

Respondents	JMAC Italy	Mega event	Cinnober		Seavus
Codes	**R1**	**R2**	**R3**	**R4**	**R5**
OPP	new			x	x
STRO COMP	new				
KT	new				
BIG PIC		x	x	x	
LOG REL		x		x	
RED UN			x		
DOC INT		x			x
DEC MAK			x	x	
PRO SEL	x		x		x
PR RES			new		x
PROG STAT			new		x
CUS UND	new	x			

Respondent 1 reveals that *"the interdependency can be positive and negative",* and he further explains that:*"when you have 5 customers for example asking you for the same topic at the same time, it can be a good opportunity, because maybe you have sources from the competencies point of view, but you also may have an issue, because, you can not use the same resources in all the projects".* He adds by saying that when two or more projects are *"linked to the same customer"* and ran simultaneously by having the same topic, it can provide the portfolio manager with *"wide and comprehensive understanding of the customer"* from different perspectives. Moreover, *"from a business point of view, this wider perspective allows you to understand there are more possibilities for business maybe at present or in future"*. According to **Respondent 2**, by managing the interdependencies effectively, the overall view and *"logical links"* among the projects can be determined, later this is documented as part of *"organizational convention"*, according to their mega-event management procedures. As per **Respondent 3**, however, PIM is *"just another task on the board"*, it *"needs to be handled"* to make things *"clear"*. Thus, he also mentions that PIM is useful for the selection of resources, decision making and achieving a progress in the projects. **Respondent 4** states that although *"the model"* they are working with in their team *"is kind of loose"* and *"their deadlines are not completely fixed"*, they still need to cope with the interdependencies among the projects.
Respondent 5 from Seavus has her view on the PIM that *"it is really important to manage*

> ***Respondent 1****: "[…]you can build stronger competencies inside, and you can get more experience by collecting the knowledge developed in one project and transfer to other projects. In general, managing the interdependencies among the project is a good opportunity."*

interdependencies […], because you need to understand what needs to be done first, in order to proceed with the other one". She explains that as they are using agile approach in project management, so the interdependencies, *"requirements for the functionalities that need to be developed" and "a list of functionalities defined in order and priority"* are identified during the *"planning session"* before starting the project. Therefore, it is very important process to ensure the success of the project later on.

Questionnaire Results

Mega-event. According to 4 people out of 9, PIM is "very important" and to 3 people it is *"important"*. The majority of project managers from **Seavus** think that managing PIs is *"important"*, as 4 people selected "important" and 2 people voted for "very important". Only one person mentioned 3 in a scale of 5. Similarly, respondent from **JMAC Europe** evaluates both his project and PIM "very important" to the organization.

5.2.4 Drawbacks of PIs

Table 11. Drawbacks of PIs

Respondents	JMAC Italy	Mega event	Cinnober		Seavus
Codes	**R1**	**R2**	**R3**	**R4**	**R5**
DEL			x	x	x
ONTIME					x
COMP RES	x		x		
CAN RES	x				x
CON RES					x
KNOW DIFFU		x	x		
CST CONST	x				x
CONF		x			

Table 11 demonstrates drawback or problems that usually take place because of interdependencies among the projects in the selected case organizations and are covered in the literature. In total, three interviewees confirm that interdependencies may cause delays and two respondents reveal that it is the main reason for the competition among the project managers to get the shared resources, and the same number sees it as a reason for the cannibalization of existing resources.

Respondent 1 from JMAC describes the challenges arising from resource interdependency by stating that it becomes *"hard to make sure that resources are committed on the tasks"*. In addition, he argues that *"the cost for the customer is an issue too, maybe they need different projects, but they are not able to start all the projects at the same time"*. **Respondent 2** highlights that knowledge diffusion is a drawback of having interdependencies and if there is *"lack of communication"* among the project managers, things can get even worse. In mega events, often *"changes in management"* causes the knowledge dependency, thus leading to the conflicts among the project managers. **Respondent 3** argues that although there might be issues related to interdependencies, he never had a big problem and *"it has always been manageable"* if right tools and techniques are used. **Respondent 4** supports by saying that because of certain characteristics of their organization in services they provide *"it is really hard to set a fix time line […], so, usually it is not completely critical"*. Therefore, they are flexible in terms of managing the projects so that most of the interdependencies are solved or handled effectively. He adds: *"we have fairly few dependencies […] between the projects, at least currently, so, it is a good situation to be […] it is hard to manage dependencies.* **Respondent 5** describes that interdependencies usually impact the start time of the task, when it depends on the previous one, thus, the whole project may have a delay and budget overrun, *"sometimes the work is blocked due to the interdependencies",* she says.

Questionnaire Results

Mega-event. Respondents from the mega-event company, nine people in total, are distinguished as 78% project managers and 22% program managers. Two people out of nine evaluated their projects as *"very important"* and the other two people, as *"important"*. All the respondents have an experience in managing projects with interdependencies and are familiar with the problems that encounter of these relationships. Thus, they mentioned that face with time related issues such as delays, schedule slippage most frequently, *"sometimes"* with resource misuse or shortage, and four people answered that it rarely creates challenges to solve short-term problems, transfer risks or exploit the organizational learning. One person assesses PIM as *"very difficult"*, which is five out of five in a scale. Two people give "4", four people "3" and two people "2" in a scale of five. Seven project managers from **Seavus** have participated in the online questionnaire and they are running 1-3 projects at the same time, although the range of projects in the portfolio vary from these numbers. When asked *"How important are your projects to the organization?"*, five people answered *"important"* and two persons mentioned that the projects that they manage are "very important" for Seavus. Most of the respondents, precisely five out of seven, reported that *"sometimes"* they face with resource misuse or shortage problem when there are interdependencies. Four people also mentions delays, late project start-ups happen *"sometimes"* because of PIs. Three people reveal the same challenges occurring "often", whereas, one person out of seven thinks that PIs *"always"* cause a resource shortage. The rest of the issues are chosen by 1-2 persons and in smaller frequency (1-hardly ever, 2-rarely). It must be linked to the challenges arisen from PIs that three people out of seven find managing interdependencies *"difficult"*. Two people voted for "3" in a scale of "5", and one person-for "1" and "2" respectively. Project manager from **JMAC Europe,** also finds it *"difficult"* to deal with PIs and thinks that the most common problem that PIs cause is resource related, then time (sometimes), budget shortage (rarely), inter-project competition (rarely) and other problems hardly happen.

5.3 Visual Management Tools

5.3.1 Tools and Techniques Used for the PIM

Using different tools and techniques can be beneficial in dealing with the challenges encountered because of PIs. The literature review revealed the most effective tools by grouping them as visual and non-visual interdependency management tools. During the interviews, additional tools were explored that are largely used in practice, which are mind-mapping tools, charts, Scrum boards, JIRA, visual boards and visual planning tools, as displayed in the table below. It was interesting to discover that in companies, project and portfolios managers are not deeply informed about the tools and methods that can be used specifically for the PIM, but they are using the elements of knowledge and general project management tools to deal with the PIs.

Table 12. Tools and techniques used for PIM

Respondents	**JMAC Italy**	**Mega event**	**Cinnober**		**Seavus**
Codes	**R1**	**R2**	**R3**	**R4**	**R5**
NONVTPIM		x	x	x	
VTPIM	x	x	x	x	x
MINDM					new
CHR		new			
SCRUM			new	x	x

VISL BRD	new			x	
JIRA			new	x	x
DATAF	new	x	x	x	

Respondent 1 discusses about the "planning tool", which "is more like a database file" that they use in JMAC, by considering it as a visual tool. He explains that this tool enables a project managers to see *"the projects they are involved, with a timeline on top […] how many days they have, at the bottom you can see how many days there are available".* In addition, a visual board is used by each team member who has a role on the board, *"they put the number of prospect contacts, they can involve to investigate business opportunity[…]it is more like a portfolio management, but on business opportunities […], but also used in a proactive way".* **Respondent 2** revealed a surprising fact about the mega-event management and using the tools for the PIM by saying that *"everyone is using […] separately for their own projects, but I can't say that they all use one system".* She mentions that *"presentations and charts"* visualizing the interdependencies among the projects are the tools that they use in her department: *"Visual tools make life so easier, but […] you should not use the tools just for the sake of using them. It all depends on the project, what are the objectives, budget and deadlines."* Both **Respondent 3** and **4** highlighted the Scrum Board as an effective tool for the PIs, *"it is just showed-up a story, if that is case"*, states Respondent 3. Using agile project management approach has certain requirements, one of which is working in small teams and meeting frequently to discuss the progress. In Cinnober, the *"story is visualized on the Scrum board"* and daily tracking of the project starts right after the project owner's confirmation. **Respondent 4** express his opinion about the Scrum board: *"I really like this process with Scrum, where we discuss, because, you normally do not book a meeting with someone, you just think up where we are".* Further, he describes the weekly meetings where project teams have *"an opportunity to communicate, ask what has been done […], is there any dependency between projects?"*, adding that *"project plans"* also help to define the interdependencies, if there are any. For the **Respondent 5** Scrum board and mind mapping tools are used in different stages, she mentions that mind mapping tool is mainly functional for the *"planning"*, whereas scrum board, is generally used *"during the development and testing phase"*.

Questionnaire Results

Mega-event. Five people out of nine use visual tools to manage PIs and four people use them to deal with other project related issues. Some examples of situations when the visual tools are used included *"during the monthly meeting", "before editing monthly report"; "every day for the timely resolution of the problems"; "during weekly meeting to discuss the project progress or the resource allocation"* and *"shift planning", "to discuss the planning and cover vacancies".* Another respondent who is a portfolio manager, explains that the tools that they use are specifically helpful *"to avoid overlapping activities on working site".* Further adding: *"You could not see this information using a typical Gantt chart".* One of the interesting points mentioned by one of the project managers was *"to be clear and synthetic, putting together more than one PM theory or instrument",* which perfectly describes the actual function of these tools. **T**he majority of respondents are using visual tools for PIM **in Seavus**, five out of seven. The other two people practice these tools for other purposes. Respondents gave example of the most common situations when they use the visual tools, such as *"during a brainstorming and planning sessions", "define tasks and activities", "prioritization", "assigning resources to each task and creating an action plan".* Although, the respondent from **JMAC Europe** utilizes

the visual tools to manage interdependencies, he has not provided any example of the situation how these tools are used exactly.

5.3.2 Benefits of Applying VIM Tools

Similar to what is displayed in the section on the benefits of PIM, all the respondents confirm that the main advantage of using visual tools for PIM is for its ability to visualize the "big picture" of the portfolio. Three interviewees out of five find it useful for illustrating the relationships among the projects, and the same number think that it is particularly effective for reflecting on the workload, project status or progress, illustrating the relationships and idea mapping. Some of the respondents also agree that using the visual tools can impact the speed of the decision making process by highlighting the problems and remembrance of the knowledge.

Table 13. Benefits of applying VIM tools

Respondents	**JMAC Italy**	**Mega event**	**Cinnober**		**Seavus**
Codes	**R1**	**R2**	**R3**	**R4**	**R5**
PLAN		x		x	new
PROG STAT			new	x	x
ILL REL			x	x	x
IM INFO	new	x	x		x
DOC INT					x
QUANTI INT			x		
BIG PIC	x	x	x	x	x
ID MAP			x	x	x
RED UN					x
WORKL	new		x		x
COMM			new		x
RED TME	new				x
RED COM	x				
HIGHL PROB			new		x
REMEMB			new		x
REC DEVKNOW			x		
MOTIV			new	x	

Respondent 1 describes the benefits of using visual tools for the PIM as *"getting immediate information about critical areas, topics, or seeing the workload of people, helping you understand if there are some bottlenecks, or there is a room for investing in new opportunities".* According to **Respondent 2** visual tools help to see visually what are the relationships with other projects and where the interdependencies lay among them. **Respondent 3** mentions that *"it is easy to get an overview"* of the current situation by using a Scrum board, for example: *"you can just walk up to the board, take a look, and you get immediate feeling of the status of each individual story"*. He also add that this tool *"helps to memorize the information"*, moreover, the *"whole team gets this feeling of things actually moving"* on the board, which *"adds a lot of value to the feeling of team"* he explains. Thus, using this visual tool for the team discussions helps to motivate the team members. **Respondent 4** confirms that the *"main purpose is to get […] better understanding of the dependencies"* by using the available visual tools and techniques. **Respondent 5** from Seavus describes the visual tools that she applies in

her projects as *"a really handy tool"* for the situation when *"there are 10 people in one room and everybody is sharing their insights and ideas"*. She adds: *"I do not think that you would be able to update 10 different documents in 10 different places if you do not have such tools. Or at least you would miss a lot of information."*

Questionnaire Results

The figures below illustrate the responses to the question: "*Is the visual knowledge management tool used in your organization useful for the following practices?"* (please mark the followings by using a scale from 0 to 5, where 0=not applicable, 1=not useful and 5=very useful)

	0	1	2	3	4	5	Total
Ability to access, distribute, adopt and review data/information/knowledge from other projects	22.22% 2	0.00% 0	11.11% 1	33.33% 3	22.22% 2	11.11% 1	9
Project management processes that help to learn from past mistakes and to avoid making the same mistakes again	22.22% 2	0.00% 0	11.11% 1	22.22% 2	22.22% 2	22.22% 2	9
Presence of formal processes to ensure that learning and information from projects are transferred to dependent and other projects	44.44% 4	0.00% 0	22.22% 2	11.11% 1	11.11% 1	11.11% 1	9
Informal mechanisms (open discussions, meetings) are regularly used to transfer learning and information to dependent and other projects	22.22% 2	0.00% 0	11.11% 1	22.22% 2	22.22% 2	22.22% 2	9
Awareness and good understanding of all the projects that my project depends upon or that impact its success	33.33% 3	0.00% 0	11.11% 1	22.22% 2	11.11% 1	22.22% 2	9
Awareness and good understanding of all the projects that depend on my project	33.33% 3	0.00% 0	11.11% 1	33.33% 3	11.11% 1	11.11% 1	9
Ability to assess complex situations and see big picture	22.22% 2	0.00% 0	0.00% 0	22.22% 2	11.11% 1	44.44% 4	9

Figure 6. Mega-event questionnaire result (sample)

	0	1	2	3	4	5	Total
Ability to access, distribute, adopt and review data/information/knowledge from other projects	0.00% 0	0.00% 0	0.00% 0	42.86% 3	28.57% 2	28.57% 2	7
Project management processes that help to learn from past mistakes and to avoid making the same mistakes again	0.00% 0	0.00% 0	14.29% 1	0.00% 0	71.43% 5	14.29% 1	7
Presence of formal processes to ensure that learning and information from projects are transferred to dependent and other projects	0.00% 0	0.00% 0	0.00% 0	71.43% 5	28.57% 2	0.00% 0	7
Informal mechanisms (open discussions, meetings) are regularly used to transfer learning and information to dependent and other projects	0.00% 0	14.29% 1	14.29% 1	14.29% 1	14.29% 1	42.86% 3	7
Awareness and good understanding of all the projects that my project depends upon or that impact its success	0.00% 0	0.00% 0	28.57% 2	0.00% 0	14.29% 1	57.14% 4	7
Awareness and good understanding of all the projects that depend on my project	0.00% 0	14.29% 1	0.00% 0	14.29% 1	28.57% 2	42.86% 3	7
Ability to assess complex situations and see big picture	0.00% 0	0.00% 0	0.00% 0	0.00% 0	57.14% 4	42.86% 3	7

Figure 7. Seavus questionnaire result (sample)

JMAC Europe. According to the respondent, visual tools are very beneficial to see the big picture and assess complex situations. He also finds them useful to access, distribute, adopt and review information or knowledge from other projects. However, he thinks they are less effective in *"project management processes that help to learn from past"* and *"presense of formal processes that help to learn from past mistakes"*.

5.3.3 Drawbacks of visual interdependency management tools

When it comes to drawbacks or limitations of applying visual tools for PIM, only few were mentioned by the respondents, the most common ones are not having enough time, complicated feature, the need to track digitally and requiring physical presence of people.

Table 14. Drawbacks of VIM tools

Respondents	JMAC Italy	Mega event	Cinnober		Seavus
Codes	**R1**	**R2**	**R3**	**R4**	**R5**
PRIOR				new	
PRESPPL	new		x		
NO TIME		x		x	
LAC KNOW					x
LIM FEAT				x	
COMP FEAT				x	x
NOSTAND TOOL		new			
TRACK DGTL			new	x	

Respondent 1 from JMAC defines the visual tools, especially the visual boards, as ***"****physical tools"* and he thinks that *"the presence of people is required to work with it"* which is a limitation. He explains the details: *"If, for example, you need to have a meeting and you do not have all the people there, it will not be as effective, as when you have all the people around. So physical presence is a limit."* **Respondent 5**, in contrast, finds the visual tools effective for the same reason, by arguing that it reduces the time and efforts when everyone comes together and solve the interdependency related issues *"in meetings"* by using the visual tools. In mega-event, *"the main problem is that everyone is using different tools according to their preferences"* says **Respondent 2**, by adding: *"sometimes the tool that is easy to use for visualizing and sharing the information is not efficient for a certain case, because others are not using it".* **Respondent 3** reveals that the downside of using some of the visual tools is that *"you can not pool reports"*, for this reason additional digital tracking is needed and in Cinnober, they use JIRA software program to achieve that. **Respondent 4**, on the other hand, finds the JIRA *"a bit more detailed"* which is not helpful in terms of *"getting an overview what you actually have in backlog"*. In case of Seavus, **Respondent 5** defines the problem linked with the fact that their clients who are also participating in the communication of project related information, as well as in the meetings, "are not used to use the visual tools". Further she guesses *"probably they are not familiar with the benefits they could get, some of them who has not had a chance to use them, think that these tools create a double work".* This might be related to the process itself when the information need to be put *"in one place, then in another"*, she adds.

