Evaluating the competitiveness of knowledge resources

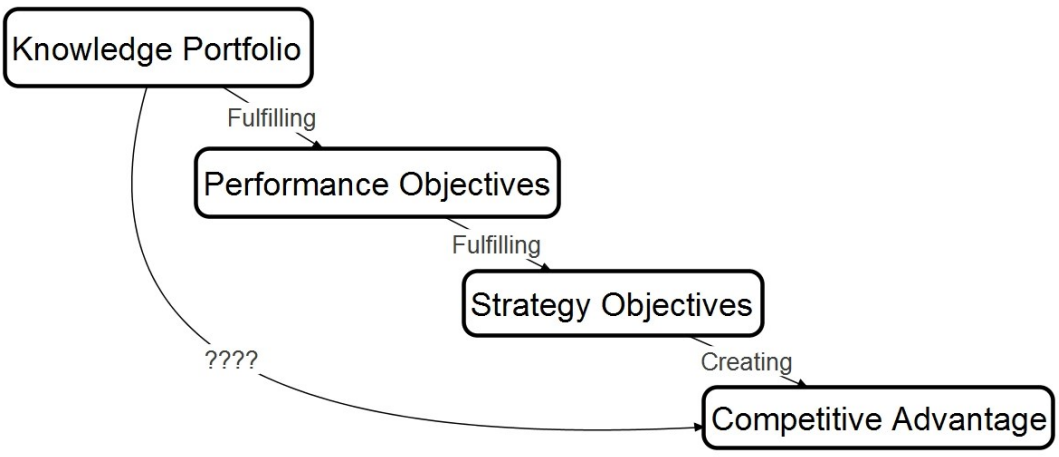
EMMA NORDSTRÖM

KTH Industrial Engineering
and Management

Master of Science Thesis
Stockholm, Sweden 2014

Evaluating the competitiveness of knowledge resources

Emma Nordström



Master of Science Thesis MMK 2014:68 MCE 311
KTH Industrial Engineering and Management
Machine Design
SE-100 44 STOCKHOLM

KTH Industrial Engineering and Management

Master of Science Thesis MMK 2014:68 MCE 311

Evaluating the competitiveness of knowledge resources

Emma Nordström

Approved	Examiner	Supervisor
2014-09-10	Sofia Ritzén	Gunilla Ölundh Sandström
	Commissioner Technische Universität München	Contact person Danilo Schmidt

Abstract

For companies to be successful in today's economy, they need to be able to identify and sustain the value of their knowledge base in order to nurture, exploit and guard it (Duane & Hitt, 2005) (Goel, et al., 2010). Knowledge Evaluation is the gathering name for assessing knowledge assets or clusters. There are several models for valuing knowledge components provided in literature, some of which have been used and reviewed by researchers at Technische Universität München where this thesis work was performed, see (Schmidt, et al., 2013) (Schmidt, et al., 2014). However, an assessment tool for the reviewing competitiveness of knowledge assets was sought. Therefore, the main purpose of this thesis was to investigate the possibility, and usefulness, of evaluating the competitiveness of knowledge assets. This followed by reviewing if such an evaluation could be a beneficial tool in Product Development (PD) processes.

In implementing this thesis work a literature review was used to find the sought evaluation. Following, the found valuation models were reviewed, and then their best aspects were chosen and built into a new model. This model was then implemented at a company. This implementation with some articles for literature support was used to answer if the model could be beneficial in product development processes.

Results say that it is possible to perform an evaluation of the competitiveness of knowledge. The proposed model here was thought useful in providing a gap analysis. It could be especially useful in PD processes, as they are knowledge intensive activities, and thus, require a full understanding of the knowledge base.

KTH Industriell teknik och management

Examensarbete MMK 2014:68 MCE 311

Värdering av kunskapsresursers konkurrenskraft

Emma Nordström

Godkänt	Examinator	Handledare
2014-09-10	Sofia Ritzén	Gunilla Ölundh Sandström
	Uppdragsgivare Technische Universität München	Kontaktperson Danilo Schmidt

Sammanfattning

Idag måste företag kunna identifiera och bibehålla värdet i sin kunskapsportfolio för att utveckla, nyttja och skydda den och på så sätt hålla sig konkurrenskraftiga (Duane & Hitt, 2005) (Goel, et al., 2010). Kunskapsevaluering är ett sammanfattande begrepp för när kunskapsresurser eller kluster värderas. Det finns en mängd tillgängliga metoder för att evaluera kunskapsresurser, varav några har använts i forskningen på Technische Universität München där detta arbete utfördes (se (Schmidt, et al., 2013) (Schmidt, et al., 2014)). Dock söktes en modell som undersöker hur enskilda kunskapsresurser bidrar till ett företags konkurrenskraft. Från detta formulerades målet med detta arbete, vilket var att undersöka möjligheten, och användbarheten, av att evaluera konkurrenskraft hos kunskapsresurser, för att sedan se om det kan vara till nytta i produktutvecklingsarbete.

För att ta reda på om det var möjligt att evaluera kunskapsresursers bidrag till ett företags konkurrenskraft gjordes en litteratursökning. De funna modellerna analyserades sedan och en ny modell byggdes upp av de bästa komponenterna av dem. Sedan testades den nya modellen på ett företag. För att svara på frågan om modellen kunde vara ett användbart redskap i produktutvecklingsprocesser användes dels resultat från testet på företaget samt ännu en, mindre, litteratursökning.

Resultat från arbetet visar att det är möjligt att evaluera konkurrenskraft hos enskilda kunskapsresurser. Modellen i detta arbete ansågs användbar då den försåg testföretaget med en ”gap-analys”. Eftersom produktutveckling är en så kallad kunskapsintensiv aktivitet, där en fullständig bild av dess kunskapsbas är fördelaktig, kan modellen även vara användbar specifikt för sådana företag.

FOREWORD

In this chapter persons that have provided assistance and inspiration, or have had a cooperative role, in the project are acknowledged.

Here I would like to give my sincere appreciations to people who have been involved in, and contributed to, this thesis work. First, I thank Danilo Schmidt, my supervisor at Technische Universität München, who has been a constant help in providing input for the thesis work, help in finding industry contacts, and also giving tips on how to get integrated in my München life. Also, I want to thank his co-supervisor Sebastian Schenkl who has given valuable advice and contacts for the thesis work.