Questionnaire Results

Mega-event. For the question regarding the limitations and drawbacks of the visual tools, six out of nine respondents stated that they do not have time to use the tools. Four people find the tools that they are using a bit complex, whereas two people think that their visual tools have limited features and are not able to fully illustrate the relationships among the projects. When the recommendations on the visual tools were asked, one of the respondents explained that the

visual tool that they are using in the construction phase can be more beneficial if it is also used throughout the complete life cycle of the project. In contrast, to the mega-event case, three respondents from **Seavus** experience that there is lack of guidelines explaining how to use the visual tools. And again, unlike the respondents from mega-event company, these project managers do not find time as a big issue to apply visual tools in management, since only two people marked that option. The same number of respondents mentioned *"complexity"* as a drawback and just one person thinks that the visual tools used in their organization considers limited number of relationships. As a way of improving the already used visual tool, it was suggested to change the mindset of users, who are not familiar with the visual tools so closely. The respondent believes that *"when people understand the usability of visual tools, the will start using them in their daily life".* On the other hand, respondent from **JMAC Europe**, considers lack of *"time and different physical locations of the stakeholders"* as factors creating the drawbacks of visual tools.

5.3.4 Visual Knowledge Management Tools

In order to recognize the KC and KT methods in the companies, interview questions such as "*What is the best way to share or transfer knowledge and create knowledge for your projects?*, "*Do you think the visualization of knowledge plays a role on that?*" and *"Do you discuss the risks and problems and try to solve them during the meeting? How useful are the visual tools for these purposes?"* were asked, which lead to the identification of the benefits and functions of VKM tools displayed in the following table:

Table 15. Benefits of applying visual knowledge management tools

Respondents	**JMAC Italy**	**Mega event**	**Cinnober**		**Seavus**
Codes	**R1**	**R2**	**R3**	**R4**	**R5**
ALW ACC			new	x	
COMM	new	x	x		
COOR IND	x	x	x	x	x
KEEPAT			x		
RSK PRO PAT	new		x	x	x
SOLV PRO	new				x
LEARN	new				x
KNOW REM			x	x	
ELOKNOW		x	x		
PROG STAT	new	x	x	x	x
ILL REL	x		x		x
INT	x	x		x	x
EXT		*Questionn. insight*	x		

The initial template was upgraded according to the interview transcripts by revealing new benefits of VKM tools, such as "always having an access", "facilitating communication process", "identification of risks, problems and patterns", "solving problems", "learning and performing progress status". At this point, it must be clarified that there was not a clear distinction between VIM and VKM tools used in the selected companies. Mostly, the same set of techniques and methods were described both as interdependency and knowledge management tools. **Respondent 1** from the consultancy company highlighted that "*in the end,*

a tool is not the aim, it is a way to communicate with others" and "*to make a group of people or a team to work better with each other*". According to the respondent, the tools that they are using lead to the coordination of individuals during the brainstorming sessions and grouping "*relational, organizational and technical"* problems, to view the relationships among them on the "*paper board"*. Working in such way helps the company to understand the reasons behind the issue, how to solve problems in a team and "*how to avoid the same issue happening in the future*". Interestingly, company also practices the preparation of business cases and their presentation in the internal monthly sessions to "*share the progress status of company, new projects, new contracts[...], revenues*". Generally, as it is stated by the interviewee in JMAC Italy, visual tools are used to communicate the information about projects to the internal parties within the organization.

Turning to the next case, the mega event, **Respondent 2** acknowledged that in their organization they mainly use presentations, charts and digital tools to communicate information among top management and departments, to coordinate individuals, to elaborate knowledge about "*what has been done"* and *"exchange with data".* The information through visual tools is mainly transmitted to the internal stakeholders. Additionally, by questionnaire results it was possible to identify the external recipients of information, who are partners, shareholders, contractors and ministry of development of several countries.

In the IT company Cinnober, both of the respondents mentioned fairly the same benefits of VKM tools. The role of visual tools in the KC and KT processes, was defined by the Respondent 3 who agrees that "*yes, visualization of knowledge plays a role, [...] but you need to have something to discuss, not just a text […], you need to draw flows between projects and products. It is really important".* Additionally, according to both respondents from Cinnober, Scrum board and JIRA tools are used in parallel to illustrate relationships, communicate the knowledge, to capture the "*day-to-day development activity within a team*" and to track this data simultaneously.

> **Respondent 3:** *"Cinnober is heavily based on Agile way of working, when you divide big teams in a smaller ones to focus on story across sprints and that is the reason why scrum board is used, [...] to get a feeling about how you are progressing across the story".*

The stories presented through visual tools can assist with finding defects in production, new functionality, information about dependent projects or about things that are not working well. Thus, all the information is prioritized there, by which project team can clearly understand priorities of tasks on the board. Also, as **Respondent 4** mentions, "*few action points"* on what they *"should work on for the next sprint*" are given in the Scrum board to guide project team. The company uses JIRA software to support tracking of above-mentioned information on a timely manner, document it, to perform weekly status reports, and always have an access to it. According to the both respondents, it is proven that JIRA and Scrum board support coordination of individuals, identification of risks, problems and patterns to keep an attention on them. Furthermore, **Respondent 3** stress that JIRA helps to have "*some indication of problems to get a quick overview of the status of the project […] to get a good understanding of how it might look".* During the communication process with customer or steering committee, this tool has a "*good base to talk around"*, because they can have *"Scrum board retrospectives"* to discuss underlying processes as stated by **Respondent 4.** Moreover, **Respondent 3** mentions that this tool can provide the remembrance of knowledge, because it is possible to "*flag recent accomplishment, recent activity, action items from the last steering committee"*, and to see "*how*

it behaves after time". Particularly, **Respondent 4** mentions that "*the knowledge stays within the team*", because they *"do not change people, very often",* but they *"change project"* and visual tools can help to recall the information. However, as **Respondent 4** notes, these tools cannot *"present information about project as a whole",* but they are efficient to keep remembrance of information just about the activities of project and their status..

According to the last case, **Respondent 5** mentions that for each project in their company they run specific *"project card templates*", where all the information related to the project from risks to other patterns of the project are presented to track status of implementataion, expenses, delays and project documentation. As interviewee mentions: "*we are using the advanced functionalities of excel for this purpose, with different colors and symbols, which is easy visually as well*". Thus, after consideration of above-mentioned features of the tool, it is presumable to categorize it as a VKM tool. These tools have an enormous help during the problem solving process, because they are conceivable to perceive "*what are the potential consequences of those risks if they happen, and what are the potential actions for mitigation*".

Also, company tracks tickets in the Scrum board and in JIRA to synchronously update resolved tasks in the system. As Respondent 5 states "*it is quite common when we receive a very similar ticket in the future, therefore we can refer to some solution that was provided before*". This process can be classified as a learning process from the knowledge-base. To illustrate relationships between parties and transfer flows, company also utilizes MS Visio. During the interview it was stated that the knowledge about the projects applying visual tools are communicated the most frequently to the internal stakeholders. The identical results were collected during the questionnaire, where respondents mentioned division managers, inter-department members, and development and sales teams of the company.

To sum up, in all cases, the informants reported that the project status and coordination of individuals can be achieved by the VKM tools. At the same time prominent number of respondents considered that the communication support and authentication of risks and patterns can also be attained. Whilst a minority recognized advantages as accessibility to the knowledge, learning, solving a problem, knowledge remembrance and knowledge elaboration; almost all used these tools to the internal communication. Together these results provide important insights into understanding of potential advantages and functionalities of knowledge visualization tools in the several operational contexts. A note of caution is due here since some tools which are mentioned as VIM was also considered by respondents as a KM tool during the interview process.

5.4 Knowledge Management

5.4.1 Knowledge Integration in Projects

Table16. Knowledge Integration in Projects

Respondents	**JMAC Italy**	**Mega event**	**Cinnober**		**Seavus**
Codes	**R1**	**R2**	**R3**	**R4**	**R5**
KE	x	x	x	x	x
UN REL				x	
REF EXP	x	x	x	x	x

COL REL	x	x	x	x	x
MEMOL				x	
KNOWFRAG		x		x	
NOSTAND				new	
ORGCULT TRANSF		x			

As **Respondent 1** from a consultancy company claims: "*in case we have different customers, then to understand formalities and topics, we can share and benefit from the experience performed in one project to be transferred in a new one",* which supports the knowledge integration within a company.

> **Respondent 1:** *"We discuss the success and failures too, you can not avoid that. If you have a failure in one project, in the end it is an issue on the company level, but in addition, you can also get affected by it. The impacts can be transferred to other initiatives and projects".*

During the inquiry about the knowledge integration processes at the mega event, **Respondent 2** highlights that sometimes organization face with the lack of communication and poor culture of KT among the divisions in their organization, which leads to the fragmentation of knowledge.

Regarding to the case study at the Cinnober, both respondents mention good collaboration, knowledge exchange and employing previous experience in their project-based organization. For instance, **Respondent 3** points out that they have a *"round a table status update meetings"*, which are done each month with project managers, where everyone show a willingness to support their colleagues and share their experience. Moreover, **Respondent 4** claims that at the weekly meetings among project teams, they talk about current progress and try to understand relationships and dependencies among projects. However, he mentions the presence of "*very few standardized procedures"*, which can affect the memory loss and knowledge fragmentation.

Answers of **Respondent 5** from Seavus confirmed the occurrence of the knowledge integration culture, which is implemented by documentation of all processes, issues and how things can be done in their Wikipages "*to refer for this experience at any time and find the answers*"; mentoring process by the technical leads and the line managers and arranging the closure meetings.

The results of empirical findings at the IT, mega-event and consultancy company cases showed appropriate level of knowledge exchange, reflection to the previous experience, understanding relationships between several working clusters and building collaborative relationships as a part of their daily work. None of the cases indicated any issues related to the reworks or reparative activities. However, it was possible to identify challenges as memory loss, knowledge fragmentation, and absence of standard procedures to transfer knowledge due to the informal methods of communication between parties. One interesting finding was that in enterprises with complex outcome such as the chosen mega-event, where the requirements to meet the "iron triangle" of the project can not be modified or prolonged, organizations can face with poor KT culture related to the time-constraints of the portfolio. To sum up, it was possible to capture sufficient level of knowledge integration practices in all cases, mobilized by top and middle management of the company.

5.4.2 Knowledge Transfer

Respondent 1 from JMAC discusses about both formal and informal KT channels at the group and organizational levels, where they "*write down business cases*, perform presentations at "*training sessions*" about projects or arrange staff meetings with schedule and agenda. Also, company uses interactive online platform to transform knowledge at the organizational level.

Table 17. Knowledge Transfer

Respondents	JMAC Italy	Mega event	Cinnober		Seavus
Codes	**R1**	**R2**	**R3**	**R4**	**R5**
IKT	x		x	x	x
FKT	x	x		x	x
IOPT	x	x		x	x
IL			x	x	x
GL	x	x	x	x	x
OL	x	x	x	x	x

Respondent 1: *"We have internal platform, where all the material [...] deliverables such as power point presentations, intermediate files, and meeting minutes [...] about the project should go to a sharepoint in the server which is accessible to everyone. This is also a responsibility, since all the colleagues will have access to that information".*

Presence of projects with the same topic to be delivered can help to build stronger competencies inside and to get more experience by collecting the knowledge developed in one project and transfer to other projects at the group level. Thus, establishing effective KT process is important to manage the interdependencies among the projects.

Respondent 2 from mega-event confirms existence of only the formal channels of KT at the group and organizational levels. Also, she adds that: "*within our division we would update everyone by sharing the progress through the share point*".

According to the case study at the Cinnober, both respondents mentioned transfer among individuals, group and organization levels. Also, the following types of the informal KT procedures such as meetings, discussions next to white boards, emails and conference calls were acknowledged by both interviewees. Moreover, we acknowledged the existence of sufficient level of interest and motivation of individuals to the KT process within a company.

Respondent 3: *"[...] starting with a meeting in front of the white board. Just trying get a people in the room to start a discussion, someone knows can show understanding of the problem, the problem is solution forward. Start to draw a picture for everyone. From that place you take discussion. You need to have it documented, but where you really get a knowledge transfer is to put a guys in front of the white board".*

Last case with Seavus demonstrated existence of informal, formal KT channels in the company maintained by meetings, mentoring by "*the technical leads and line managers",* interactive platforms as "*project template cards*", JIRA, and Wikipages, which are used at all levels of the company.

The consultancy and IT-companies in both cases utilize a combination of socialization and formal methods to transfer explicit and tacit knowledge, while mega-event heavily rely on formal procedures due to the characteristics of the projects. Thus, the interview results represented that the area, where organization does its business, has a considerable impact on the method of assortment of suitable knowledge management processes and practices. Regards the levels in which knowledge are transmitted, the mega-event and consultancy firm case studies mostly mentioned group and organizational levels, while results from IT case studies demonstrated occurrence of transfer at all levels.

5.4.3 Knowledge Creation

To have a willingness to continuously create knowledge all companies implement specific processes from involving external specialist to cooperation between project and portfolio members.

As was stated by **Respondent 1**, to be able to always provide required skills to several projects, they employ organizational model to build competencies and create a new knowledge, which have vertical and horizontal profiles, where "*one is more specific, and the other one is more flexible".* In cases when they do not have experience in specific topics, they might involve external specialist. Moreover, to continuously update capabilities of project team they present business cases on topics related to new methods in the field and successful management approaches of other projects. If there is an issue in the project, the brainstorming sessions are immediately organized as an environment to the open innovation and cooperation by implication of the visual tools "*to make a group of people or a team to work better with each other*".

Table 18. Knowledge Creation

Respondents	JMAC Italy	Mega event	Cinnober		Seavus
Codes	**R1**	**R2**	**R3**	**R4**	**R5**
EXT SPEC	new			x	
INTER LEAR	new		x	x	x
OP INNOV	x		x		
COOP	x	x	x	x	x
CRECONT	x	x	x	x	x

Informant at the mega-event case study emphasized the cooperation between individuals as a main source for creation of new knowledge. However, due to the time constraints of the project, they *"don't have time for discussing the success and failures"* of projects, which can be good source for the inter-organizational learning.

According to the case study at the Cinnober, it is summarized that company exploits several ways of inter-organizational learning and cooperation from monthly meetings with project managers, where everyone has a chance to express their ideas and ask help at brainstorming sessions to have "*team discussions".* After an interview with **Respondent 3**, it is ascertained that the company supports open innovation environment, for instance, by "*meeting in front of the white board*" to start a discussion. In contrast, **Respondent 4** did not mention any direct demonstration of open innovation in his answers. But, it was possible to capture practice of

involving external specialist to attain a new knowledge. In overall, Respondent 4 stress that "*usually many people from each team knows what is going on",* thus it can be summarized that company has a high level of knowledge integration within its projects.

Lastly, **Respondent 5** accented existence of cooperation and interorganizational learning activities. For instance, it is mentoring practice by "*providing some assistance whenever junior colleagues bump into complex issues"*, which assists KC attempts of the organization.

To sum, during the qualitative analysis it was possible to determine that all companies were able to create new knowledge and effectively cooperate within their organizational setting. Moreover, almost all companies, except mega-event due to the "*[lack of] time for discussing the success and failures"*, sufficiently organized interorganizational learning by mentoring, meetings and brainstorming sessions.

5.5 Impacts of Visual Management Tools on Project Outcomes

Due to the reason that respondents did not make a distinction betwen VKM and VIM, it was decided to ask questions like "*How the visual tools can be beneficial for the project outcomes?"* and *"In which phase(s) the visual tools are used the most?"* during the interview and questionnaire. Thus, it was possible to identify the impact of visual tools on the project outcomes.

Table 19. Impacts of visual tools on Project Outcomes

Respondents	**JMAC Italy**	**Mega event**	**Cinnober**		**Seavus**
Codes	**R1**	**R2**	**R3**	**R4**	**R5**
PRCST	x		x		
TIMC	x		x		
SCP	x		x		
RISKM	x		x		
START	x		x		x
EXECU		x	x	x	
CLOSE		*Questionn. insight*	x		
QUAL	x				x

Interview and questionnaire results with the consultancy company **(Respondent 1**) revealed that visual tools can be highly effective to the monitoring of KPIs at all stages of the project. **Respondent 1** in the interview emphasizes that: *"the most important to use [visual tools] since the beginning"* to clarify some details that are not so visible at the start and to implement risk safe approach.

> **Respondent 1:** "*I am a supporter of the visual tools and I can say that visual tools can bring huge benefits in terms of time, cost, risk, scope and so on, since they all are related".*

Regarding the mega-event case, the interview showed that visual tools were used when they were needed. Particularly, they used them during the project execution phase depending on the availability of their time to manage it. Thus, **Respondent 2** says that: *"[visual tools] are very important [for achieving better project results] and should be used, if you have time".* As for the questionnaire results, a common view amongst interviewees were that visual tools can

intensify better estimates of schedules and control of time during a project execution phase. Interestingly, questionnaire results indicated that visual tools support an adapting of project structure to new work processes in line with other projects in portfolio during the project start, as well as communicating project status and performance to stakeholders at the close-out phases.

Turning to the third case study with Cinnober, visual tools are emphasized as the fundamental for achieving better project results. **Respondent 3** says that "*Scrum [can be used] in all phases".*

> **Respondent 3:** *"Most of the benefits can be seen in development and testing sides. That is the key purpose of the board. To understand development and testing progress".*

In contrast, **Respondent 4** highlights that visual tools are used to continuously synchronize that planning is still on track. Same idea was stated during the interview with the Seavus.

> **Respondent 5:** *"I find them very-very useful in the planning phase, and if you start the project wrong, it can be a mess at later stages, so, if you start the project successfully, and then there is a higher chance that it will be finished successfully".*

At the same time, over half of those surveyed from the Seavus company reported that the better estimates of time, risks and their control can be achieved during the project planning, which indirectly influence the project quality.

Overall, these results indicate that the vast majority of respondents in all four cases consider occurrence of prominent influence of visual tools on the project results in terms of the iron triangle and management of risks. A variety of perspectives were expressed about a phase when these tools have a biggest usefulness, therefore during the interview and questionnaire process both the project start and project execution phases were noted the most by all the interviewees.

6. Discussion

During the extensive literature review, it was revealed that PIM and KM are the areas that have been studied by many researchers separately, and the tools and techniques that are practiced for both are targeted in mainly isolated studies. There is lack of investigations to find out the links and the relationships between these two phenomena in order to merge their functions, and thus, strengthen the capabilities to increase the impact on the success of the project and portfolios. Therefore, the current study explored and intended to explain in details the existing relationships, interactions between PIM and KT and KC, which are integral parts of KM. In order to answer two research questions, this chapter will compare and contrast the research findings with the literature review. The discussion is centered on three parts based on the research model, developed during the theoretical framework (the Figure 4), with the following sections: relationship between PIM and KC, KT; the usability of VKM for the PIM; the relationship between VIM and VKM. The previous version of model described in the theoretical framework displayed the existence of PIs within portfolios (Rungi, 2010, p.117; Perminova et al. 2008, p.265; Collyer andWarren 2009, p.56; Aritua et al. 2009, p.34), while the empirical findings resulted in changing of this notion to multi-project environment. The reason is that in all the selected cases interdependency were approached not only from the perspective of the portfolio level, but also among the projects in the organization in general. This section ends with a revision of the previously established research model with the incorporation of empirical research findings. Thus, it enables answer the research questions which govern the study and will be addressed directly in the following chapter.

6.1 Part I - Relationship between project interdependency and knowledge integration processes

Firstly, the relationship between 3 phenomena, which are PIM, KT and KC, was the focus of the current thesis. The following discussion will guide through the existing literature in comparison to the data analyzed in the previous section, as a result of which the first objective and the research question will been answered.

During the literature review and analysis of empirical findings it was possible to see the impact and role of the knowledge integration practices in the better management of interdependencies among projects. It has been assumed in the literature review part that to perform an effective PIM it is necessary to understand and review complicacy of projects to facilitate proper portfolio management (Teller et al., 2012, p. 597). Similarly Danilovic and Sandkull (2005, p.193) emphasize that to investigate and to be able to control the uncertainties and interdependencies related to the scarce resources and intense competition for getting the resources, it is important to exchange information and gain understanding of contexts and relationships among projects. The presence of uncertainties arisen from interdependencies are distinctive to the nature of multi-project environment. Also, the vast majority of issues caused by interdependencies found in the empirical data analysis part of the current research study are associated with competition for the resources, cannibalization of existing resources, conflicts in resource sharing, knowledge diffusion and conflicts between the managers. In other words, most of them were related to the resource dependencies, which can be better explored and managed by the knowledge integration processes.

By analysing the questionnaire and interview results, it was possible to identify that organizations in all four cases were able to successfully perform interdependency management practices by the employment of knowledge integration activities. This is reported as a necessary process, specially to deal with the management of resource interdependencies. Thus, an appropriate level of knowledge exchange, reflection to the previous experience, understanding relationships among several groups and collaboration were established to manage resource dependencies in all four cases, representing IT, mega-event and consultancy spheres.

Also, it was possible to identify the challenges such as memory loss, knowledge fragmentation, and absence of standard procedures to transfer knowledge due to the informal methods of communication between parties. One interesting finding was that in enterprises with complex outcomes such as mega-event, where the requirements to meet the "iron triangle" of the project can not be modified or prolonged, organizations can face with poor KT culture related to the time constraints. This finding is in-line with what has been stated by Andersen and Hanstad (2013, p. 239), who notes that complex multi-project environments with interdependencies among projects often fail to develop and transfer knowledge from one project to another, and perform KM in the attempt to overcome new challenges. The reason of this fail is either lack of time, capabilities to identify or reflect upon past projects and see the "big picture". Hence, it was possible to see a strong impact of knowledge integration processes on the PIs.

In project-based organizations, where complexity is high and projects are dependent from each other, the existence of central management to handle the overlaps, scarce resources, lack of general overview and uncertainty needs to be assured (Danilovic and Sandkull, 2005, p.193). PIM plays an essential role in identifying and balancing the relationships among projects through the usage of tools and techniques that are largely practiced in project-based organizations (Teller et al., 2012, p. 597; Reyck et al., 2005, p. 525). This argument was supported by the data analyzes from four cases summed up as "PIM is helpful for the resource selection and prioritization", which is critical for these organizations, since they reported that mostly resource dependencies among the projects are experienced. While knowledge is also one of the most important resources in the selected cases, according to empirical findings, knowledge dependency is as common as resource dependency and the role of effective KM is very significant for the companies. From the other perspective, some respondents view the interdependency as an opportunity to transfer and create knowledge among the projects, which increases the competency level of the teams and positively affects the learning process. By helping to see the big picture, PIM leads to the effective and faster decision making (Rungi, 2010, p.117), as it is highlighted both in the literature and empirical data. On the other hand, if the interdependency is strong among the projects, it usually leads to project delays, as the respondents mentioned. By this, it was defined that PIs are strongly linked with the KT and KC, and they can have both positive and negative impact on KM practices in the organization. This link proves the ***mutual relationships*** between the targeted phenomenas.

According to the above-mentioned, this thesis achieved its first objective to uncover the relationships between PIs among projects and KI, including KT and KC. The empirical data that was collected through semi-structured interviews and questionnaires, which provided evidences to support the argument that in a complex multi-project environment not only KC and KT impacts and contributes to the PIM, but also PIM influences KC and KT. Hence, they have a mutual impact on each other, which is in accord with the literature review part (the Figure 8).

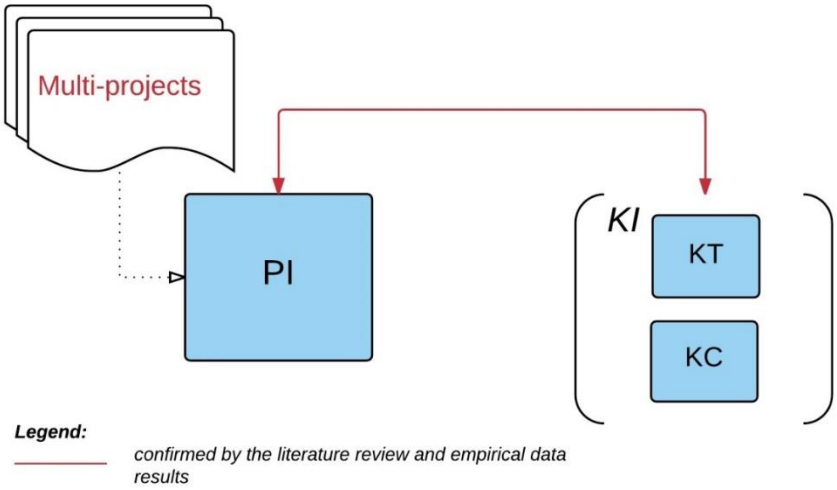


Figure 8. Relationship between PIM and KT, KC

6.2 Part II - Usability of Knowledge Management Visualization Tools for the Project Interdependency Management

With respect to the second objective, which is to investigate why the VKM tools can be used to deal with the PIs, the previous studies and empirical data is compared to determine the possible ways and situations. Very little was found in the literature about the potential usage of VKM tools for the purpose of managing PIs. Although, the existing literature provides a list of benefits of applying VKM tools and implementing KM practices in general, it neither presents any relationship between KM and PIM, nor shows the impacts of using the VKM tools on PIs. Therefore, this study aimed to identify the link between these two phenomena that is not covered by the researchers.

The researchers state that KM's ultimate goal is to reach a common understanding across all individuals and stakeholders, with an idea of what the project need to achieve for the business (Reich et al., 2014). It was found that VKM tools support this mission by fulfilling certain benefits as displayed in the table below. This table shows the similarities and differences between data presented from theoretical framework and empirical perspectives:

As the Table 20 illustrates, there is a consistency between issues that project managers in selected cases encounter because of PIs, and covered in the existing literature (Rungi, 2010, p.150). In addition, the benefits based on functions of VKM tools that are mentioned in the theoretical framework (Burkard and Meier, 2005, p.480; Burkhard and Eppler, 2005, p.491) are mostly similar with the results of interviews and questionnaires. However, mainly features related to people factors, such as motivation, energizing team members, address emotions, did not match the answers in the empirical results. On the other hand, additional benefits of usingVKM tools were revealed from the interviews, which are "always accessible", "communication", "solving problems" and "progress status".

Table 20. Comparison between identified drawbacks of interdependencies among projects and VKM tools in the literature and practice

	Interdependency drawbacks (literature)	**Interdependency drawbacks (in practice)**	**VKM tools benefits (literature)**	**Benefits of VKM tools (in practice)**
SIMILARITY	Delays	Delays	Illustrate relations	Illustrating relationships
	Cannibalization of existing resources	Cannibalization of existing resources	Discover trends, patterns, outliers	Identifying risk, problems and patterns
	Budget overrun or shortage	Cost constraints	To get and keep the attention of recipients	Keeping an attention
	Competition for the resources	Competition for the resources	To support remembrance and recall	Knowledge remembrance
	Not being able to start a project	Not being able to start a project	To present both and overview and details	Elaboration of knowledge
	Conflicts in resource sharing	Conflicts in resource sharing	To facilitate learning	Learning
	Knowledge diffusion across projects	Knowledge diffusion across projects	To coordinate individuals	Coordination of individuals
	Conflicts between the managers	Conflicts between the managers		
DIFFERENCE	Modularization	-	To motivate people and establish a mutual story	Always accessible
			To motivate people and establish a mutual story	Communication
			To energize people and initiate actions	Solving problems
			To address emotions	Progress status

It was possible to observe that the issues that project managers encounter because of the PIs can be handled by using the VKM tools, in addition to VIM tools. As it is demonstrated in the table below, the features of VKM tools allow to cope with various challenges that were described both in the literature and during the empirical data collection. Hence, the second objective has found a reply that the VKM tools should not be used only for the KM processes, they can be used to deal with the interdependencies among projects as well, as the data analysis gave the results to support this argument. It was mentioned by the respondents that visual tools help them to illustrate and see the flows, connections among the project in order to identify what information, data, knowledge and with whom needs to be shared. Moreover, as it is summarized in the Table 21, VKM tools that are effective in identifying patterns, risks and problems, visualizing the relationships and progress, stimulating the learning and communication, elaborating knowledge and coordinating the individuals directly become a solution for the problems that are described in the first column.

Table 21. Usability of VKM tools for the PIM

Issues related to interdependency	**Solutions from using VKM tools**			
Knowledge diffusion across projects	Elaboration of knowledge	Knowledge remembrance	Learning	Illustrating relationships
Competition for the resources	Identifying risk, problems and patterns	Illustrating relationships	Always accessible	

Cannibalization of existing resources	Illustrating relationships	Identifying risk, problems and patterns	Coordination of individuals
Conflicts in resource sharing	Coordination of individuals	Illustrating relationships	Always accessible
Conflicts between the managers	Communication	Solving problems	Always accessible
Delays	Progress status	Illustrating relationships	
Not being able to start a project	Communication	Elaboration of knowledge	
Cost constraints	Identifying risk, problems and patterns	Illustrating relationships	

Here below Figure 9 illustrates the possibility to employ VKM tools for handling PIs in multi-project environment based on our theoretical assumptions and updated according to the results from the qualitative study.

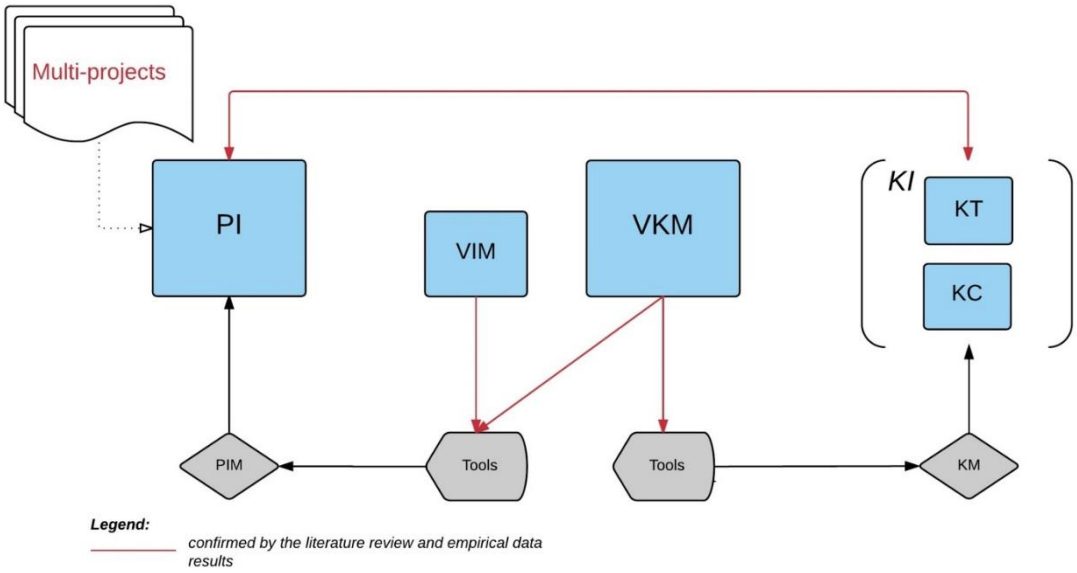


Figure 9. Usability of VKM tools for the PIM

6.3 Part III - The Relationship between Visual Interdependency and Visual Knowledge Management Tools

To investigate the reasons for integrating the VIM tools into the KM area, two steps analysis of empirical findings are done within the discussion part of this thesis. Firstly, the empirical material related to the benefits and functions of VIM tools is compared with already specified functions from the theoretical framework referring to Danilovic and Sandkull (2005, pp.193-202), Sibbet (2010, p.14), Dickinson et al. (2001, pp. 523-527), Killen et al. (2009, pp.2-6) and Rungi (2010b, pp.111-114). The same logic of comparison is done with VKM tools, where benefits and functions collected from the qualitative study are confronted with functions generated from the literature review (Burkard and Meier, 2005, p.480; Burkhard and Eppler, 2005, p.491). Consequently, it was possible to justify and see presence of functions listed in the literature review part (see “similar” section in the vertical part of the Table 22) and determine

new benefits and functionalities according to the results of the empirical study (see "new insights" section in the Table 22). For instance, emergent capacities and benefits of the VIM tool such as planning, seeing workload and skills of people, communication and reducing time, reducing complexity, highlighting problems, remembrance are gathered. At the same time, VKM tools have been supplemented by additional functionalities and benefits, such as accessibility of information, communication, identification of risks, problems and patterns, solving problems, learning and status tracking.

Table 22. Comparing the Empirical Material with the Theoretical Framework (VIM, VKM)

	Functions of VIM tools (literature)	**Benefits and functions of VIM tools (in practice)**	**Functions of VKM tools (literature)**	**Benefits and functions of VKM tools (in practice)**
SIMILARITY	Motivation and engagement	Motivation	"Coordination" of individuals in the communication process	Coordination of individuals
	Ability to see "a big picture" with the logical links and relationships between the objects	Illustrating relationships	Keeping an "attention"	Keeping an attention
		Ability to see big picture		
	Idea mappings increasing the group memory	Idea mapping	Improving "recall" and remembrance of knowledge	Knowledge remembrance
	Documenting and mathematically quantifying the interdependency	Document interdependency		
		Quantification of interdependency	"Elaboration" of knowledge in teams by physical models and sketches	Elaboration of knowledge
	Reduces the uncertainty and complexity	Reducing uncertainty		
	Capturing, displaying and updating information on interdependencies	Reducing uncertainty	"New insights"	Illustrating relationships
		Getting immeadiate information		
DIFFERENCE	Represents the "web" nature of inter-project relationships	Planning	"Motivation" and inspiration of viewers	Always accessible
		Seeing workload and skills of people		Communication
		Communication		Identifying risk, problems and patterns
		Reducing time		Solving problems
		Reducing complexity		Learning
		Highlights problems		Progress status
		Remembrance		
		Recognize the need for the development of new knowledge		

After the review of benefits and functions of the VIM tools identified in practice, we affirmed the common functions and benefits with VKM tools, which are presented in the Figure 10 below.

The functions and benefits listed in the left side of the Venn diagram entirely belong to the VIM tools, because they are fully focused on the interrelationship management (e.c. quantification of interdependency, getting an immediate information, planning and reducing time). In contrast, the right side consists of the functions and benefits of the VKM tools only, which are verified through empirical data. Meanwhile, the central part of the figure combines similar features for both types of the tools.

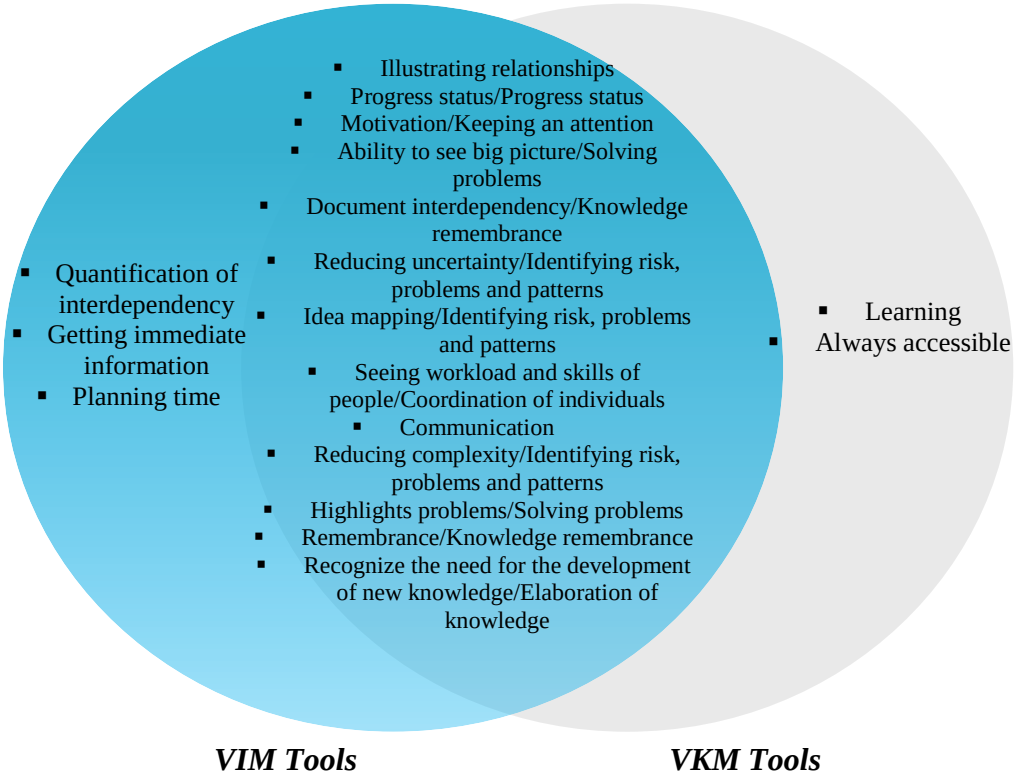


Figure 10. Benefits of VIM tools vs. VKM tools in practice

These results are likely to be related to the strong connection between VIM and VKM tools. Additionally, it is clear that the benefits and characteristics of the VKM tools to some extent present broader approach to the project and portfolio management. We inclined to think that there is a need to enclose more specific and interdependency focused tools in the comprehensive context of VKM. Serving to this need, the functions and benefits of VIM tools can be implemented as a part of general KM area, and somewhat meet the requirements of VKM tools (the Figure 11). It is important to bear in mind that, in practice, there is scarce distinction between VIM and VKM tools, which also support the idea to integrate VIM tools into KM area and consider these tools as a part of KM.