Furthermore, I want to thank Gunilla Ölundh Sandström, my supervisor at KTH Royal Institute of Technology. First for introducing me to the subject, for the initial help with keeping contact and managing the issues arosen from writing the thesis abroad, for all the constructive input, and more.

Although kept anonymous, I want to thank the student and company interviewee, that were willing to help a student in need of test persons. Thank you for taking time, for being interested in my work and for the feedback you gave.

Finally, I would like to thank my family and friends for helping me through these five, sometimes heavy, but mostly fun, years of studies.

I wish the best, for all of you in your future endeavours,

Sincere regards,

Emma Nordström

Stockholm, September 2014

NOMENCLATURE

Abbreviations used in this report are presented in the list below.

Abbreviations

AHP	Analytic Hierarchy Process
IC	Intellectual Capital
ICBS	Intellectual Capital Benchmarking System
ICPA	Importance Comparative Performance Analysis
IPD	Integrated Product Development
KAVCM	Knowledge Assets Value Creation Map
KBV	Knowledge Based View
KISA	Knowledge Intensive Service Activities
KTH	Royal Institute of Technology
PD	Product Development
RBV	Resource Based View
R&D	Research and Development
RQ	Research Question
SKPA	Strategic Knowledge Portfolio Assessment
TUM	Technische Universität München
WKCI	World Knowledge Competitiveness Index

TABLE OF CONTENTS

TABLE OF FIGURES

TABLE OF TABLES

1 INTRODUCTION

In this chapter the background, problem definition and purpose of the thesis are presented. Subsequent, the proposed research questions are lifted, which, are followed by the set limitations and a short description of the selected method of the thesis work.

1.1 Background

This paper is performed as a master thesis of the master programme Integrated Product Development (IPD) at the Royal Institute of Technology (KTH). The proposed thesis was done for the Product Development Institution at Technische Universität München (TUM), and aimed to add to their research on Knowledge Evaluation.

Knowledge Evaluation is part of the Knowledge Management (KM) area, which is a company strategy that aims to acquire the right knowledge, placing it with the right people and make sure this knowledge is transferred and developed to benefit firm performance (Goel, et al., 2010). To have this resource and capability focus, and to classify and evaluate knowledge is in literature more and more related to increased performance (Urgal, et al., 2013) and competitive advantage of companies (Grant, 2010) (Haas & Hansen, 2005). One example of a schematic model illustrating the connection between knowledge management and competitive advantage, by Edvardsson et al, is shown in Figure 1 (Edvardsson & Oskarsson, 2011).

Some even argue that knowledge resources are the most important source of competitive advantage a company has, that notion is what is called Resource Based View (RBV) or Knowledge Based View (KBV). Arguments for this are that, due to the ambiguity of capabilities and resources, they are difficult to imitate, therefore they provide an advantage for the company owning the competence (Grant, 2010). Also as technological knowledge is the main ingredient required for creating innovation (Urgal, et al., 2013). Due to its high importance, companies need to protect their knowledge assets from competitor imitation (Haas & Hansen, 2005).

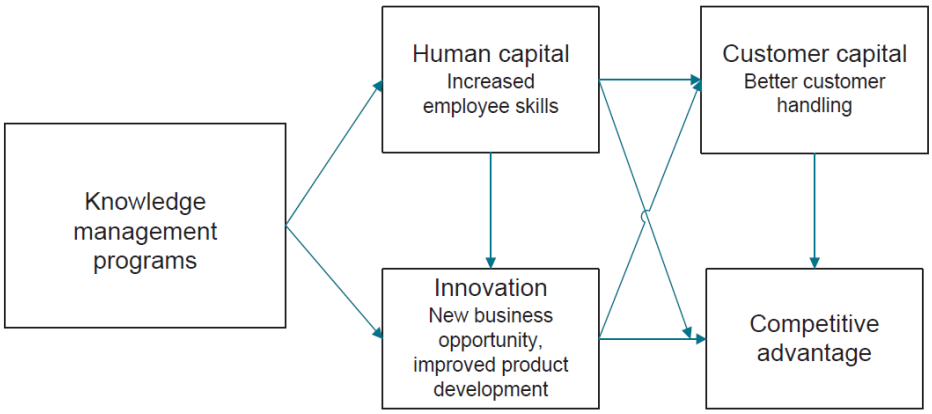


Figure 1. Schematic illustration of relationship of knowledge management initiatives and competitive advantage[1]

[1] Image retrieved from article: Edvardsson, I. R. & Oskarsson, G. K., 2011. Knowledge management and value creation in service firms. MEASURING BUSINESS EXCELLENCE, VOL. 15(No. 4), pp. 7-15.

Independent of the name used for handling the business knowledge base, to develop ways for knowledge to grow in the hands of people or teams is a key challenge for companies in their quest for competitive advantage (Duane & Hitt, 2005) (Haas & Hansen, 2005). For companies to be successful in today's economy, they need to be able identify and sustain the value of their knowledge base in order to nurture, exploit and guard it (Duane & Hitt, 2005) (Goel, et al., 2010).

1.2 Problem Definition

There are several models for evaluating knowledge components provided in literature, some of which have been used and reviewed by researchers at TUM, see (Schmidt, et al., 2013) (Schmidt, et al., 2014). However, an assessment tool for finding the competitiveness of knowledge is sought. That is, a model or framework reviewing the impact individual knowledge assets has on firm competitiveness. Such an evaluation is sought as it, not only would help a company identify its knowledge base, but also to assess the importance of these resources to find out what assets might need further developing, protection or exploitation. Thus, enable evaluation of one of the firm's main sources of competitive advantage, to enable their continual development. Moreover, in Product Development (PD) more complex products and services are required, and developed, creating a need for companies in PD to clarify their knowledge base, especially in the knowledge intensive activity of PD processes (Schmidt, et al., 2013). The main purpose of this thesis is to investigate the possibility, and usefulness, of evaluating competitiveness of knowledge asset. In addition, if such an evaluation could be a beneficial tool in PD processes is sought.

1.3 Research Questions

To structure the investigation, two main Research Questions (RQs) were proposed, these are presented below. First, to explore the possibility of evaluating knowledge resources according to competitiveness (RQ 1) is examined.

> *RQ 1. Is an evaluation of competitiveness of knowledge conceivable, and, if so, is this assessment useful?*

Thus, exploring in areas of competitiveness, internal and external resources in addition to the application of the knowledge assets, this to then, evaluate the usefulness of the valuation. Following, to investigate the applicability of this valuated knowledge in companies working with PD, RQ 2 is posed.