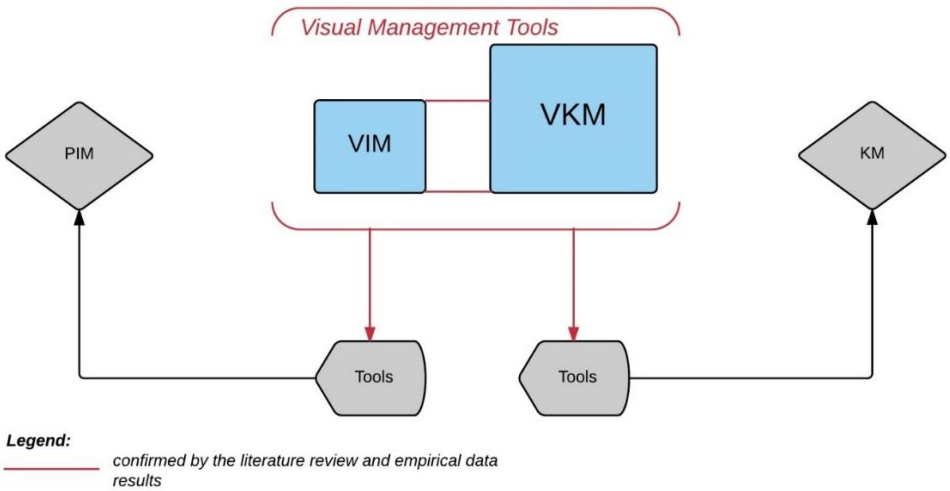


Figure 11. The Relationship between Visual Interdependency and VKM Tools

6.4 Part IV - Impacts of the "Visual Management Tools" on the Project Outcomes

As mentioned in the literature review part, when PIM is facilitated effectively, it leads to the clarification and analysis of project complexities, thus helping to achieve better portfolio management. This, in turn impacts portfolio outcomes and success (Teller et al., 2012, p. 597). Empirical data collected for the current study also supports this statement, as respondents highlight the importance of PIM, using tools and techniques for this purpose in different phases of the project, and mainly planning phase was mentioned the most. It is also reported that when in the planning phase all the interdependencies, relationships among the projects are identified, resources allocated accordingly, next steps and logical order of the events planned, the chances of getting more successful results are much higher. It does not come as a surprise that the majority of questionnaire respondents also mentioned PIM as "very important" or "important" process in their companies understanding its impacts on the project and portfolio outcomes as a whole. It was also stated by all the respondents that the role of VIM tools is undeniable in effective PIM practices. As an example, different planning, brainstorming, visual board, Scrum board and digital tools were presented by the respondents. Although, the literature puts an emphasize on the decision making aspect and how the VIM tools have the ability to overcome certain challenges that managers face during the decision making process (Killen. 2007, p.3), there was no direct reference of this from the respondents' perspective. Nevertheless, indirectly, they mentioned all the factors related to the VIM tools that makes the decision making process easier and less complicated for them. This can be determined when they describe VIM tools effective for visualizing and defining relationships, activities, for their selection and prioritization, which leads to better and faster decision making.

At the same time, a number of authors have considered the effects of KM for both organizational performance and project success in terms of key parameters such as pre-set budget, planned schedule and agreed scope (Chen and Chen, 2005, p. 32; Sokhanvar et al., 2014, p. 1826; Todorović et al. 2014, p.782). If some researchers consider that KM has direct and indirect, financial and non-financial impacts on the firm's performance (Massingham, 2014, p. 1098), others claim that knowledge alignment does not have any effect on the schedule and budget, but can be beneficial for the achievement of business value from the project (Reich et al. (2014, p. 599). Numerous studies have attempted to explain requirements for successful knowledge development and transfer processes in project-based organizations within KM. To support such processes, reference to different competencies and personal knowledge, reflecting upon experiences, understanding social relationships, routinizing lessons learned by organizational management is essential (Søderlund et al., 2008, p. 518; Andersen and Hanstad, 2013, p. 246). From this perspective, the empirical findings of this study analyzed the effect of visual tools on the management of knowledge, which can elaborate several competences of specialists and achieve common understanding of projects, in others words, to manage organizational knowledge.

During the analysis of qualitative data results it has been seen that all cases present relatively good level of KM organized by middle and top management of company by continuous employment of visual tools. These results are in accord with studies indicating that it is the manager's task to define directions and procedure of implementation of the KM system in terms of definite organizational goals to motivate individuals (Love et al., 2005, p.12). According to the respondents, a possible explanation of proper KM in consultancy and IT companies is an organization-wide utilization of tools with support from management to gain an understanding

and motivation among employees; sufficient level of face-to-face communications to build trust and better interpretation of results; an easy and apprehensible design of all tools (e.c. mind-mapping tools, charts, scrum board, visual boards, JIRA and brainstorming session with white boards). Again, it is noticeable that, from the respondents' perspective, there is limited distinguishing between VIM and VKM tools. Moreover, in the previous part of the discussion, it is suggested to integrate VIM tools into KM area and consider it as a part of it. Which is why, to identify an impact of both VKM and VIM tools on the organizational performance and project success, we decided to identify impacts of visual tools altogether and further consider them as "visual management tools" within a frame of this study.

The investigations of impacts of "visual management tools" in this study have shown that the vast majority of respondents in all four cases realize prominent influence of visual tools to the project results in terms of achieving the "iron triangle" and ability to manage risks. Contrary to expectations, this study did not find any influence of visual tools to the business value. A variety of perspectives were expressed about a phase when these tools have the highest benefits to the project, especially the project start-up and project execution phases were indicated the most by the respondents. Moreover, it was possible to determine in some answers the influence of visual tools to the project close-out phase during the communication of project status and performance to stakeholders. Eventually, these findings suggest that the visual tools can have presumable effect to the project performance throughout the whole life cycle of the project.

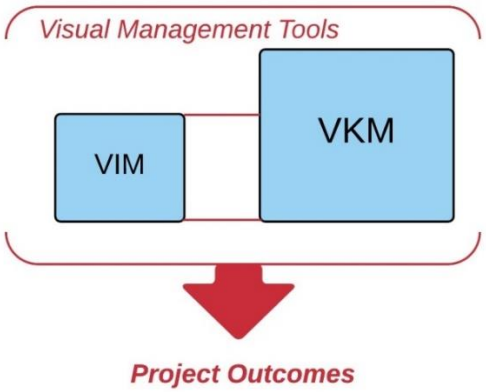


Figure 12. Impact of the "visual management tools" on the project outcomes

6.5 Revised Model

The model that was initially developed in the literature review part of the thesis has been revised and notions reviewed according to the empirical data described above. The strands included in the model remained the same, however, the relationships and links showing the impacts between the phenomena have been viewed from different angles. As it is shown in the Figure 13, the model includes Multi-project Environment, which is usually accompanied with PIs, that consequently create complexities and uncertainties in the organization. On the other hand, KC and KT, which are integral parts of Knowledge Management, largely used in project-based companies, are considered within the model as well. As it was discussed in this section, in complex multi-project environment, existence of PIs may be impactful to the KT and KC processes, and visa-versa, when the KT and KC is implemented properly, this leads to the solution of certain challenges caused by PIs. Therefore, the interaction between two sides of the model is mutual, one having an impact on the other one.

In contrary, to the existing literature, which reviews and covers PI and KM separately, neglecting their potential to support and positively influence each other, the current study investigated the possible ways of integration of these phenomena. Hence, the tools that are employed for the KM, more precisely, VKM tools, have been proved to be beneficial in terms of PIM as well. VIM tools that are discussed in the existing literature separately were found to be suitable for the KM practices. The integration of the VIM tools into VKM tools and their implementation and research as a whole is recommended, because it might lead to the increase of the usage of VIM tools and enhance the VKM. This, in turn, will positively influence KM area as a whole.

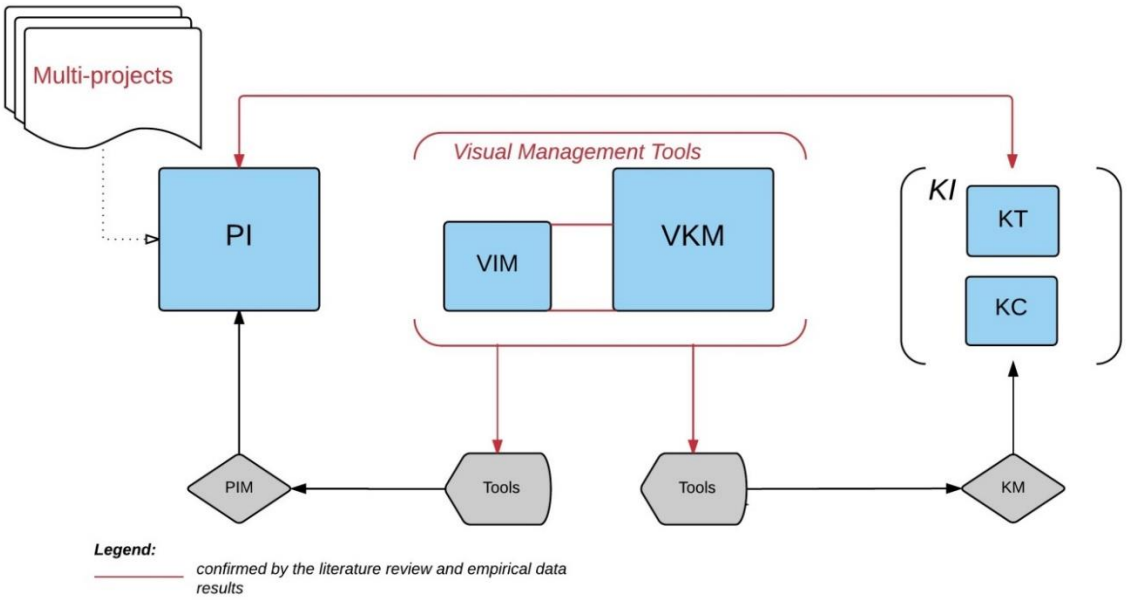


Figure 13. Revised Research Model

7. Conclusions and Recommendations

The main goal of the current study is to consider project portfolio, interdependency management and KC and transfer processes as a coherent model and to identify and explain the impacts of using VIM tools and their potential to be considered within the KM practices, by using this new model. In order to fulfill this purpose, we have conducted a qualitative study with involvement of four companies from three different sectors. The study was done with the participation of the companies representing consultancy, IT and mega-event business spheres. This served a purpose to achieve a broad understanding of the practical approaches and managerial perspectives of the practitioners in regards with project, interdependency and knowledge management concepts using the visual management tools in their experience. By conducting a multi-method study with interview and questionnaire in four cases we have been able to gain a cross-case comparison and obtain wider amount of information to perform a triangulation and increase the validity of findings. This section of the thesis will focus on answering "***why and how do KT and KC processes impact the interdependencies among projects in the project-based organizations"*** and ***"why should visual interdependency management tools be used as a part of knowledge management practices"*** by gaining literal replication of results through multiple sources of empirical data.

7.1 Main Conclusions

The first conclusion that can be drawn is about certain impacts of KC and KT processes on the project interdependencies in multi-project environment. Traditionally, it has been argued that interdependencies among projects occur mainly in the project portfolio context (Rungi, 2009c, p.1508), while according to empirical findings, in practice, interdependencies also take place in any company with multiple projects, not requiring to have portfolio or program of projects. Thereby, this study investigated the relationships between the PIs and KI processes both in a portfolio and in a multi-project environment observed in the selected cases. Moreover, this study has identified that an effective PIM requires comprehension and analysis of project issues, broadly presented by challenges related to the resourcing, such as competition for resources, resource cannibalization, conflicts because of resources, and knowledge diffusion. The results of this research establish that a sufficient level of knowledge exchange, utilization of previous experience, ability to see a big picture and understanding of company-wide relationships within KC and KT processes are substantial to the effective PIM as an enhancement of resource management practices at the different settings. The present study investigated four companies from three different areas, whereas previous researchers have studied PIs mainly in the construction sector (Kjølle et al., 2012, p. 81).

The second conclusion is concerned with the positive influence of PIM on the KC and KT processes. This result may be explained by the role, which PIM plays in identifying and balancing the relationships among projects through a number of PIM tools and techniques, which are the "cornerstones" of successful knowledge integration. Thus, it was demonstrated that PIM is useful for the resource prioritization and short listing, which has indisputable impact on the KC and KT processes. Furthermore, the interdependency among projects can be also viewed as a possibility to transmit and develop new knowledge among projects to enhance knowledge integration activities across the company. Although, relying on the existing literature we assumed that in addition to positive impacts, PIs may also have negative effects on the KC and KT, the empirical results did not present an evidence to confirm this statement. ***Altogether, the above-mentioned two findings provide the answer to the first research***

question and confirm the presence of mutual impact between KC, KT processes and PIs. Therefore, the findings have certain strength and contributions to the existing literature and the practical area, since they provide an important opportunity to advance the understanding of challenges of project-based organizations in terms of interdependencies and mutual impact with the knowledge integration, encompassed by the KC and KT processes.

The ***third finding*** was that the features of VKM tools provide an opportunity to cope with various issues related to the interdependencies among projects. The evidence from this study suggests that VKM tools are effective in identifying patterns, risks and problems, visualizing the relationships and progress, fostering the learning and communication, expanding knowledge and coordinating the individuals to manage knowledge diffusion across projects, competition for the resources, cannibalization of existing resources, conflicts in resource sharing and delays.

The fourth conclusion relates to the similarities of VIM and VKM tools. The elaboration of empirical findings by multiple-case design revealed that the vast majority of VIM functions are also supported by VKM tools and there is a limited distinction in practice between VIM and VKM tools. For instance, motivation, keeping an attention, ability to see the big picture, communication, solving problems or highlighting them, remembrance of knowledge, progress status, illustrating relationships are distinctive for both types of the tools. VIM tools by nature are specialized and focused on interdependency management, whereas VKM tools also hold the similar features within them, as they have broad-scale capabilities to solve various kinds of PM issues, including the complexities caused by PIs. Therefore, it is feasible to integrate the VIM into knowledge management area through VKM tools. The current study made this conclusion based on the results of the interviews with the managers who are using the visual management tools in their daily lives and shared with their experiences, challenges and practical examples of both VIM and VKM together. This is an additional value to the research of this topic, since previous researchers have mainly investigated the usage of VIM and VKM tools in an isolated manner and separate from each other, and in most cases it has been done through experiments, where the environment is set and conditions may not reflect the reality.

The ***fifth and last conclusion*** indicates relevancy to consider project portfolio, interdependency management and KC and KT processes as a coherent model, as a consequence of inter-mutual influence of PIs to the KC and KT processes (see the Figure 13). Henceforth, the impact between two sides of the model is mutual and VKM tools, which are employed for the KM, are beneficial in terms of PIM as well. VIM tools that are discussed in the existing literature separately were found to be suitable for the KM practices. We recommend to distinguish, implement and research the VIM tools as a part of the VKM tools. Also, we credit that it can positively influence the practical application of VIM tools and enhancement of the VKM, which in turn will affect the KM area as a whole. ***The relevance of considering VIM tools as part of KM is clearly supported by the current findings summarized in the last three conclusions, which provide an answer to the second research question.***Because of this, we acknowledge that the present study has both practical and academic contributions, which are presented further, and summarized findings are applicable in the relevant context.

7.2 Theoretical Implications

The results presented in this thesis supplement the studies previously performed in the field of PIM and KM in project-based organizations and diverged from some theoretical annals. In this study, it is aimed to enhance the KM area by integrating tools and techniques used for PIM and bring new insights to certain aspects of visual management tools. Although the study is based on the existing literature, later empirical findings have been elaborated which resulted in building of new model with a different relationships between the phenomena.

The current study foster the exploration of PIM from a new perspective seeking for relationships with KI, identifies practically applicable PIM tools and techniques that are considered to be fragmentally studied by the current state of academic papers (Rungi, 2010a, p.117; Rungi and Himola, 2011, p. 158; Killen and Kjaer, 2012, p. 555; Staudenmayer, 1997, p. 27; Söderlund, 2004, p. 659; Collyer and Warren, 2009, p. 359). Furthermore, the input is also done through holistic overview of PIM tools, which are not covered extensively in the current literature (Rungi, 2009b, pp. 111-112).

As it was indicated in the earlier findings, the role of cooperation and influence of visual tools need to be understood deeper for the KC and KT processes (Massingham, 2014, p. 1098; Hong, 2012, p.211, Love et al., 2005, p. 43; Du Chatenier et al., 2009, p.371) and the present study followed this direction.

Presently, the overwhelming majority of previous researches about KM tools consider only one specific KM tool within a paper (Massingham, 2014, p. 1075) and does not view the opportunity of visual representations for the transfer and creation of knowledge (Burkhard, 2005, p.138; Burkard and Meier, 2005, p.480; Eppler and Burkhard, 2007, p.112-113). This fact guided the current study to investigate various types of visual tools at different settings (e.c. mind maps, charts, scrum boards, visual boards, JIRA) by multiple case study. Furthermore it is affirmed that the visualization processes enhance KC and KT processes, and thus help to successfully perform projects in terms of predetermined budget, schedule, scope during start up, execution and close-out phases.