> *RQ 2. How can an evaluation of the competitiveness knowledge be applied in Product Development (PD) processes?*

1.4 Delimitations

This thesis work focuses on finding a model applicable to the set research questions, hence only covering a part of the knowledge management area. Furthermore, in the application of found model only one company was examined. Therefore, only a company subjective view, and not one of industry, was be gained by using the model. Moreover, the project was limited to only 20 weeks of full time work. Further limitations specific for the methodology have also been set, see Chapter 3.

2 FRAME OF REFERENCE

This chapter presents the theoretical reference frame that was necessary for the performed research. To get a proper perspective, and to be able to give a relevant answer to the posed research questions, several areas of literature need to be included. These areas are presented shortly here.

2.1 Competitiveness

A key aspect in this research is the concept of competitiveness. Often competitive advantage is thought of as higher profitability in a firm compared to its main competitors. However, there are more aspects to competitiveness that might not be visible through the profitability, for example superior technology, customer loyalty or innovation capability. (Grant, 2010) In our time the companies that keep innovating, using new technologies, exploiting skills and capabilities of personnel, instead of focusing on physical products, are the ones reaching success. In this perspective, knowledge assets really are key resources to a firm. (Lerro, et al., 2012)

Creating a competitive advantage via firm capabilities is achievable in four ways. First a firm can possess valuable capabilities, which can help a company take advantage of opportunities or remove threats. Moreover, it can hold rare capabilities, thus differentiating the firm from its competitors. Another possibility is to have capabilities that are costly to imitate, this could be a strong brand name, unique organisational culture, great customer relations, or simply ambiguous use of capabilities. The final option is to possess capabilities that cannot be substituted. (Hitt, et al., 2007)

To be able to maintain competitive advantage is a journey not a goal, and is referred to as Sustainable Competitive Advantage, which, can be achieved by having resources and capabilities that are durable and difficult to replicate or transfer. (Grant, 2010) (McEvily & Chakravarthy, 2002) (Hitt, et al., 2007) (Chaharbaghi & Lynch, 1999) Another important factor when determining a firm's competitive advantage is its dynamic capabilities – its ability to organise assets, its flexibility, and ability to respond to change (Netland & Aspelund, 2013) (Grant, 2010).

2.2 Knowledge Evaluation

Knowledge is a widely known, but also a widely defined notion, however, one quite clear definition by Probst et al is:

> *Knowledge is the whole body of cognitions and skills which individuals use to solve problems. It includes theories and practical, everyday rules and instructions for action. Knowledge is based on data and information, but unlike these, it is always bound to persons. It is constructed by individuals, and represents their beliefs about causal relationships. (Probst, et al., 2000, p. 24)*

Moving on, when evaluating knowledge, considerations might be taken on individual level or from a more holistic view of the organisation and the knowledge built into it. This holistic perspective is called an epistemological approach, where practices and knowledge in an organization are reviewed individually as well as to their interactions in the organisation. (Håkansson, 2010) There are examples of firms with competitive advantage achieved mainly from their ability to manage the firm's collective knowledge. (Probst, et al., 2000)

In general there are two main management approaches in assessing knowledge assets; value communication and value management. The first, value communication, aims to communicate the value a knowledge resource provides the firm. Following, value management aims to give support to value creation and improve performance by providing information about knowledge assets, how to attain them, their value, and their progress. (Lerro, et al., 2012) Moreover, there are two main evaluation structures available; scorecard- or index-based. The scorecard based structure uses a top-down approach at valuating knowledge assets according to set criteria relating to the firms strategic goals, thus, translating organisational objectives into activities. Index based evaluations, however, tries to find measures that create collective knowledge information. (Lerro, et al., 2012)

Combining these two managerial evaluation approaches, with the two evaluation structures, four categories of knowledge resource appraisal are found, see Figure 2. First, Knowledge Asset Measurement Strategy (KAMS) aims to enable achievement of set performance objectives by detecting and assessing knowledge in an organisation. Following, Knowledge Domain Assessment Strategy (KDAS) focus on evaluating core knowledge assets to discover, attain, protect and develop those competencies that give the firm a competitive advantage. Subsequent, Knowledge Asset Accounting Strategy (KAAS) is an analytical approach aiming to provide managers with information about the knowledge base of the firm for monitoring purposes. Lastly, Knowledge Asset Communication Strategy (KACS) communicates the value of firms' knowledge assets to the firms' stakeholders, and to its market. (Lerro, et al., 2012)

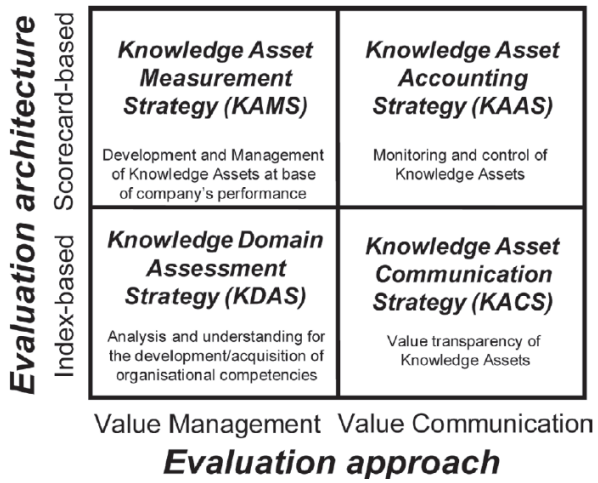


Figure 2. Four categories of knowledge asset evaluation[2]

[2] Image retrieved from article: Lerro, A., Iacobone, F. A. & Schiuma, G., 2012. Knowledge assets assessment strategies: organizational value, processes, approaches and evaluation architectures. JOURNAL OF KNOWLEDGE MANAGEMENT, VOL. 16 (NO. 4), pp. 563-575.

3 METHOD

In this chapter the working process is described, step by step, according to the chosen research methodologies of the project work is presented.

3.1 Research Overview

As mentioned earlier, the chosen methodology for this thesis was primarily a literature review. This review began with examining the possibility of evaluating competitiveness of knowledge (RQ 1), thus trying to identify a model for assessment of knowledge. Following, the found models applicability in PD processes (RQ 2) was examined. Moreover, to explore and appraise its usefulness in PD processes (RQ 2), found/created model was tested at a company. An overview of the planned implementation is shown in Figure 3.

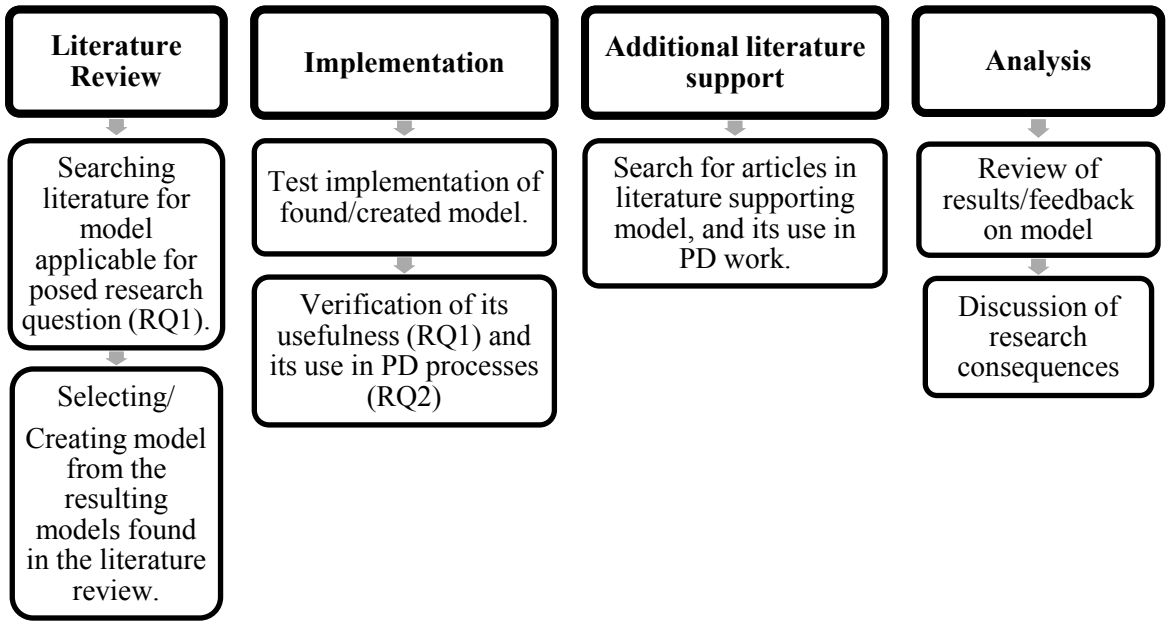


Figure 3. Overview of project work

3.2 Research Methodology

By using both a literature review, where information is gathered in a structured manner with an analytical aspect on applied theory, and an industrial evaluation example, where a more exploratory view is used a triangulation was created around the researched areas. This as a mix of quantitative and qualitative methods was used, and, as both conceptual an empirical aspects are considered. By using triangulation, problems were viewed from several perspectives, and, the risk of subjective biasness was decreased. Furthermore, by using more than one method the level of bias in the result from those methods was reduced. (Malterud, 2001)

As RQ 1 mainly aimed to find an existing model for evaluating competitiveness of knowledge, it was sensible to search existing literature with a methodological approach (Denney & Tewksbury, 2012). Furthermore, once a model was found, it was to be evaluated and tested, and perhaps slightly modified depending on literature recommendations, to suit the research aims. Thereby, via the model and its test, make an attempt to answer the second part of RQ 1 and part of RQ 2.

Proposed literature review in the thesis work is a traditional (narrative) literature review but with some influences from a systematic literature review, namely a structured review protocol. Thus using the benefit of a classic literature review of being selective in what sources are used, but also, gaining from limiting the search. (Strech & Soafer, 2012) Moreover, as systematic reviews are transparent and should be replicable, they improve the quality of the study process. (Crossan & Apaydin, 2010)

3.3 Literature Review: Search for an evaluation model

This literature review began with a data collection, trying to identify a model for assessment of knowledge competitiveness (RQ 1), hence, exploring in areas of competitiveness, internal and external resources in addition to the actual application of the knowledge assets.

Identifying potentially relevant studies was done by searching multiple bibliographic databases and looking over reference lists of existing reviews and appropriate studies. Chosen literature review for the thesis work was a narrative literature review but with some influences from a systematic literature review, namely a structured review protocol. This means that the author could, and should, be selective in choosing articles thus only representing a limited area of literature. However, the addition of systematic approaches of limiting the search and adding selection criteria enabled more searches to be made and lessened subjectivity in article selection. Set limitations for the search were:

- Use of empirical and theoretical works with focus on:
    - Conceptual frameworks or models evaluating knowledge.
    - Theoretical fundamentals and contemporary discussions in relevant areas:
        - Knowledge Management/Evaluation
        - Resource Based Views
        - Dynamic Capabilities
        - Contemporary Strategy
- Only use published peer-reviewed journal articles.
- Only literature published earliest in 1999.
- Only literature published in English.

Limiting the search to focused works (first bullet above) was done to aid in the selection of relevant sources only. In an attempt to decrease biasness and to find studies with more significant results, the study is also limited to only include peer-reviewed journal articles. To only use fairly contemporary data, a time limit of 15 years was chosen, thus only using literature published after 1999. Finally, since this thesis is executed for two universities where the mutual language is English, only articles in English were used.

During the search, some articles were selected, or dismissed, depending on if their title fit the research topic. Following the article key words were reviewed, and, if still unclear the abstract was read to enable a decision. Succeeding, an initial data analysis was made through an evaluation of the gathered articles using the PQRS system (Preview, Question, Read, Summarise) where an indexing system was used in the question step, including; title, author, met criteria, purpose, methodology, findings, outcomes, personal notes and main insights. (Cronin, et al., 2008) This was done to systemise the literature review and to facilitate order in the research.

Regarding databases searched in, some were chosen due to their specialisation in the management area, those were Business Source Elite and Emerald eJournals. Other journals were chosen because they have a wider scope, these were JSTOR, Science Direct and Web of Science. Finally, the database Journal Citation Reports was chosen as it can be an aid in reviewing the suitability of a specific article.