The research has also shown alternative visual formats like mind maps, charts, scrum boards, visual boards, JIRA to supplement traditional instruments such as Gantt Charts (Burkhard and Meier, 2005, p.475) to manage PIs and integrate knowledge. During the literature review authors identified a lack of research, which considers knowledge visualization tools as a means to manage interdependencies between projects, thus to better manage projects (Durant-Low, 2012, p.76; Andersen and Hanstad, 2013, p. 239; Lindner and Wald 2011, p. 877). Regarding empirical findings, none of the practitioners participating in the research strictly distinguishes VKM tools from VIM, and this is mainly related to the lack of usage of the academic terminology in practice. However, different tools are used for the KI and PIM purposes, but having similar features within the PM processes.

The key contribution of this paper is the change of the focus from separate and isolated research of KM and PIM in project-based organizations to the integrated and combined investigations of both notions as a coherent model (Figure 13). The empirical findings in this study provide more awareness about the reality oriented practical tools that are not well covered in the literature. The most obvious finding to emerge from this study is that VKM and VIM

tools are representation of one continuum, which is essential in order to identify the relationships in a multi-project environment. It is suggested to consider these tools altogether and further study them as "visual management tools" in academic papers.

7.3 Managerial Implications

The results of the present research can be used in companies with similar context and business approaches. It should be mentioned that a statistical generalizability was not the aim of the present study, even though the findings provide guidelines for the managers to achieve successful PIM and knowledge integration while managing interdependent projects. These recommendations are formed from the explanation of relationships between the PIs and KT and KC processes, description of VIM and VKM tools, the evaluation of their applicability and recommendations on their integrated implication.

Firstly, the study has raised the awareness on the existence of such understanding as PIM, because in all four cases managers were not quite familiar with this term and have not even thought about the specific tools that can deal with PIs. Instead, largely project management or tracking tools with the features and functions that are able to help to manage PIs are considered and utilized. Therefore, a brief introduction to the topic has been provided to all the research participants to clarify the term and to give them a chance to reflect on their experience. Thus, the current study helps the managers to identify the ways and methods they are using for managing interdependencies and improving them according to the findings of this thesis. Those who neither apply PIM nor have a sufficient knowledge on how to employ the tools and techniques for that, may get aware of the limitations and benefits of using them, drawbacks of having PIs and get ideas on how to overcome the challenges encountered because of PIs.

Secondly, the companies where KM practices and tools are broadly employed can explore the VIM tools for themselves and integrate them into the KM, as it is suggested by us. Hence, a more enhanced and diverse set of tools and techniques will bring more benefits and will strengthen their ability to cope with the challenges and issues while facing with different types of PIs.

Another important contribution and suggestion is that managers will be aware of the mutual relationships and impacts between PIs and knowledge transfer and creation processes, which are proved through the literature review and empirical findings in this study. Consequently, they can devote some attention and try to take advantage of this fact by benefiting from the effective processes that will support and improve each other.

7.3 Limitations and Future Studies

There are three primary limitations of this thesis. Firstly, the methodology used for this study included triangulation using different sources of data, namely, semi-structured interviews and questionnaires, that had to be conducted within the frame of short time. It might be beneficial for the researchers to consider performing a longitudinal study, which would capture the dynamics of investigated coherent model of project portfolio, interdependency management and KC and transfer processes.

Secondly, future studies investigating and explaining the relationships between PIs and KM can be conducted either quantitatively using larger sample or following the mixed method research to gain more objective and generalizable results. It can be achieved by triangulation and reassuring validity of initially gained data. We consider mixed-method approach as an ability to better understand the topic and explain complex or contradictory responses. We also inclined to think that combination of methods can lead for identification of new areas of the research.

Thirdly, as case study approach was considered suitable for this research, four different companies from Europe and mainly project and portfolio managers have been involved. Two managers from one company and one manager from the each of other three companies have participated in the interviews. However, it would be interesting to enlarge the geographical reach and conduct interviews with the increased number of companies and employees, including other stakeholders, who are also using the visual management tools. Additionally, instead of Skype interviews, only face-to-face interviews can be held within the future studies, considering their effectiveness and an opportunity to observe real environment, as well as the usage of the tools and techniques in the company. Also, other sectors can be involved to have richer and more applicable results.

In terms of directions for future research, further work could view the VIM tools as integrated part of KM area. It would be beneficial in terms of practical usage of these tools and increase their popularity. Therefore, researchers may consider this direction of investigations to find out real applicability of VIM tools as knowledge management incentives and study in depth the advantages of using them as described in the discussion part of the present thesis.

Moreover, further research is required to determine that existence of PIs can have a negative effect on KT, KC processes, considering identified drawbacks arising from PIs. These drawbacks are project delays, competitions for the shared resources, cannibalization of existing resources, knowledge diffusion, and conflicts caused by having shared resources.

References

Ajmal, M. (2009). *Managing Knowledge in Project-based Organizations: A Cultural Perspective*. Available at: http://www.uva.fi/materiaali/pdf/isbn_978-952-476-278-6.pdf [Accessed December 1, 2015].

Al-Alawi, I. A., Al-Marzooqi, Y. N. & Mohammed, F.Y. (2007). Organizational culture and knowledge sharing: critical success factors. *Journal of Knowledge Management*, 11(2), pp.22–42. Available at: http://www.emeraldinsight.com/doi/abs/10.1108/13673270710738898.

Alavi, M. & Leidner, D.E. (2001). Review: Knowledge management and knowledge management systems: conceptual foundations and research. *MIS quarterly*, 25(1), pp.107–136.

Andersen, S.S. & Hanstad, D.V. (2013). Knowledge development and transfer in a mindful project-organization. International Journal of Managing Projects in Business, 6(2), pp.236–250. Available at: http://www.emeraldinsight.com/10.1108/17538371311319007.

APM (2015). Knowledge management in project-based organizations: the good, the bad and the ugly. Youtube. Available at: https://www.youtube.com/watch?v=WAjyT6oKBOg [Accessed September 30, 2015].

Archer, N. & Ghasemzadeh, F. (1999). An integrated framework for project portfolio selection. International Journal of Project Management, 17(4), pp.207–216.

Aritua, B., Smith, N.J. & Bower, D. (2009). Construction client multi-projects - A complex adaptive systems perspective. *International Journal of Project Management*, 27(1), pp.72–79. Available at: http://dx.doi.org/10.1016/j.ijproman.2008.02.005.

Arkell, D. (2007). Get our heads into it. *Boeing Frontiers*, (October), pp.12–17. Available at: http://www.boeing.com/news/frontiers/archive/2007/october/cover.pdf.

Artto, K., Karlos A., Dietrich, P.H. (2007). Strategic Business Management Through Multiple Projects. *The Wiley guide to managing projects*, pp.144–176.

Balestrin, A., Vargas L.M., and Fayard, P. (2008). Knowledge creation in small-firm network. *Journal of Knowledge Management*, Vol. 12, No. 2, pp. 94-100.

Barker, C., Pistrang, N. & Elliott, R. (2002). Research methods in clinical psychology: An introduction for students and practitioners. 2nd edition. Chichester, England: John Wiley and Sons.

Benta, D., Podean, M. & Mircean, C. (2011). On Best Practices for Risk Management in Complex Projects - Umeå universitetsbibliotek. Informatica Economica Journal, pp.142–152. Available at: http://revistaie.ase.ro/ [Accessed October 29, 2015].

Bhaskar, R. & Danermark, B. (2006). Metatheory, Interdisciplinarity and Disability Research: A Critical Realist Perspective. Scandinavian Journal of Disability Research, 2006, 8(4), 295.

Bhaskar, R.(2011). *Reclaiming Reality: A critical introduction to contemporary philosophy*. Capital & Class, 13, p.2.

Blau, G., Pekny, J., Varma, V. and Bunch, P. (2004), "Managing a Portfolio of Interdependent New Product Candidates in the Pharmaceutical Industry", Journal of Product Innovation Management, Vol. 21 No. 4, 233.

Blichfeldt, B.S. & Eskerod, P. (2008). Project portfolio management - There's more to it than what management enacts. International Journal of Project Management, 26(4), pp.357–365.

Blomquist, T., & Müller, R. (2006). Practices, roles and responsibilities of middle managers in program and portfolio management. Project Management Journal, 37(1), 52–66.

Blumberg, B., Cooper, D. R ; Schindler, P. S. (2011). *Business Research Methods* London : McGraw-Hill Higher Education, 3rd European edition

Bromley, D. B. (1986). The case-study method in psychology and related disciplines. Chichester, Wiley.

Bryman, A. & Bell, E. (2007). *Business Research Methods*. Second edition. New York: Oxford University Press.

Bryman, A. and Bell, E. (2011). *Business Research Methods*. Third Edition. Oxford: Oxford University Press.

Bryman, A. and Bell, E. (2015). *Business Research Methods*. Fourth Edition. Oxford: Oxford University Press.

Burkhard, R. & Eppler, M.J. (2007). Visual representations in knowledge management: framework and cases. *Journal of Knowledge Management*, 11(4), pp.112–122.

Burkhard, R. & Meier, M. (2005). Tube Map Visualization: Evaluation of a Novel Knowledge Visualization Application for the Transfer of Knowledge in Long-Term Projects. *Journal of Universal Computer Science*, 11(November), pp.473–494.

Burkhard, R. (2004). Learning from architects:the difference between knowledge visualization and information visualization. *In Information Visualisation, 2004. IV 2004. Proceedings. Eighth International Conference on IEEE.*, pp.519–524. Available at: http://ieeexplore.ieee.org/lpdocs/epic03/wrapper.htm?arnumber=1320194.

Burkhard, R. (2005). Knowledge Visualization: The Use of Complementary Visual Representations for the Transfer of Knowledge. *Encyclopedia of Knowledge Management*. Available at: http://www.gregjudelman.com/media/judelmanThesis2004.pdf.

Burkhard, R. et al. (2005). Beyond excel and powerpoint: Knowledge maps for the transfer and creation of knowledge in organizations. *Proceedings of the International Conference on Information Visualisation*, 2005, pp.76–84.

Burkhard, R., Spescha, G. & Meier, M. (2005b). "A-ha!": How to Visualize Strategies with Complementary Visualizations". *Conference on Visualising and Presenting Indicator Systems*, (April 2005), pp.1–10.

Cabrera Á. and Cabrera E. F. (2002). Knowledge-sharing Dilemmas. Organization Studies. W*alter de Gruyter GmbH and Co. KG*, 23(5), pp.687-710. Available at: http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.192.4368&rep=rep1&type=pdf.

Cañas, A.J. et al. (2005). Concept Maps : Integrating Knowledge and Information Visualization. *Knowledge and information visualization*, (2004), pp.205–219. Available at: http://pdf.aminer.org/000/479/225/concept_maps_integrating_knowledge_and_information_visualization.pdf.

Canonico, P., & Söderlund, J. (2010). Getting control of multi-project organizations: Combining contingent control mechanisms. International Journal of Project Management, 28(8), 796-806. doi: http://dx.doi.org/10.1016/j.ijproman.2010.05.005

Cassel, C., & Symon, G. (1990). Qualitative methods in organizational research. London: Sage Publications.

Cepeda, Cicmil, S., Cooke-Davies, T., Crawford, L. & Richardson, K. (2009). Exporing the complexity of projects: implications of complexity theory for project management practice, Project Management Institute, Atlanta, GA.

Chen, M.Y.C. and Chen, A.P. (2005). Knowledge management performance evaluation: a decade review from 1995 to 2004. Available at: https://ir.nctu.edu.tw/bitstream/11536/12822/1/000236053800003.pdf [Accessed September 30, 2015].

Collyer, S. & Warren, C.M.J. (2009). Project management approaches for dynamic environments. *International Journal of Project Management*, 27(4), pp.355–364. Available at: http://linkinghub.elsevier.com/retrieve/pii/S0263786308000550.

Cooper, R.G., Edgett, S.J. & Kleinschmidt, E.J. (1999). New Product Portfolio Management: Practices and Performance. *Elsevier Science Inc.* Available at: http://www.mmt3000.dk/Upload/O3 New_product_portfolio_management-Practices_and_performance.pdf [Accessed September 30, 2015].

Cooper, R.G., Edgett, S.J. & Kleinschmidt, E.J. (2001). Portfolio Management for New Product Development: Results of an Industry Practices Study. *R&D Management (Industrial Research Institute, Inc.)*. Available at: http://www.stage-gate.net/downloads/wp/wp_13.pdf [Accessed September 30, 2015].

Creswell, J.W. (2013). *Qualitative inquiry and research design*. 3rd edition. Thousand Oaks: Sage Publications.

Creswell, J.W. (2014). *Research design: qualitative, quantitative, and mixed methods approaches*. 4th edition. Thousand Oaks: Sage Publications. Available at: https://uk.sagepub.com/en-gb/eur/research-design/book237357#contents [Accessed January 2, 2016].

Danilovic, M. & Sandkull, B. (2005). The use of dependence structure matrix and domain mapping matrix in managing uncertainty in multiple project situations. *International Journal of Project Management*, 23(3), pp.193–203. Available at: http://linkinghub.elsevier.com/retrieve/pii/S0263786304001036.

Dansereau, D.F. & Simpson, D.D. (2009). A picture is worth a thousand words: The case for graphic representations. *Professional Psychology: Research and Practice*, 40(1), pp.104–110. Available at: http://doi.apa.org/getdoi.cfm?doi=10.1037/a0011827.

David, M. & Sutton, C. D. (2011). Social Research: An Introduction. London, UK: SAGE Publications Ltd.

De Maio, A., Verganti, R. & Corso, M. (1994). "A multi-project management framework for new product development". European Journal of Operational Research, 78 (2), 178-191.

De Marrais, K. (2004). Qualitative interview studies: Learning through experience. In K. deMarrais & S.D.Lapan (Eds.), *Foundations for research*,pp.51-68. Mahwah, NJ: Erlbaum

Desouza, K. C.,& Evaristo, J.R. (2004). Managing knowledge in distributed projects. Communications of the ACM, 47(4), 87–91.

Dickinson, M.W., Thornton, A.C. & Graves, S. (2001). Technology portfolio management: Optimizing interdependent projects over multiple time periods. *IEEE Transactions on Engineering Management*, 48(4), pp.518–527.

Dietrich, P., Lehtonen, P. (2005). Succesful management of strategic intentions through multiple projects – reflections from empirical study. International Journal of Project Management 23 (5), 386-391.

Dooley, L., Lupton, G., O'Sullivan, D. (2005). Multiple project management: a modern competitive necessity. Journal of Manufacturing Technology Manage- ment 16 (5), 466–482

Du Chatenier, E. et al. (2009). The Challenges of Collaborative Knowledge Creation in Open Innovation Teams. *Human Resource Development Review*, 8(3), pp.350–381. Available at: http://hrd.sagepub.com/content/8/3/350.abstract.

Durant-Low, G. (2012). Network project management: visualising collective knowledge to better understand and model a project-portfolio. *University of Canberra*, (January). Available at: http://www.durantlaw.info/sites/durantlaw.info/files/GDL_PhD_Final_2012.pdf.

Dye, L. D., and J. S. Pennypacker. (1999). An introduction to project portfolio management. In Project portfolio management: Selecting and prioritizing projects for competitive

advantage, ed. L. D. Dye and J. S. Pennypacker xi–xvi. West Chester, PA: Center for Business Practices.

Easterby-Smith, M., Thorpe, R. & Jackson, P. (2012). Management Research. 4 edition. London, UK: SAGE Publication Ltd.

Easton, G., 2010. Critical realism in case study research. *Industrial Marketing Management*, 39(1), pp.118–128. Available at: http://dx.doi.org/10.1016/j.indmarman.2008.06.004.

Edmondson, A.C. & McManus, S.E. (2007). Methodological fit in management field research.Academy of Management Review, 32 (4), 1155–1179.

Eisenhardt, K. M. & Graebner, M. E. (2007). Theory Building from Cases: Opportunities and Challenges. Academy of Management Journal, 50(1), 25-32.

Elonen, S., & Artto, K.A. (2002). Problems in managing internal development projects in multi-project environments. International Journal of Project Management, 21, 395-402.

Engwall, M. (2003). "No project is an island: linking projects to history and context", Research Policy, Vol. 32, pp. 789-808.

Eppler, M.J. (2006). A comparison between concept maps, mind maps, conceptual diagrams, and visual metaphors as complementary tools for knowledge construction and sharing. *Information Visualization*, 5(3), pp.202–210. Available at: http://ivi.sagepub.com/lookup/doi/10.1057/palgrave.ivs.9500131.

Evans, T. & Hardy, M. (2010). *Evidence and Knowledge for Practice*. Cambridge, UK: Polity Press.

Fink, A. (2013) *How to conduct surveys: A step-by-step Guide.* Sage Publications

Flyvbjerg, B. (2006). Five Misunderstandings About Case-Study Research. *Qualitative Inquiry*, 12(2), pp.219–245. Available at: http://eds.b.ebscohost.com.ezproxy1.hw.ac.uk/eds/detail/detail?vid=2&sid=11320329-2bd9-4d91-8904-8ae18188eee4%40sessionmgr198&hid=104&bdata=JnNpdGU9ZWRzLWxpdmU%3d#AN=1304.1186&db=edsarx [Accessed December 13, 2015].

Formentini, M. & Romano, P. (2011). Using value analysis to support knowledge transfer in the multi-project setting. *International Journal of Production Economics*, 131(2), pp.545–560. Available at: http://linkinghub.elsevier.com/retrieve/pii/S0925527311000387.

Gasik, S. (2012). A Model of Project Knowledge Management. Available at: http://eds.b.ebscohost.com.ezproxy1.hw.ac.uk/eds/pdfviewer/pdfviewer?sid=8cb74f2d-089b-442f-8337-df6d6ee3a8b9@sessionmgr112&vid=3&hid=126 [Accessed September 30, 2015].

Ghauri, P. N. & Grønhaug, K. (2010). Research Methods in Business Studies. 4 edition. London: Prentice Hall.

Guba, E. G. & Lincoln, Y. S. (1994). Competing paradigms in qualitative research. In Denzin, N. K. & Lincoln, Y. S. (eds.) Handbook of qualitative research. London, UK: SAGE Publications.

Gummesson, E. (2007). Case study research and network theory: birds of a feathe. *Qualitative Research in Organizations and Management: An International Journal*, 2(3), pp.226 – 248. Available at: http://www.emeraldinsight.com.proxy.ub.umu.se/doi/pdfplus/10.1108/17465640710835373 [Accessed December 10, 2015].

Hardy, M. and Bryman, A. (2004). *Handbook of Data Analysis.* 1st edition. Thousand Oaks: Sage Publications. Available at: https://uk.sagepub.com/en-gb/eur/handbook-of-data-analysis/book209824#contents [Accessed January 2, 2016].

Hong, J.F.L. (2012). Glocalizing Nonaka's knowledge creation model: Issues and challenges. *Management Learning*, 43(2), pp.199–215. Available at: http://mlq.sagepub.com/cgi/doi/10.1177/1350507611428853.

Hossain, L., & Ruwanpura, J. (2008). Optimisation of Multi-Project Environment (OPMPE). In: WSC 2008 Simulation Conference, December 1-10

Hyde, K. (2000). Recognising deductive processes in qualitative research. Qualitative Market Research: An International Journal, 3(2), pp. 82-90.

Javernick-Will, A. (2013). Local Embeddedness and Knowledge Management Strategies for Project-Based Multi-National Firms. *Engineering Management Journal*, 25(3), pp.16–26.

Killen, C.P. & Kjaer, C. (2012). Understanding project interdependencies: The role of visual representation, culture and process. International Journal of Project Management, 30(5), pp.554–566. Available at: http://www.sciencedirect.com/science/article/pii/S0263786312000269 [Accessed September 30, 2015].

Killen, C.P. (2013). Evaluation of project interdependency visualizations through decision scenario experimentation. *International Journal of Project Management*, 31(6), pp.804–816. Available at: http://dx.doi.org/10.1016/j.ijproman.2012.09.005.

Killen, C.P. et al. (2009). Managing project interdependencies: exploring new approaches. In *Asia Pacific Expert Seminar (APES2009): Managing Projects, Programs And Ventures In Times Of Uncertainty And Disruptive Change*. pp. 1–8.

Kjølle, G.H. et al. (2012). Risk analysis of critical infrastructures emphasizing electricity supply and interdependencies. Reliability Engineering and System Safety, doi:10.1016/j.ress.2012.02.006.

Klein, S. (2005). Knowledge Visualization in Practice: Challenges for Future Corporate Communication. *Ninth International Conference on Information Visualisation (IV'05)*, pp.70–75. Available at: http://ieeexplore.ieee.org/lpdocs/epic03/wrapper.htm?arnumber=1509061.

Kotnour, T. (1999). A learning framework for project management, Project Management Journal, June, pp.32-38.

Kvale Steinar (2007). "Doing interviews". 1. ed. Thousand Oaks, Calif.: Sage Publications, 157

Landaeta, R.E. (2008) Evaluating Benefits and Challenges of Knowledge Transfer Across Projects, Engineering Management Journal, Vol.20,No.1,pp.29-38.

Levine, H.A. (2005). Project Portfolio Management: A Practical Guide to Selecting Projects, Managing Portfolios, and Maximizing Benefits, Jossey-Bass, Portland

Lindner, F. & Wald, A. (2011). Success factors of knowledge management in temporary organizations. *International Journal of Project Management*, 29(7), pp.877–888. Available at: http://linkinghub.elsevier.com/retrieve/pii/S0263786310001328.

Long. R., White, M.C., Friedman, W.H., Brazeal, D.V. (2000). The 'Qualitative' versus 'Quantitative' research rebate: a question of metaphorical assumptions? International Journal of Value-Based Management, 13, pp. 189–197.

Lord, Michael D.Ranft, A.L. (2000). Organizational Learning About New International Markets: Exploring the Internal Transfer of Local Market Knowledge. *Journal of International Business Studies*, 31(4), pp.573–589.

Love, P.E.D., Fong, P.S.W. & Zahir, I. (2005). *Management of Knowledge in Project Environments*, Elsevier. Available at: http://www.sciencedirect.com/science/article/pii/B9780750662512500018 [Accessed December 1, 2015].

Malterud, K. (2001). Qualitative research: standards, challenges, and guidelines. The Lancet, 358(9280), 483-488

Martinsson, I. (2010). *Standardized Knowledge Transfer: A study of Project-Based Organizations in the Construction and IT Sectors*. Available at: http://su.diva-portal.org/smash/get/diva2:280581/FULLTEXT02.pdf [Accessed December 1, 2015].

Martinsuo, M. & Lehtonen, P. (2007). Role of single-project management in achieving portfolio management efficiency. *International Journal of Project Management*, 25, pp.56–65.

Massingham, P. (2014). An evaluation of knowledge management tools: Part 1 – managing knowledge resources. *Journal of Knowledge Management*, 18(6), pp.1075–1100. Available at: http://www.emeraldinsight.com/doi/abs/10.1108/JKM-11-2013-0449.

Matzler K., Renzl B., Müller J., Herting S. and Mooradian T. A. (2008). Personality traits and knowledge sharing. *Journal of Economic Psychology*, 29(3), pp. 301-313. Available at: http://www.sciencedirect.com.proxy.ub.umu.se/science/article/pii/S0167487007000499 [Accessed September 30, 2015].

Maylor, H., Brady, T., Cooke-Davies, T. and Hodgson, D. (2006). "From projectification to programmification", *International Journal of Project Management*, No. 8, pp. 663-674

Merriam, S.B. (2009). *Qualitative research : a guide to design and implementation* [Accessed December 12, 2015].

Midler, C. (1999). "Projectification" of the firm: the Renault case. Scandinavian Journal of Management, 11(4). 363–76.

Morales-Arroyo, M., Chang, Y. K., & De las Nievas Sánchez-Guerro, G. (2010). The Use of KM Tools and Techniques to Reduce Coordination Problems in Project Management. *Convergence of Project Management and Knowledge Management*, p. 61.

Morris, P.W.G. and Hough, G.H. (1987). *The Anatomy of Major Projects: A Study of the Reality of Project Management*, Wiley, Oxford, UK.

Munns, A. K. & Bjeirmi, B.F. (1996). The role of project management in achieving project success. *International Journal of Project Management*, 14(2), pp.81–87. Available at: http://www.sciencedirect.com/science/article/pii/0263786395000577.

Müller, R. et al. (2013). Project Management Knowledge Flows in Networks of Project Managers and Project Management Offices: A Case Study in the Pharmaceutical Industry. Available at: http://eds.a.ebscohost.com.ezproxy1.hw.ac.uk/eds/pdfviewer/pdfviewer?sid=d99d7356-9355-4196-9550-302efb6d9f15%40sessionmgr4002&vid=1&hid=4202 [Accessed September 30, 2015].

Müller, R., Martinsuo, M. & Blomquist, T. (2008). Project Portfolio Control and PortfolioManagement Performance in Different Contexts. *Project Management Journal*, pp.28–42.

Newell, S., Goussevskaia, A., Swan, J., Bresnen, M., and Obembe, A. (2008). "Interdependencies in Complex Project Ecologies: The Case of Biomedical Innovation" *Long Range Planning*, Vol. 41, No.1, pp. 33-54.

Nonaka, I. & Peltokorpi, V. (2006). Objectivity and Subjectivity in Knowledge Management: A Review of 20 top Articles. *Knowledge and Process Management*, 13(2), pp.73–82. Available at: http://www.researchgate.net/profile/Vesa_Peltokorpi/publication/227712846_Objectivity_and_subjectivity_in_knowledge_management_a_review_of_20_top_articles/links/550760dd0cf2d7a28124edc6.pdf [Accessed September 30, 2015].

Nonaka, I. & Takeuchi, H. (1995). *The Knowledge-Creating Company: How Japanese Companies Create the Dynamics of Innovation*, Oxford University Press. Available at: https://books.google.com/books?hl=en&lr=&id=tmziBwAAQBAJ&pgis=1 [Accessed January 1, 2016].

Nonaka, I. (1994). A Dynamic Theory of Organizational Knowledge Creation. *Organization Science*, 5(1), pp.14–37. Available at: http://www.jstor.org.proxy.ub.umu.se/stable/2635068?seq=1#page_scan_tab_contents [Accessed December 2, 2015].

Owen, J., & Burstein, F. (2005). Where knowledge management resides within project management. Case Studies in Knowledge Management, 138-153.

Patanakul, P., & Milosevic, D. (2009). The effectiveness in managing a group of multiple projects: Factors of influence and measurement criteria. International Journal of Project Management, 27(3), 124.

Patton, M.Q. (2002).Qualitative research and evaluation methods (3rd ed.). Thousand Oaks, CA: Sage Polity Press.

Pemsel, S. & Wiewiora, A. (2013). Project management office a knowledge broker in project-based organizations. *International Journal of Project Management*, 31(1), pp.31–42. Available at: http://linkinghub.elsevier.com/retrieve/pii/S0263786312000464.

Pentland, B.T. (1995). Information systems and organizational learning: The social epistemology of organizational knowledge systems. *Accounting, Management and Information Technologies*, 5(1), pp.1–21. Available at: http://www.sciencedirect.com/science/article/pii/095980229590011X [Accessed December 2, 2015].

Perminova, O., Gustafsson, M. & Wikström, K. (2008). Defining uncertainty in projects – a new perspective. *International Journal of Project Management*, 26(1), pp.73–79. Available at: http://linkinghub.elsevier.com/retrieve/pii/S0263786307001263.

Platenkamp, V. & Botterill, D., 2013. Critical realism, rationality and tourism knowledge. *Annals of Tourism Research*, 41, pp.110–129. Available at: http://dx.doi.org/10.1016/j.annals.2012.12.006.

Prencipe, A. & Tell, F. (2001). Inter-project learning: processes and outcomes of knowledge codification in project-based firms. *Research Policy*, 30(9), pp.1373–1394. Available at: http://www.sciencedirect.com/science/article/pii/S0048733301001573 [Accessed October 10, 2015].

Project Management Institute (2013). *PMBOK*. 5th edition. Newton Square, Pennsylvania: Project Management Institute, Inc.

Quintas, P., Lefrere, P. & Jones, G. (1997). Knowledge Management: a Strategic Agenda. *Long Range Planning*, 30(3), pp.385–391. Available at: http://www.researchgate.net/profile/Paul_Lefrere/publication/222487231_Knowledge_management_A_strategic_agenda/links/02bfe511cf2d44b84c000000.pdf [Accessed September 30, 2015].

Reich, B.H., Gemino, A. & Sauer, C. (2014). How knowledge management impacts performance in projects: An empirical study. *International Journal of Project Management*, 32(4), pp.590–602. Available at: http://linkinghub.elsevier.com/retrieve/pii/S0263786313001269.

Remenyi, D., Williams, B., Money, A. & Swartz, E. (1998). Doing Research in Business and Management: An Introduction to

Reyck, B. De et al. (2005). The impact of project portfolio management on information technology projects. *International Journal of Project Management*, 23(7), pp.524–537. Available at: http://linkinghub.elsevier.com/retrieve/pii/S0263786305000323.

Riege, A., 2005. Three-dozen knowledge-sharing barriers managers must consider. *Journal of Knowledge Management*, 9(3), pp.18–35. Available at: http://www.emeraldinsight.com/doi/abs/10.1108/13673270510602746.

Ritchie, J., Lewis, J. & Elam, G. (2003). Designing and Selecting Samples. In Ritchie, J. & Lewis, J. (eds.) Qualitative Research Practice: A Guide for Social Science Students and Researchers. London, England: SAGE Publications.

Robertson, S. (2002). A tale of two knowledge-sharing systems. *Journal of Knowledge Management*, 6(3), pp.295–308. Available at: http://www.emeraldinsight.com/doi/abs/10.1108/13673270210434395.

Rungi, M. & Hilmola, O. (2011). Interdependency management of projects: survey comparison between Estonia and Finland. Baltic Journal of Management, 6(2), pp.146–162. Available at: http://www.emeraldinsight.com/doi/abs/10.1108/17465261111131785.

Rungi, M. (2009a). "Interdependency Management: Survey Comparison between Small, Medium and Large Companies", in Proc. 9th EURAM Annual Conference, Liverpool, UK

Rungi, M. (2009b). "Interdependency Management in Project Portfolio Management: Bibliometric Citation and Clustering Analyses," in Exploring new research avenues of industrial management, M. Torkkeli and O.-P, Hilmola, Ed. Research Report 217, Lappeenranta, Finland: Lappeenranta University of Technology, pp.111-136.

Rungi, M. (2009c). Managing resource and technology interdependencies in project portfolio: A case-study results. *IEEM 2009 - IEEE International Conference on Industrial Engineering and Engineering Management*, pp.1508–1512.

Rungi, M. (2010a). Foundation of interdependency management in project portfolio management: A strategic view. *2010 IEEE International Conference on Management of Innovation & Technology*, pp.117–122. Available at: http://ieeexplore.ieee.org/lpdocs/epic03/wrapper.htm?arnumber=5492828.

Rungi, M. (2010b). Success rate and resource consumption from project interdependencies. *Industrial Management & Data Systems*, 110(1), pp.93–110. Available at: http://www.emeraldinsight.com/doi/abs/10.1108/02635571011008425. [accessed 10 September 2015].

Sandberg, J. & Alvesson, M. (2011). *Ways of constructing research questions: Gap-spotting or problematization?* Organization 18(1): 30

Santhanam, R., & Kyparisis, G. J. (1996). *A decision model for interdependent information system project selection*. European Journal of Operational Research, 89(2), 382

Saunders, M., Lewis, P., & Thornhill, A. (2012). *Research methods for business students*. 6th edition. Harlow: Pearson Education.

Sayer, A. (1992). *Method in social science: A realist approach.* 2nd edition. London: Routledge

Sayer, A. (2000). *Realism and social science*. London: Sage Publications.

Schmidt, R. L. (1993). A model for R&D: project selection with combined benefit, outcome and resource interactions. IEEE Transactions on Engineering Management, 40(4), 403-410. doi: 10.1109/17.257733.

Sibbet, D. (2010). *Visual Meetings: How Graphics, Sticky Notes and Idea Mapping Can Transform Group Productivity*. John Wiley and Sons

Silverman, D. (2011). Interpreting Qualitative Data. 4 th edition. London, UK: SAGE Publications Ltd.

Smith, V., J. (2011). *It's the relationship that matters: a qualitative analysis of the role of the student/tutor relationship in counselling training.* Counselling Psychology Quarterly, 24 (3). pp. 233-246.

Smits, M.T. & De Moor, A.R.E.M. (2003). Effective Knowledge Management in Project-Based Organizations. *Igarss 2014*, (1), pp.1–44.

Snider,K. F.,& Nissen, M. E. (2003). Beyond the body of knowledge: A knowledge-flow approach to project management theory and practice. Project Management Journal, 34(2), 4–12.

Sokhanvar, S., Matthews, J. & Yarlagadda, P. (2014). Importance of Knowledge Management Processes in a Project-based organization: A Case Study of Research Enterprise. *Procedia Engineering*, 97, pp.1825–1830. Available at: http://linkinghub.elsevier.com/retrieve/pii/S1877705814034043.

Staudenmayer, N. (1997). Interdependency: Conceptual, Empirical, & Practical Issues. The International Centerfor Research on the Management of Technology.

Strauss, A. L. (1987). Qualitative Analysis for Social Scientists. Cambridge, UK: Cambridge University Press.

Styhre, A. & Gluch, P. (2009). Visual representations and knowledge-intensive work. *Vine*, 39(2), pp.108–124. Available at: http://www.emeraldinsight.com/doi/abs/10.1108/03055720910988832.

Szulanski, G. (2003). *Sticky knowledge: barriers to knowing in the firm*, London: Sage Publications.

Söderlund, J. (2004). Building theories of project management: Past research, questions for the future. International Journal of Project Management, 22, 183–191

Søderlund, J., Vaagaasar, A.L. and Andersen, E.S. (2008), "Relating, reflecting and routinizing: developing project competence in cooperation with others", International Journal of Project Management, Vol. 26 No. 5, pp. 517-526.

Teller, J. et al. (2012). Formalization of project portfolio management: The moderating role of project portfolio complexity. International Journal of Project Management, pp.596–607. Available at: http://ac.els-cdn.com.proxy.ub.umu.se/S0263786312000282/1-s2.0-S0263786312000282-main.pdf?_tid=c4760c62-6a32-11e5-9e1b-00000aab0f6b&acdnat=1443920378_5c019bab952e3f7506ecbe0f1315384d [accessed 4 October 2015].

Tergan, S. O., & Keller, T. (2005). Knowledge and information visualization: Searching for synergies. Heidelberg, Germany: Springer- Verlag.

Thiry, M. (2004). Program management: A strategic decision management process. In P. W. G. Morris, & J. K. Pinto (Eds.), The Wiley guide to managing projects (pp. 257–287). New York: John Wiley & Sons.

Thiry, M. and Deguire, M. (2007). Recent developments in project-based organizations. *International Journal of Project Management*, 25 (7), pp. 649-658. Available at: http://www.sciencedirect.com/science/article/pii/S0263786307000348 [Accessed December 1, 2015].

Thompson, J. D. (2003). Organizations in action: Social science bases of administrative theory.New Brunswick, NJ: Transaction Publishers.

Todorović, M.L. et al. (2014). Project success analysis framework: A knowledge-based approach in project management. *International Journal of Project Management*, 33(4), pp.772–783. Available at: http://www.sciencedirect.com/science/article/pii/S0263786314001665 [Accessed September 10, 2015].

Turner, J.R. (2009). The Handbook of Project-based Management. 3rd edition. McGraw- Hill, New York, NY.

Turner, R. (2007). Gower Handbook of Project Management, 4th edition, Gower Publishing Limited.

Van De Ven, A. and Johnson, P. (2006). 'Knowledge for Theory and Practice', Academy of Management Review, Vol. 31, No. 4, pp. 802–21.

Wang S. and Noe R. A. (2010). Knowledge sharing: A review and directions for future research. *Human Resource Management Review*, 20(2), pp. 115-131. Available at: http://www.sciencedirect.com.proxy.ub.umu.se/science/article/pii/S1053482209000904 [Accessed December 1, 2015].