Keywords used in search of a proper model were:

- Knowledge Management
- Resource/Knowledge Based View
- Knowledge/Knowledge Maps/Knowledge Evaluation/Intellectual Capital
- Competitive Advantage/Sustainable Competitive Advantage/Competitiveness

When performing the search these words were used in combination using Boolean search terms AND and OR, for example "evaluate knowledge AND (map OR measure) AND (competitive*)", for full search list see Appendix 1. When skimming through key words or abstracts of articles these words were also thought interesting; dynamic capabilities, epistemology, collective knowledge, contemporary strategy, strategy. To create traceability, the search string of each chosen article was documented. In the searches, the results included only peer-reviewed articles and were sorted on relevance (a selection made in the databases when amongst the search result list), and the first 15 articles of each search were reviewed as they were thought to be the most relevant ones. This limitation of 15 articles was made because in several of the searches there were over 2000 found articles, but very few appeared relevant, thus new searches were made. In total, for the first review, 1050 (not including whether the same article was retrieved in several searches) articles were reviewed either on only title, key words or followed by abstract, or full text.

An exception from this search methodology is part of the initial background search, where books (Grant, 2010) (Hitt, et al., 2007) (Probst, et al., 2000) were used and less systematic selection criteria too. This was done to get a quick overview of available literature and to get settled in the area. In addition, some articles were included on recommendation from the academic supervisors of this project, for example (Schenkl, et al., 2014) (Windahl & Lakemond, 2010) (Oliva & Kallenberg, 2003).

3.4 Model selection

Following, further data analysis was performed in reviewing the found models. Three possible scenarios for results after the literature review were available; finding of a perfect model, finding related models, or, no relevant models found. Here, several models related to the sought evaluation were identified, thus the second scenario. From here, there were two options, to weigh the models and select one, or, to select the best aspects from the models and assemble a new model. Thought important matters in competitiveness of knowledge were what aspects that determined whether a competence was competitive or not. Also, whether the manner of how the knowledge is applied (effective use) matters. Subsequent, how knowledge's value relates to that of a company's competitors. Furthermore, if a knowledge resource is suitable for PD work, and how that knowledge can be organised, was interesting for this thesis work. Thus, in the initial stages the following criteria, for the sought model, were set in discussion with the supervisor of this project, one of the researchers at Technische Universität München:

1. Relevant criteria, provided in the model, should be the determent of competitiveness.
2. How the knowledge is applied, on its function, should be included in the evaluation.
3. Model should provide possibility for rating the knowledge base in comparison with competing companies.
4. An available recommendation of appropriate application areas for the assessed knowledge was desired.
5. Suggestions of how assessed knowledge can be managed should be provided.
6. Objectivity in evaluation.

In the first criteria, the measurement of competitiveness was approached. As mentioned in the frame of reference, there are several views on competitiveness and some might be more suitable for this research than others. For example, only focusing on cost positioning or return on assets might be misrepresentative. According to Grant, to main factors determine whether a capability can create competitive advantage; scarcity and relevance (Grant, 2010), thus the model should include assessment of these somehow. The second criterion, aimed at including whether the application or exploitation of the knowledge asset was brought into the evaluation model. According to Urgal et al, how a firm uses its knowledge resources is closely related to its innovation capability, thus also linked to its competitiveness (Urgal, et al., 2013). Haas and Hansen also point out how evaluating the knowledge impact on task performance gives a clearer evaluation than simply looking at the amount of knowledge a firm possesses (Haas & Hansen, 2005). For example, a company might possess expertise knowledge in customer needs but might not actually implement, or exploit, this knowledge in their value creation processes.

Moving on, the third criterion determined whether the model actually included a comparison amongst competitors, thus a main part in investigating of the competitiveness. The fourth criterion aimed to clarify whether the found model had specific areas in industry where its use was suitable, thus including part of RQ 2. Furthermore, once the knowledge was assessed, it could be useful for a manager to get some advice on how to handle this new knowledge, thus the fifth criterion was added. Finally, for the evaluation to be as reliable as possible, objectivity was sought in the model (sixth criterion). In chapter 4 Result each found model is summarised and reviewed, both according to their fit to the research questions and to the criteria above.

3.5 Model Design

In building the new model a backwards approach was used while evaluating the models chosen to focus on. Thus aiming for the final result of the chosen models and reviewing the necessary steps to achieve them, reverse engineering. This is explained more in detail for the case here in Chapter 4.3. In the chosen steps for the model, some methods for applying the model were inevitable. However, for some of the steps modifications were possible, and sometimes necessary, in comparison to the original steps in the models used to build the new model.

As the model had fully formulated questions that required answering some clear methodical alternatives were available, such as questionnaires, storytelling, and unstructured/semi-structured/structured interviews. Among these, semi-structured interviews were selected as they provide the means to follow a certain manuscript while allowing for addition of questions. Pure storytelling was dismissed as the information sought was rather matter of fact and did not require that kind of step/holistic view. However, in the semi-structured interviews the interviewee had a chance to use a storytelling way for answering the questions. As the questions might need extra explanations, or reformulations, for an interviewee not familiar with the vocabulary used in knowledge management, use of questionnaires were also dismissed to favour semi-structured interviews. Ideal interviewee for the model is someone in a managerial position, this to gain information more likely to be accurate. Moreover, the model was constructed so that either only one person (department/team manager) had to be interviewed, or divided into two, where one answers more general questions about the firm and its competitive position and a second on a departmental level.

3.6 Model implementation

In this thesis work, two interviews were performed in total; one with a student and one with a team leader at a firm. The first interview (student) followed the full model, in Chapter 4.4, whereas, the second (firm) trailed only the most important steps of the model, thus the shortened version, see Chapter 4.6. To verify the steps of the model, the estimated time for performing each step, and, remove flaws before the actual test at a company, a general-rehearsal for the model was made with the help of a student colleague. This student evaluated his own knowledge assets from when he performed a thesis for a company a while back. Though this student did not possess the knowledge that a manager (ideal case for the evaluation) would have, it was thought enough for this initial evaluation of the model. During this initial test, the steps of the model (see Chapter 4.4) were followed by performing semi-structured interviews answering the questions of the specific steps. Simultaneously, the interviewer documented the answers by taking notes and placing the data in an excel file with the appropriate matrix structures.

Also for the final test implementation of the model, at a company, the steps in Chapter 4.4 was used, however a shortened version with only the most necessary steps. Semi-structured interviews, with aid from decision trees were used here as well. However, to make the interview more efficient, the interview was also recorded for the interviewer not to have to take complete notes simultaneously. The person interviewed here was the team leader in a product and process development team, with a team size of about 10 people. Moreover, the interviewee had an understanding of knowledge management.

3.7 Finding literature support for model application in PD

In the second scan through literature, several aspects were sought. First, whether the evaluation of competitiveness of knowledge is useful. And second, whether it could be applied in companies working with PD processes. As in the first literature review, identifying potentially relevant studies was done by searching multiple bibliographic databases and looking over reference lists of found articles. Likewise, a narrative literature review, with some influences from a systematic literature review, was used once again. Set limitations for the search were:

- Use of empirical and theoretical works with focus on:
    - Reviews of conceptual frameworks, or models, evaluating knowledge.
    - Contemporary articles combining the areas of;
        - Knowledge Evaluation and;
        - Product Development
- Only use published peer-reviewed journal articles.
- Only literature published earliest in 1999.
- Only literature published in English.

Business Source Elite, Emerald eJournals, Web of Science and Science Direct were all searched for investigating this topic. As previously, some articles were selected, or dismissed, due to their title during the search, see 3.3. Keywords used in the search were; Knowledge Evaluation and Product/Service Development Process in combination using Boolean search terms AND and OR. For this search only a single search string was used in all the databases "((product development process) OR (service development process)) AND ((knowledge management) OR (knowledge measurement) OR (knowledge evaluation))".

In the searches, the results included only peer-reviewed articles and were sorted on relevance, and the first 15 articles of each search were reviewed as they were thought to be the most relevant ones. This limitation of 15 articles was made for the same reason as in the literature review. In total, for the second review, 60 (not including whether the same article was retrieved in several searches) articles were reviewed either on only title, key words or followed by abstract, or full text.

4 RESULTS

In the results chapter the outcomes from implementation of the thesis work, obtained with the methods described in the methodology chapter, are compiled.

4.1 Literature Review: Search of evaluation model

From the literature review several articles of interest were identified, models from these articles are presented in the following paragraphs. The models are summarised in text, with important illustrations and finally reviewed on advantages and disadvantages to create a state of the art in competitiveness of knowledge evaluation models.

Model 1: Importance-Comparative Analysis Map

In their work in assessing the Knowledge Management (KM) practices of a company compared to its competitors, Kale and Karaman use Importance-Comparative Performance Analysis Maps (ICPA Maps) (Kale & Karaman, 2011). In their article they aim to offer managers of construction firms a tool that can evaluate their firm's KM practices, and, to assist them in identifying their competitive advantages and disadvantages in each practice, and finally to aid in the prioritising of management actions in these practices. An ICPA Map is a simple tool for visualising the relation between a KM's comparative performance ratio and importance weights.

To achieve an ICPA Map they first select which KM practice to evaluate, and then gather data for benchmarking, this is followed by a rating of the KM practices by using weights from Multilayer Perception (MLP) neutral networks, and finally the map is created. Example of an ICPA Map, from their case study, is presented in Figure 4. There, they compare the KMs; organizational culture (CUL) and structure (STR); knowledge acquisition process (ACQ), conversion process (CON), application process (APP) and protection process (PRO). These are presented in a graph displaying the relationship between their comparative performance ratio and their importance weight. In this graph, the lines represent the industry average, thus the case business performs well on CUL and ACQ, whereas, CON, ICT and APP are large weaknesses of the firms KM.

It is possible to use different comparative performance ratios when creating the ICPA map, however, the authors chose to: divide a firm's performance rating, for a specific KM practice, with the average performance rating for that practice in all of the benchmarked companies. Thus, the authors use numeric measures to evaluate performance in specific usage areas between companies in their rating of competitiveness. To determine importance weights the authors used Multilayer Perception (MLP) neutral networks, thus systematically determining a specific KM practices importance.

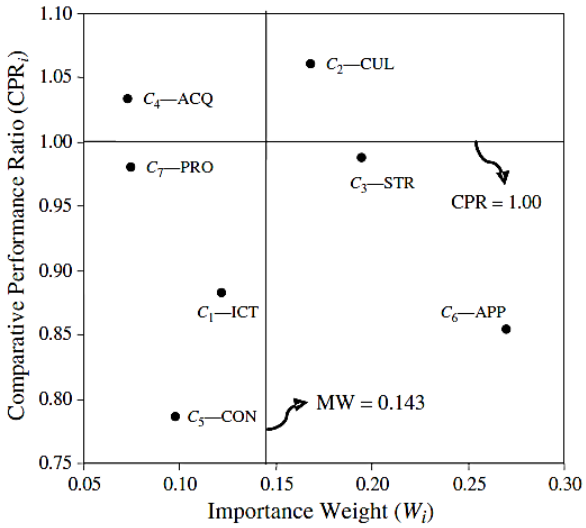


Figure 4. Example of a ICPA Map from a case firm[3]

Though this model does not actually measure the competitiveness of knowledge, but the competitiveness of a company's KM processes, it was still included as a model in this thesis because it provided a simple and easily understandable comparison model that not only measured a company's internal aspects, but, also included aspects from an external view; its competitors. Benefits and disadvantages of using ICPA, both in general and in this thesis context, are listed in Table 1.

Table 1. Advantages and disadvantages of ICPA

Advantages	Disadvantages
Simple visual tool providing an overview of KM practices for further activities	Only looks at a process perspective of KM
Can be used as internal assessment, but also includes competitors in assessment	Risk for biasness from data collection – market tendencies
Pin-points which practice need immediate attention, or opposite, thus providing strategic recommendations	Requires numeric values of aspects to be evaluated – could be difficult to apply on intangible knowledge assets
Creates a common language for handling intangible assets	Does not actually measure competitiveness of knowledge (rather of KM activities)
Promotes "learning from the best"	
Numeric values in evaluation (objectivity)	

[3] Image retrieved from: Kale, S. & Karaman, E., 2011. Evaluating the Knowledge Management Practices of Construction Firms by Using Importance-Comparative Performance Analysis Maps. Journal of Construction Engineering & Management, 137(12), pp. 1142-1152.

Model 2: World Knowledge Competitiveness Index

The World Knowledge Competitiveness Index (WKCI) (Huggins & Izushi, 2008) benchmarking tool is used to assess the knowledge competitiveness of different regions, and, in their article on the method Huggins and Izushi explain and evaluate the use of the WKCI for such measurements. The purpose of a WKCI is to create a general benchmark of the capability, knowledge capacity and knowledge sustainability of a region; furthermore, it identifies which knowledge is transferred into economic value. Huggins and Izushi identify knowledge as a fundamental element in the competitiveness of firms as it is a company's ability to generate new ideas.