Ward, J., De Hertogh, S., & Viaene, S. (2007). Managing Benefits from IS/IT Investments: An Empirical Investigation into Current Practice. In: HICSS 2007 40th Annual Hawaii International Conference on the System Sciences. January.

Verma, D. and Sinha, K. (2002), "Toward a theory of project interdependencies in high tech R&D environments", Journal of Operations Management, Vol. 20, pp. 451-468.

Yang, C.W., Fang, S.C. & Lin, J.L. (2010). Organizational knowledge creation strategies: A conceptual framework. *International Journal of Information Management*, 30(3),

pp.231–238. Available at: http://www.sciencedirect.com/science/article/pii/S0268401209001091 [Accessed September 19, 2015].
Yin, R. K. (2003). *Applications of Case Study Research*. 2nd edition. Sage Publications
Yin, R. K. (2009). *Case Study Research: Design and Methods*. 4th edition. London: SAGE Publications.
Yin, R. K. (2013). *Case Study Research: Design and Methods*. 5th edition. London: SAGE Publications.
Zuluaga, A., Sefair, J. A., & Medaglia, A. L. (2007). Model for the Selection and Scheduling of Interdependent Projects. In: SIEDS 2007 IEEE the Systems and Information Engineering Design Symposium. April 27-27.

Appendix 1. Interview Guide

Section A: Introduction and General Questions

1. Would you mind if we record the interview?
2. Could you please tell us briefly about your job role, department, and years of experience?
3. What best describes the structure of your organization?
4. How many employees do you have in the organization?
5. How many projects do you run at the same time (on average)?
6. How many projects within one portfolio you managed?
7. What is the most important resource for your project?
8. How do you get the resources needed for your project?

Section B: Project Interdependencies

1. Have you managed a project(s) that was dependent on other projects by any means?
2. Have you been involved in more than one project at the same time that were interdependent? If yes, how were you managing the interdependencies between them?
3. Usually what kind of dependency exists or existed between the projects?
4. What are the benefits of managing project interdependencies?
5. What are the problems that you usually encounter because of the interdependencies?
6. How difficult do you find managing project interdependencies?

Section C: Visual Tools

1. Do you use any tools or techniques to manage the interdependencies between projects or deal with the problems caused by interdependency?
2. If yes, how often do you use these tools?
3. In which situations are these tools and techniques applicable? Please, give an example of a situation or cases when did you use these tools and techniques?
4. What are the other benefits of applying these tools?
5. What are the drawbacks or limitations of applying these tools? Do you think that they can be improved? If yes, how?
6. Who are the interested parties (both internal and external) that you communicate the knowledge about the projects using visual tools most frequently?

Section D: Knowledge Management

1. How often you communicate with the project team? How many people are in your team?
2. How often you communicate with other project managers? What do you discuss and share when you meet with other project staff? Do you openly discuss the success and failures of your projects?
3. Do you discuss the risks and problems and try to solve them during the meeting? How useful are the visual tools for these purposes?
4. Do you have formal or informal processes to ensure that learning and information from projects are collected and transferred to other projects?
5. Are the visual tools used for the knowledge sharing or knowledge transfer between projects? If yes, please explain how?
6. Do you use these tools to create new knowledge, to develop existing knowledge?

Section E: Project Outcomes

1. Do you involve visual representation to explain the results and outcomes of the project when it is finished?
2. How the visual tools can be beneficial for the project outcomes?
3. Do you think that visual tools play any role in achieving better project results? If yes, how?
4. In which phase(s) the visual tools are used the most?

Appendix 2. Questionnaire

In our Master thesis research we are planning to understand from practical view, whether visual tools enhance an organization's capability to manage its project portfolio and how effective they are as knowledge management tools. For this purpose, we would like to carry out this survey and to find out how this issue is tackled in your company's projects. If you have any questions, feel free to contact us:
- Bekzat Musrepova by bemu0002@student.umu.se or
- Khuraman Mammadova by khaz0002@student.umu.se
(https://www.surveymonkey.com/r/CDWD5VM)

Section A: Introduction
1. Would you like to keep your anonymity? **Yes/No**
2. Would you like to keep the name of the organisation to be confidential? **Yes/No**
3. Do you want to get results of this survey? **Yes/No**

Section B: General Questions
1. What is your responsibility in the organisation? **Portfolio/program/project manager**
2. What best describes the structure of your organisation?

Entirely project based/Mainly based on projects/Partly based on projects (e.g. project managers have limited authority)/Organisation is not grouped by projects (e.g. grouped by functional departments)

3. How many employees do you have in the organisation?

Less than 20/ Between 20 and 50/ Between 50 and 250/ More than 25

4. How many projects do you run at the same time (on average)?

1-10/ 10-50/ 50-100/ >100

5. How many projects have you managed within one portfolio?

1-10/ 10-50/ 50-100/ >10

Section C: Project Interdependencies Management
1. Do you have projects in your portfolio that are dependent on each other by any means? **Yes/No**
2. Please weight the importance of each project (in your portfolio) to your organisation

Ex: Project A - important

3. Please describe the dependency between the projects in your portfolio

Choose: **Knowledge/ Resources/Time/Output/Benefits/Finance**
arrow ***"=>"*** *means impact*
Ex: Project A => Project B (finance)

4. What are the problems that you usually encounter because of the interdependencies? (please rank the most applicable practice in order of its importance from 1 to 5, 0- not applicable)

Negative effects from failed PI management	**Select and rank those applicable**
Time (schedule slippage, delay, expected duration)	
Recourse misuse and shortage	
Budget shortage	
Inter-project competition	
Reactive behavior of projects and portfolios (short-term problem solving)	
Failure to exploit organization learning	
Risk transferences	

5. According to you, how important is the management of project interdependencies in a project portfolio?

Not important**_____*****Very important***

6. How difficult do you find managing project interdependencies?

Not difficult**_____*****Very difficult***

7. Do you use any tools or techniques to deal with the problems arising from interdependencies between projects?

(open question)

8. Please give example of situations when you use these tools and techniques.

(open question)

9. Who are the stakeholders (both internal and external) that you communicate the knowledge about the projects using visual tools most frequently? Please write their positions and weight the stakeholders as:

Section D: Understanding of Interdependencies within Portfolios by Visual Knowledge Management Tools

1. Is the visual knowledge management tool used in your organisation useful for the following practices? *Please rank from 1 (not useful) to 5 (very useful)*

Practices	**Select and rank those applicable**
Ability to access, distribute, adopt and review data/information/knowledge from other projects	
Project management processes that help to learn from past mistakes and to avoid making the same mistakes again	
Project learning captured through end-of-project reviews	
Project learning captured through reporting on project milestones	
Ability to transfer and share data/information/knowledge to other projects	
Open discussions between project managers about their projects' weaknesses and failures in order to share lessons learned	
Open discussions between project managers about their projects' achievements and success stories in order to share lessons learned	
Presence of formal processes to ensure that learning and information from projects are transferred to dependent projects	
Informal mechanisms are regularly used to transfer learning and information to dependent projects	
Good understanding of the project interdependencies across the project portfolio	
Awareness of all the projects that my project depends upon or that impact its success	
Awareness of all the projects that depend on my project	
Common activity among different project managers	
Common activity among different project teams	

2. What are the drawbacks or limitations of the visual tool used in your organisation?
   - o not enough time to implement
   - o complexity
   - o considers limited number of relationships
   - o limited instructions on how to use the tool
   - o (your option)

3. Can it be improved? If yes, how? ***(open question)***

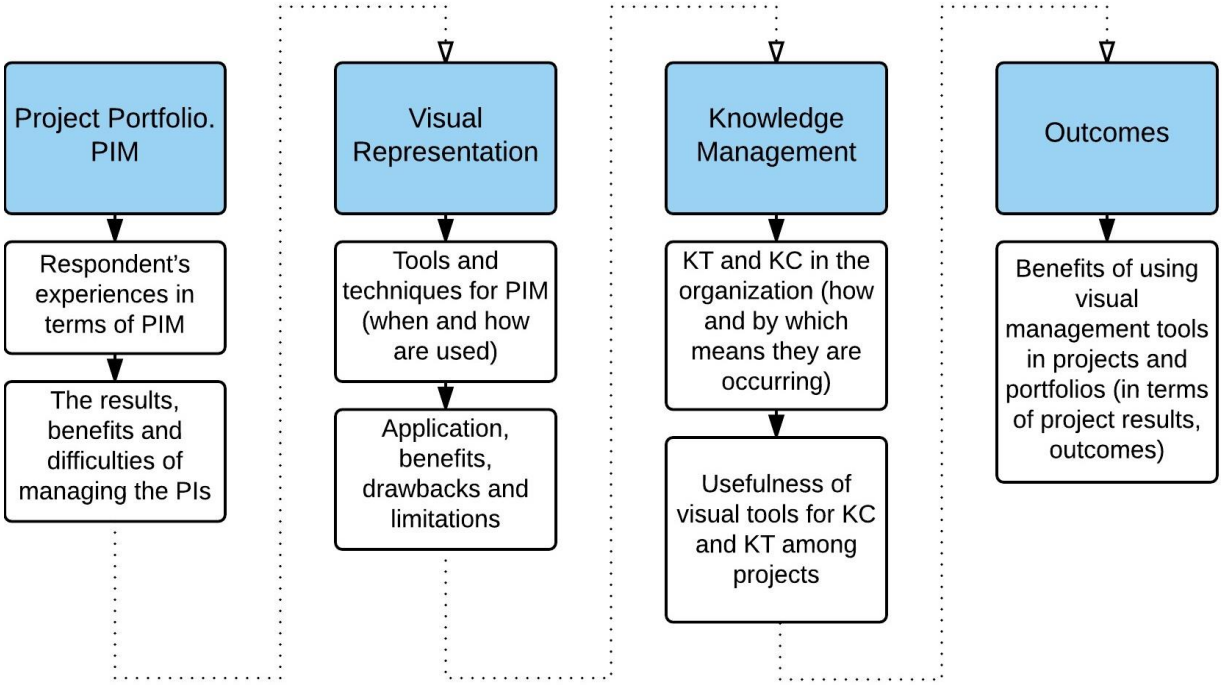
Section E: The Impact and Features of Visual Knowledge Management Tools on the Project Performance and Portfolio Management as a Whole

Which project competencies shown below have been enhanced as a result of using visual knowledge management tools on the project performance and portfolio management as a whole?
(please say whether you agree or disagree with statements given below, using the following scale: 5 = strongly agree, 4=agree, 3=neither agree or disagree, 2=disagree, 1=strongly disagree, 0=not applicable). Please put an 'X' in the appropriate box selected.

The visual knowledge management tool has enhanced following Project Competencies:	**1 Strongly disagree**	**2**	**3**	**4**	**5 Strongly agree**
Ability to assess complex situations and see big picture					
Better estimates of project costs and their control					
Improve cost efficiency					
Better estimates of schedules and control of time					
Better estimates and control of project risks					
Ability to better manage project start-up phase					
Ability to adapt project structure to new work processes in line with other projects in portfolio					
Ensuring the alignment of the project with organisational strategy					

Ability to better manage project during execution phase					
Abilities to meet project objectives (i.e., cost, schedule and performance requirements)					
Ability to adjust team dynamics to unforeseen contingencies					
Creating high level of innovative solutions in our organisation					
Having a high level of understanding among different portfolios in our organisation					
Ability to better manage project during close-out					
Transferring of new knowledge quickly to other projects					
Communicating project status and performance to stakeholders					
Documenting the lessons learnt to apply to future projects					

Appendix 3. Plan for the Interview Guide

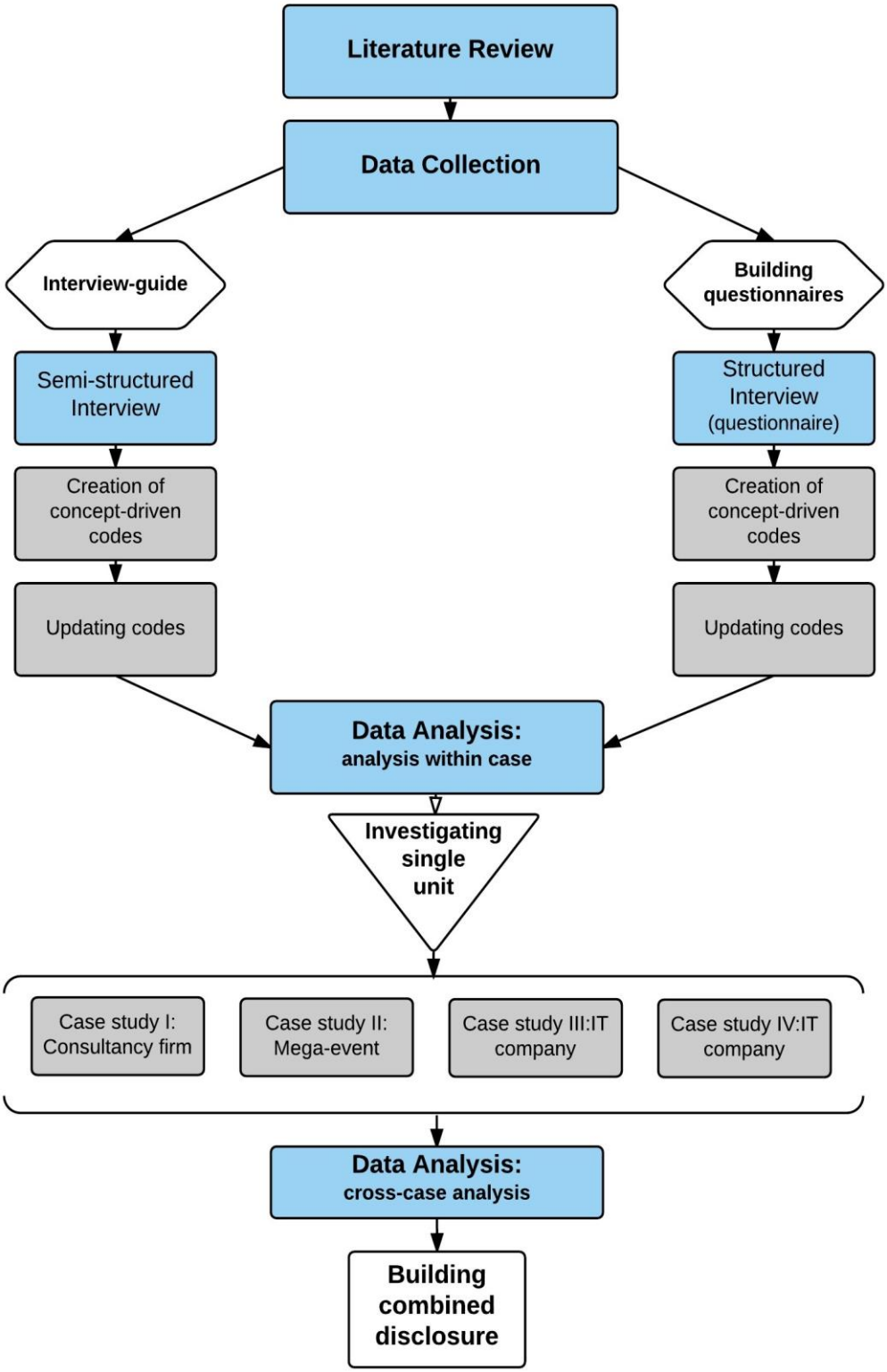


Appendix 4. Introduction to Companies

№	Participated company name	Company profile	Respondent details (participated in the interviews)
1	**JMAC Europe**	JMAC Europe is an integral part of the Japan Management Association Consultants (JMAC) and is based in Milan, Italy. There is a regional office of the company in Sweden as well, which is managing the Scandinavian region. The company has over 1500 employees around the world, more than 500 of which are consultants. The first respondent participating in the current study, Luca Cavone, represents JMAC Italy.	**Respondent 1** – **Luca Cavone** was working as a consultant in the innovation management, has more than 5 years of experience in this sphere. Before JMAC Italy he was working for a company in the aerospace industry. Overall, he has more than 10 years of experience. Luca has been involved both in customer and internal projects in JMAC Italy, mainly for the development of new methodologies, tools, and new business opportunities. He was usually working with 3-4 projects at the same time, either as a project manager or a team member, depending on different factors, such as customer, topic, competences required and so on.
2	**Mega event (anonymous)**	The second case selected for the current study belongs to the mega-event management area operating as a multinational enterprise with complex outcomes. The company that is managing the event is divided into departments and blocks, and each block has its own management team, including directors and project managers.	**Respondent 2 –** Second respondent whose anonymity is remained according to her request, is involved in projects since 2010. She has an experience of working in a two mega-events as a project manager, within the strategic department, operations division and participants division.
3	**Cinnober**	Cinnober, which is a company operating in financial IT sector, provides its clients in trading and clearing venues with innovative technological solutions through projects. The company was founded about in 1998 in Stockholm and employs over 200 people currently. It implements around 10-15 product development or customization projects simultaneously through agile management approach. Each of these big projects consists of several minor projects that lead to the final product in trading and clearing.	**Respondent 3 – Niclas Holmberg** Niclas Holmberg has been working with Cinnober as a project manager for almost 2 years now. He joined the company since early 2000s, first as a team developer, then team leader and project manager. Currently, he is in charge of customization part of the project, which is divided into several sub-projects. **Respondent 4 – Magnus Larsson** Magnus Larsson is working for Cinnober since 2009, he is a project manager in the product organization. He is in charge of a team and together they develop applications or libraries for big customization projects. He is mainly in charge of internally delivered projects. Magnus stated his role as "a bit of everything". Originally, being a developer, he is still involved in development part of the project. Moreover, he is a member of a team to handle a content working with other teams.
4	**Seavus**	Seavus is an example of a project-based organization which implies agile approach as well. It has different divisions based on the knowledge areas, which include Telecom, Banking and Finance, Product Development, Embedded Technologies, Gaming, Managed Service	**Respondent 5 – Liljana Krstanoska** Liljana has been part of Seavus for more than 8 years. She worked in different provisions in Macedonia starting in Marketing, Sales and Customer support, then she moved to the Product Management and was a product manager for a specific

		divisions. Each division implements separate projects. Similar to Cinnober, Seavus is also driven by innovation in the software development solutions that they provide in 6 countries for over 3000 customers. Company was established in 1999 in Sweden, and its biggest Research and Development Center is in Macedonia.	tool to be applied within the company. For the last 5 years she has been working as a project manager in the Telecom Division of Seavus. This division is mainly focused on the software development and providing services to the telecom operators. Currently, she is involved in 2 development and 4 resourcing projects.