Essentially, WKCI is an Index; it was created by collecting data, which then was converted into zeroes and ones for the mean and variance of each variable. Following, factor analysis was applied to simplify the relationships and then a maximum likelihood method for extraction was used, to then be rotated by using Varimax. Finally, the factor analysis provides mutual dimensions in the structure, sub-indices, which then are grouped to create a single compound by using data envelopment analysis. Five main dimensions are brought into the WKCI analysis; they, with some of the measured criteria within, are listed in Table 2.

Table 2. Selected criteria from the World Knowledge Competitiveness Index

Human capital components:	• Economic activity rate; • Number of managers per 1,000 inhabitants; • Employment in high-tech services per 1,000 inhabitants.
Financial components	• Private equity investment per capita.
Knowledge capital components	• Expenditures on R&D performed by government per capita; • Expenditures on R&D performed by business per capita; • Number of patents registered per one million inhabitants.
Regional economy outputs	• Labour productivity; • Mean gross monthly earnings;
Knowledge sustainability	• Public expenditures on primary and secondary education per capita; • Public expenditures on higher education per capita; • Broadband access per 1,000 inhabitants.

In general WKCI evaluates on a very broad level. For one its view on knowledge competitiveness is measured in the number of employees in a specific business context, or amount of investments made on R&D. Thus not including the appropriateness, or level of expertise, in the people holding the positions or actual R&D outcome. Advantages and disadvantages of using WKCI, both in general and in this thesis context, are listed in Table 3.

Table 3. Advantages and disadvantages of World Knowledge Competitiveness Index

Advantages	Disadvantages
Uses only quantitative data (objective)	Difficult to apply on more intangible areas
Produces a table of relative data, includes competitors of a sort	Does not actually measure competitiveness of knowledge, only region's numeric competitiveness
Pin-points strong and weak points of a region to facilitate improvements	Assesses knowledge competitiveness on a more distant/abstract level than sought in this thesis work

Model 3: Critical Knowledge-Intensive Service Activities

In their article on Knowledge-Intensive Service Activities (KISA) application in innovation dynamics, Albors et al. aim to add to the assessment of a firm's innovative activities (Albors, et al., 2008). By performing this evaluation, using a KISA perspective, they assess a company's innovation initiatives in relation to their competitiveness. Knowledge Intensive Service Activities are for example services in R&D, Management Consulting, Information Technology (IT), Human Resource Management (HRM), etc. The method used here first identifies knowledge-intensive activities in companies; this was done with a questionnaire and literature search. Once identified, these knowledge-intensive activities were gathered into groups to enable a multivariate analysis. To simplify this analysis, some variables were then converted into composite variables. Some of the used variables in their analysis are presented in Table 4.

Table 4. Variables used in the Critical-KISA model

Marketing-KISA	Internal and external marketing functions of the firm (marketing research, benchmarking, segmentation, strategy)
Distribution-KISA	Agreements and services associated with the firm's distribution system, retail network, etc.
Design-KISA	Internal and external design activities
Public-KISA	PR activities (event-sponsoring, publicity, design of communication material, attendance on exhibitions etc.)
R&D-KISA	R&D external relationships with industry research organizations.
Customer-Knowledge	Knowledge of customer demand (measure by firm's effort in this direction)
Return-On-Assets	Return on Total Assets
Innovation-Level	Innovation performance, represented by no. new products to market presented annually

Following, a factor analysis was made to find the most important variables. Resulting from this, three groups were created and since they were all related, the first group became; Innovation-level, Training, Education, Marketing-KISA, Design-KISA, Public-KISA, Return-on-Total-Assets-KISA, IT-KISA, and Distribution-KISA. The second group contains only Return-on-Assets, and the third group omits Empowerment. From the first group a, new variable, Critical-KISA was created, combining all of the sub-components:

$$CriticalKISA = MarketingKISA + DistributionKISA + DesignKISA + PublicKISA + ReturnOnTotalAssetsKISA + ITKISA + Training$$

Subsequent, to assess the competitiveness three variables were identified; Return-On-Assets, Unit-Price and Export. Thus:

$$Competitiveness = ReturnOnAssets + UnitPrice + Export$$

Finally, to visualise the connection between the critical activities and competitiveness, a graph is created showing which companies performed best in a KISA perspective on competitiveness, Figure 5. The clusters represent high, medium and low performing companies according to KISA.

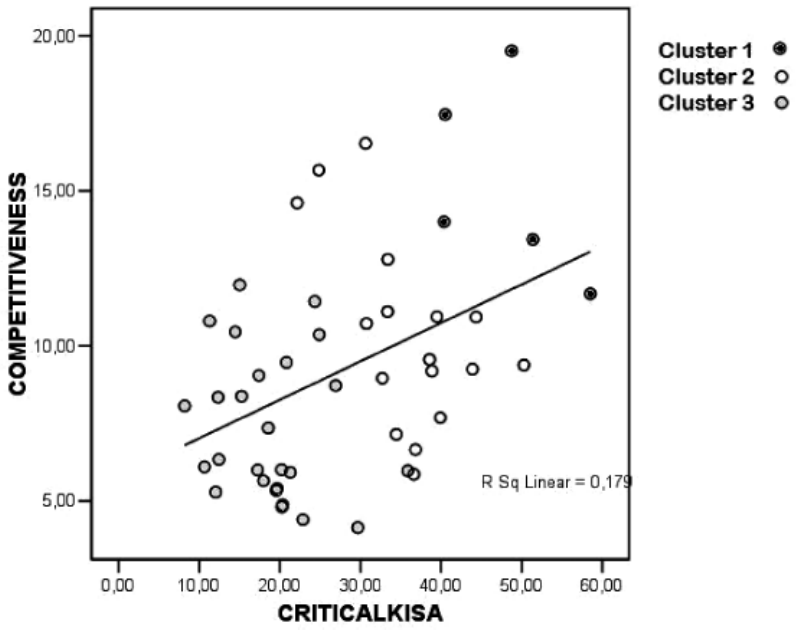


Figure 5. Example of a Critical-KISA and competitiveness graph from case companies in study by Albors et al.[4]

In this model, competitiveness is only determined by the return of assets, export and price per unit, thus not including more ambiguous aspects such as customer relations or innovation capability. Furthermore, having a low unit price might not say anything about actual CA. Benefits and disadvantages of using Critical-KISA, both in general and in this thesis context, are listed in Table 5.

.