Appendix 5. Research Process



Appendix 6. Initial Template

№	Data Aggregation	Code
1	**Project Interdependencies**	**PI**
1.1	**Most important resource to the project**	**IMPRES**
1.1.1	Knowledge	KNOW
1.1.2	Finance	FINAN
1.1.3	People	PEOP
1.2	**Types of interdependencies in the project**	**TI**
1.2.1	Knowledge	KNOW
1.2.2	Outcome	OUT
1.2.3	Benefit	BEN
1.2.4	Time	TME
1.2.5	Resource	RES
1.3	**Benefits of project interdependency management**	**BPIM**
1.3.1	Ability to see big picture	BIGPIC
1.3.2	Ability to see logical relationships	LOG REL
1.3.3	Reducing uncertainty	RED UN
1.3.4	Reducing complexity	RED COM
1.3.5	Documenting interdependency	DOC INT
1.3.6	Faster decision making	DEC MAK
1.3.7	Better project selection	PRO SEL
1.4	**Interdepency drawbacks**	**INTD**
1.4.1	Delays	DEL
1.4.2	Not starting project on time	NOTIME
1.4.3	Competition for the resources	COMP RES
1.4.4	Cannibilization of existing resources	CAN RES
1.4.5	Conflicts in resource sharing	CON RES
1.4.6	Knowledge diffusion	KNOW DIFFU
1.4.7	Budget overrun	BUDGOV
1.4.8	Conflicts between the managers	CONF
1.5	**Tools and techniques for PIM**	**TPIM**
1.5.1	Non-visual tools and techniques	NONVTPIM
1.5.2	Visual tools and techniques	VTPIM
2	**Visual tools**	**VT**
2.1	**Benefits of applying visual interdependency management tools**	**BVIM**
2.1.1	Illustrating relationships	ILL REL
2.1.2	Document interdependency	DOC INT
2.1.3	Quantification of interdependency	QUANTI INT
2.1.4	Ability to see big picture	BIGPIC
2.1.5	Idea mapping	ID MAP
2.1.6	Reducing uncertainty	RED UN
2.1.7	Reducing complexity	RED COM

2.1.8	Recognize the need for the development of new knowledge	REC DEVKNOW
2.2	**Benefits of applying visual knowledge management tools**	**BVKM**
2.2.1	Coordination of individuals	COOR IND
2.2.2	Keeping an attention	KEEPAT
2.2.3	Representation of emotions	REPEMO
2.2.4	Identifying patterns	ID PAT
2.2.5	Knowledge remembrance	KNOW REM
2.2.6	Motivation	MOTIV
2.2.7	Elaboration of knowledge	ELOKNOW
2.2.8	Illustrating relationships	ILL REL
2.3	**Drawbacks of visual interdependency management tools**	**DVIM**
2.3.1	Not enough time	NO TIME
2.3.2	Lack of knowledge	LAC KNOW
2.3.3	Limited features	LIM FEAT
2.3.4	Complicated features	COMP FEAT
2.4	**Drawbacks of visual knowledge management tools**	**DVKM**
2.4.1	Confusion	CONF
2.4.2	Overload	OVERL
2.4.3	Oversimplification	OVERS
2.4.4	Misrepresentation	MISREP
2.4.5	Manipulation	MANI
2.4.6	Ambigiuty	AMBG
2.4.7	Time	TME
2.4.8	Cost	CST
2.5	**Parties involved**	**PART**
2.5.1	Internal	INT
2.5.2	External	EXT
3	**Knowledge Management**	**KM**
3.1	**Knowledge Integration in Projects**	**KIP**
3.1.1	Knowledge Exchange	KE
3.1.2	Understanding about relationships	UN REL
3.1.3	Reflect upon experiences	REFEXP
3.1.4	Collobarative relationships	COL REL
3.2	**Challenges of Knowledge Integration**	**CKI**
3.2.1	Memory loss	MEMOL
3.2.2	Knowledge fragmentation	KNOWFRAG
3.2.3	Reworks	REW
3.2.4	Organizational culture to transfer	ORGCULT TRANSF
3.3	**Knowledge Transfer**	**KT**
3.3.1	Informal methods of transfer	IKT
3.3.2	Formal methods of transfer	FKT
3.3.3	Interactive online platforms to transfer	IOPT

3.3.4	Individual level	IL
3.3.5	Group level	GL
3.3.6	Organizational level	OL
3.4	**Knowledge Creation**	**KC**
3.4.1	Knowledge creation outside the organization	KNOWCREOA
3.4.2	Interorganizational learning	INTERLEAR
3.4.3	Open innovation teams	OPINNOVTMS
3.4.4	Cooperation between project and portfolio members	COOP
3.4.5	Creation new content	CRECONT
3.4.6	Replacing existing content	REPCONT
4	**Outcomes (to the project by visual tools)**	**OUTPRO**
4.1	Project cost	PRCST
4.2	Time control	TIMC
4.3	Scope	SCP
4.4	Risk management	RISKM
4.5	Business Value	BUSVAL
4.6	Better project Start-up phase management	START
4.7	Better project Execution management	EXECU
4.8	Better project Close-Out management	CLOSE
4.9	Project quality	QUAL

Appendix 7. Revised Template

№	Data Aggregation	Code	new Code presence
1	**Project Interdependencies**	**PI**	
1.1	**Most important resource to the project**	**IMPRES**	
1.1.1	Knowledge	KNOW	
-	~~Finance~~	~~FINAN~~	
1.1.2	People	PPL	
1.2	**Resource Selection**	**RES SELEC**	new
1.2.1	Competencies	COMP	new
1.2.2	Availability	AvAIL	new
1.2.3	Negotiation	NEGOT	new
1.3	**Types of interdependencies in the project**	**TI**	
1.3.1	Same customer	CUST	new
1.3.2	Same topic	TOP	new
1.3.3	Knowledge	KNOW	
1.3.4	Outcome	OUT	
1.3.5	Benefit	BEN	
1.3.6	Time	TME	
1.3.7	Resource	RES	
1.4	**Benefits of project interdependency management**	**BPIM**	
1.4.1	Opportunity to cooperate, discuss and understand	OPP	new
1.4.2	Building stronger competencies	STRO COMP	new
1.4.3	Knowledge transfer	KT	new
1.4.4	Ability to see big picture	BIG PIC	
1.4.5	Ability to see logical relationships	LOG REL	
1.4.6	Reducing complexity	RED COM	
1.4.7	Documenting interdependency	DOC INT	
1.4.8	Faster decision making	DEC MAK	
1.4.9	Better project selection	PRO SEL	
1.4.10	Prioritization of resources	PR RES	new
1.4.11	Project status update	PROG STAT	new
1.4.12	Customer understanding	CUS UND	
1.5	**Interdepency drawbacks**	INTD	
1.5.1	Delays	DEL	
1.5.2	Not starting project on time	ONTIME	
1.5.3	Competition for the resources	COMP RES	
1.5.4	Cannibilization of existing resources	CAN RES	
1.5.5	Conflicts in resource sharing	CON RES	
1.5.6	Knowledge diffusion	KNOW DIFFU	
1.5.7	Cost constraints	CST CONST	
1.5.8	Conflicts between the managers	CONF	
1.6	**Tools and techniques for PIM**	TPIM	
1.6.1	Non-visual tools and techniques	NONVTPIM	
1.6.2	visual tools and techniques	VTPIM	
1.6.3	Mind-Mapping tool	MINDM	new
1.6.4	Charts	CHR	new
1.6.5	Scrum Board	SCRUM	new

1.6.6	visual Board	VISL BRD	new
1.6.7	GIRA	GIRA	new
1.6.8	Database file	DATAF	new
2	Visual Tools	VT	
2.1	**Benefits of applying visual interdependency management tools**	**BVIM**	
2.1.1	Planning	PLAN	new
2.1.2	Progress status	PROG STAT	new
2.1.3	Illustrating relationships	ILL REL	
2.1.4	Getting immeadiate information	IM INFO	new
2.1.5	Document interdependency	DOC INT	
2.1.6	Quantification of interdependency	QUANTI INT	
2.1.7	Ability to see big picture	BIG PIC	
2.1.8	Idea mapping	ID MAP	
2.1.9	Reducing uncertainty	RED UN	
2.1.10	Seeing workload and skills of people	WORKL	new
2.1.11	Communication	COMM	new
2.1.12	Reducing time	RED TME	new
2.1.13	Reducing complexity	RED COM	
2.1.14	Narrative story	NARSTOR	new
2.1.15	Highlights problems	HIGHL PROB	new
2.1.16	Rememberance	REMEMB	new
2.1.17	Recognize the need for the development of new knowledge	REC DEVKNOW	
2.1.18	Motivation	MOTIV	new
2.2	**Benefits of applying visual knowledge management tools**	**BVKM**	
2.2.1	Always accessible	ALW ACC	new
2.2.2	Communication	COMM	new
2.2.3	Coordination of individuals	COOR IND	
2.2.4	Keeping an attention	KEEPAT	
-	~~Representation of emotions~~	~~REPEMO~~	
2.2.5	Identifying risk, problems and patterns	RSK PRO PAT	new
2.2.6	Solving problems	SOLV PRO	new
2.2.7	Learning	LEARN	new
2.2.8	Knowledge remembrance	KNOW REM	
-	~~Motivation~~	~~MOTIV~~	
2.2.9	Elaboration of knowledge	ELOKNOW	
2.2.10	Progress status	PROG STAT	new
2.2.11	Illustrating relationships	ILL REL	
2.3	**Drawbacks of visual interdependency management tools**	**DVIM**	
2.3.1	Task prioritization	PRIOR	new
2.3.2	Physical presence of people	PRESPPL	new
2.3.3	Not enough time	NO TIME	
2.3.4	Lack of knowledge	LAC KNOW	
2.3.5	Limited features	LIM FEAT	
2.3.6	Complicated features	COMP FEAT	
2.3.7	Absence of standard tools	NOSTAND TOOL	new
2.3.8	Track it also digitally	TRACK DGTL	new
-	~~**Drawbacks of visual knowledge management tools**~~	~~**DVKM**~~	
-	~~Confusion~~	~~CONF~~	
-	~~Overload~~	~~OVERL~~	

-	~~Oversimplification~~	~~OVERS~~	
-	~~Misrepresentation~~	~~MISREP~~	
-	~~Manipulation~~	~~MANI~~	
-	~~Ambigiuty~~	~~AMBG~~	
-	~~Time~~	TME	
-	~~Cost~~	~~CST~~	
2.4	**Parties involved**	**PART**	
2.4.1	Internal	INT	
2.4.2	External	EXT	
3	**Knowledge Management**	**KM**	
3.1	**Knowledge Integration in Projects**	**KIP**	
3.1.1	Knowledge Exchange	KE	
3.1.2	Understanding about relationships	UN REL	
3.1.3	Reflect upon experiences	REF EXP	
3.1.4	Collobarative relationships	COL REL	
3.2	**Challenges of Knowledge Integration**	**CKI**	
3.2.1	Memory loss	MEMOL	
3.2.2	Knowledge fragmentation	KNOWFRAG	
-	~~Reworks~~	~~REW~~	
3.2.3	Absence of standard methods	NOSTAND	new
3.2.4	Lack of organizational culture to transfer	ORGCULT TRANSF	
3.3	**Knowledge Transfer**	**KT**	
3.3.1	Informal methods of transfer	IKT	
3.3.2	Formal methods of transfer	FKT	
3.3.3	Interactive online platforms to transfer	IOPT	
3.3.4	Individual level	IL	
3.3.5	Group level	GL	
3.3.6	Organizational level	OL	
3.4	**Knowledge Creation**	**KC**	
3.4.1	Involve external specialist	EXT SPEC	new
-	~~Knowledge creation outside the organization~~	~~KNOWCREOA~~	
3.4.2	Interorganizational learning	INTER LEAR	new
3.4.3	Open innovation teams	OP INNOv	
3.4.4	Cooperation between project and portfolio members	COOP	
-	~~Creation new content~~	~~CRECONT~~	
-	~~Replacing existing content~~	~~REPCONT~~	
4	Outcomes (to the project by visual tools)	**OUTPRO**	
4.1	Project cost	PRCST	
4.2	Time control	TIMC	
4.3	Scope	SCP	
4.4	Risk management	RISKM	
-	~~Business value~~	~~BUSVAL~~	
4.5	Better project Start-up phase management	START	
4.6	Better project Execution management	EXECU	
4.7	Better project Close-Out management	CLOSE	
4.8	Project Quality	QUAL	

Appendix 8. Final Template

№	Data Aggregation	Code
1	**Project Interdependencies**	**PI**
1.1	**Most important resource to the project**	**IMPRES**
1.1.1	Knowledge	KNOW
1.1.2	People	PPL
1.2	**Resource Selection**	**RES SELEC**
1.2.1	Competencies	COMP
1.2.2	Availability	AvAIL
1.2.3	Negotiation	NEGOT
1.3	**Types of interdependencies in the project**	**TI**
1.3.1	Same customer	CUST
1.3.2	Same topic	TOP
1.3.3	Knowledge	KNOW
1.3.4	Outcome	OUT
1.3.5	Benefit	BEN
1.3.6	Time	TME
1.3.7	Resource	RES
1.4	**Benefits of project interdependency management**	**BPIM**
1.4.1	Opportunity to cooperate, discuss and understand	OPP
1.4.2	Building stronger competencies	STRO COMP
1.4.3	Knowledge transfer	KT
1.4.4	Ability to see big picture	BIG PIC
1.4.5	Ability to see logical relationships	LOG REL
1.4.6	Reducing complexity	RED COM
1.4.7	Documenting interdependency	DOC INT
1.4.8	Faster decision making	DEC MAK
1.4.9	Better project selection	PRO SEL
1.4.10	Prioritization of resources	PR RES
1.4.11	Project status update	PROG STAT
1.4.12	Customer understanding	CUS UND
1.5	**Interdepency drawbacks**	INTD
1.5.1	Delays	DEL
1.5.2	Not starting project on time	ONTIME
1.5.3	Competition for the resources	COMP RES
1.5.4	Cannibilization of existing resources	CAN RES
1.5.5	Conflicts in resource sharing	CON RES
1.5.6	Knowledge diffusion	KNOW DIFFU
1.5.7	Cost constraints	CST CONST
1.5.8	Conflicts between the managers	CONF
1.6	**Tools and techniques for PIM**	TPIM

1.6.1	Non-visual tools and techniques	NONVTPIM
1.6.2	visual tools and techniques	VTPIM
1.6.3	Mind-Mapping tool	MINDM
1.6.4	Charts	CHR
1.6.5	Scrum Board	SCRUM
1.6.6	visual Board	VISL BRD
1.6.7	GIRA	GIRA
1.6.8	Database file	DATAF
2	**Visual Tools**	**VT**
2.1	**Benefits of applying visual interdependency management tools**	**BVIM**
2.1.1	Planning	PLAN
2.1.2	Progress status	PROG STAT
2.1.3	Illustrating relationships	ILL REL
2.1.4	Getting immeadiate information	IM INFO
2.1.5	Document interdependency	DOC INT
2.1.6	Quantification of interdependency	QUANTI INT
2.1.7	Ability to see big picture	BIG PIC
2.1.8	Idea mapping	ID MAP
2.1.9	Reducing uncertainty	RED UN
2.1.10	Seeing workload and skills of people	WORKL
2.1.11	Communication	COMM
2.1.12	Reducing time	RED TME
2.1.13	Reducing complexity	RED COM
2.1.14	Narrative story	NARSTOR
2.1.15	Highlights problems	HIGHL PROB
2.1.16	Rememberance	REMEMB
2.1.17	Recognize the need for the development of new knowledge	REC DEVKNOW
2.1.18	Motivation	MOTIV
2.2	**Benefits of applying visual knowledge management tools**	**BVKM**
2.2.1	Always accessible	ALW ACC
2.2.2	Communication	COMM
2.2.3	Coordination of individuals	COOR IND
2.2.4	Keeping an attention	KEEPAT
2.2.5	Identifying risk, problems and patterns	RSK PRO PAT
2.2.6	Solving problems	SOLV PRO
2.2.7	Learning	LEARN
2.2.8	Knowledge remembrance	KNOW REM
2.2.9	Elaboration of knowledge	ELOKNOW
2.2.10	Progress status	PROG STAT
2.2.11	Illustrating relationships	ILL REL
2.3	**Drawbacks of visual interdependency management tools**	**DVIM**
2.3.1	Task prioritization	PRIOR

2.3.2	Physical presence of people	PRESPPL
2.3.3	Not enough time	NO TIME
2.3.4	Lack of knowledge	LAC KNOW
2.3.5	Limited features	LIM FEAT
2.3.6	Complicated features	COMP FEAT
2.3.7	Absence of standard tools	NOSTAND TOOL
2.3.8	Track it also digitally	TRACK DGTL
2.4	**Parties involved**	**PART**
2.4.1	Internal	INT
2.4.2	External	EXT
3	**Knowledge Management**	**KM**
3.1	**Knowledge Integration in Projects**	**KIP**
3.1.1	Knowledge Exchange	KE
3.1.2	Understanding about relationships	UN REL
3.1.3	Reflect upon experiences	REF EXP
3.1.4	Collobarative relationships	COL REL
3.2	**Challenges of Knowledge Integration**	**CKI**
3.2.1	Memory loss	MEMOL
3.2.2	Knowledge fragmentation	KNOWFRAG
3.2.3	Absence of standard methods	NOSTAND
3.2.4	Lack of organizational culture to transfer	ORGCULT TRANSF
3.3	**Knowledge Transfer**	**KT**
3.3.1	Informal methods of transfer	IKT
3.3.2	Formal methods of transfer	FKT
3.3.3	Interactive online platforms to transfer	IOPT
3.3.4	Individual level	IL
3.3.5	Group level	GL
3.3.6	Organizational level	OL
3.4	**Knowledge Creation**	**KC**
3.4.1	Involve external specialist	EXT SPEC
3.4.2	Interorganizational learning	INTER LEAR
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