[4] Image retrieved from: Albors, J., Hervas, J. L. & Marquez, P., 2008. Application of the KISA concept to innovation dynamics and its impact on firms' performance. Management Research News, 31(17), pp. 404-417.

Table 5. Advantages and disadvantages of Critical-KISA

Advantages	Disadvantages
Relates critical organisational competencies to competitiveness	Only measures clusters of organisational knowledge resources, do not assess individual assets and their impact
Visual	Complex
Includes external environment	Final results show competitiveness of the entire organisations knowledge assets – not individual asset performance
Provides recommendations	Sees competitiveness only from an economic perspective

Model 4: Intellectual Capital Benchmarking System

The creator of Intellectual Capital Benchmarking System (ICBS) (Marti, 2001) founded the model in a perceived gap between the widespread awareness that KM is essential for competitiveness, and the small understanding of how to actually manage knowledge. Aim of the model is to enable learning from a firm's best competitors by facilitating identification, assessment and benchmark of a company's core competencies or main intellectual capital (IC). By finding these core competencies, industry specific competitiveness elements and drivers can also be found.

When applying ICBS to a firm, its core competencies are considered compared to the core competencies of the world market leader. As two companies seldom are the same or entirely comparable, the firms are divided into business units, in which core competencies are identified through value chains – these are the components benchmarked in this model. Moreover, the company's activities are viewed as potential value adders, which can enable competitiveness, to a product or service, as they are necessary for developing, marketing and distribute them. A visualisation of the location of core competencies (CC), IC, outsourcing (O), and core business (CB) is seen in Figure 6.

ICBS was founded in the Excellence model that strives to look at how sustainable competitive advantage can be achieved, by focusing only on core business activities and outsource all other, in a global/generic perspective. From there, the founder of ICBS used the eight factors that are the basis for the excellence model to create a business specific benchmarking system (see Figure 7); Products, Architecture, Alliances, Competitive Advantage, R&D Innovation, Core Competencies, Culture, Leadership.

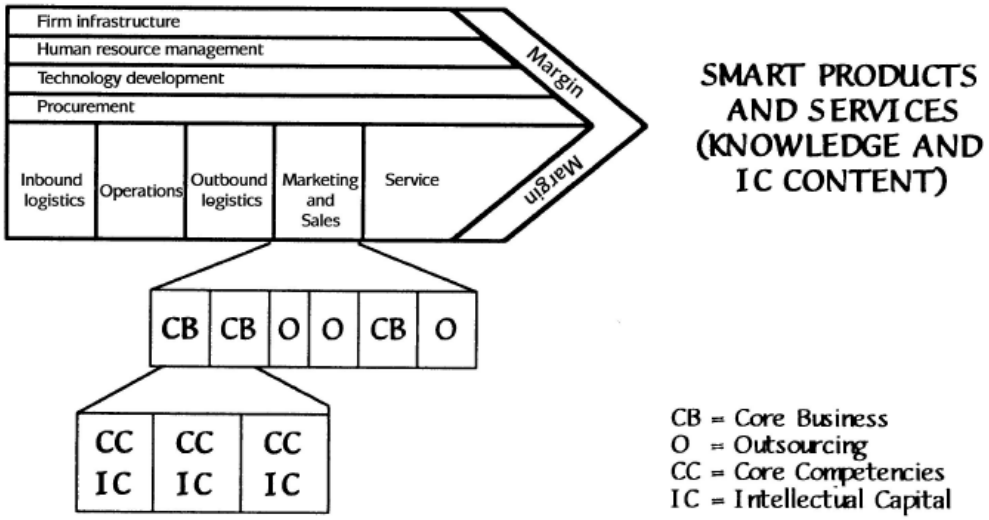


Figure 6. Intellectual Capital and Core Competencies in the value chain (ICBS)[5]

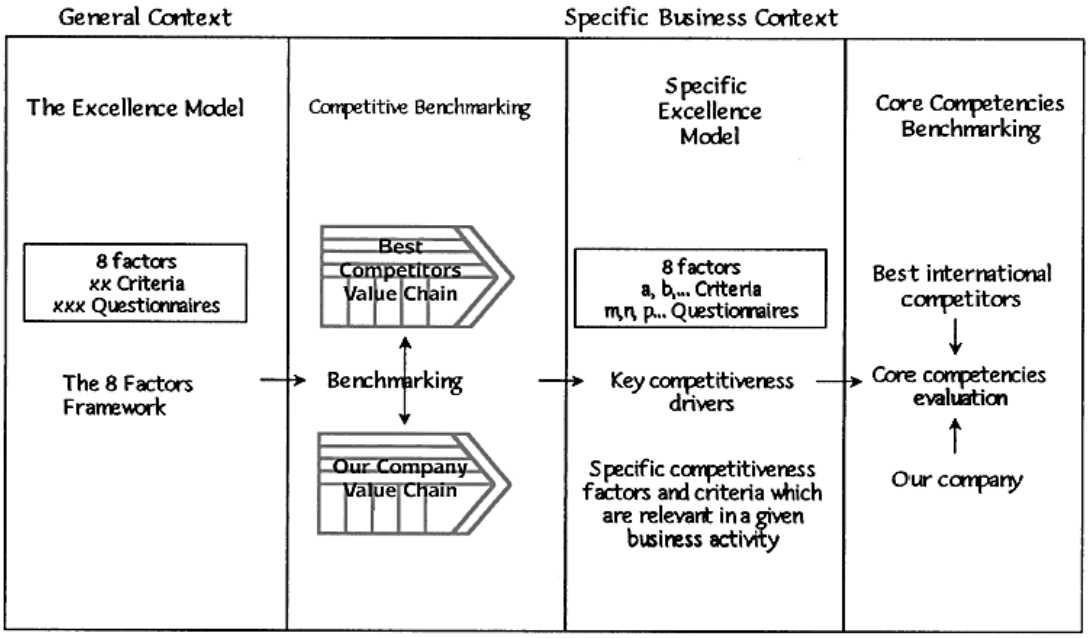


Figure 7. Specific market excellence model (ICBS) [5]

When implementing IBCS, first a general database containing all questionnaires and criterion is created – these are then configured for the specific business context. With answers from the questionnaires, a separate database for an individual firm is created. Finally, the information is processed to produce the competitiveness figures, example Figure 8.

[5] Image retrieved from: Marti, J. M. V., 2001. ICBS - Intellectual Capital Benchmarking System. Journal of Intellectual Capital, 2(2), pp. 148-165.

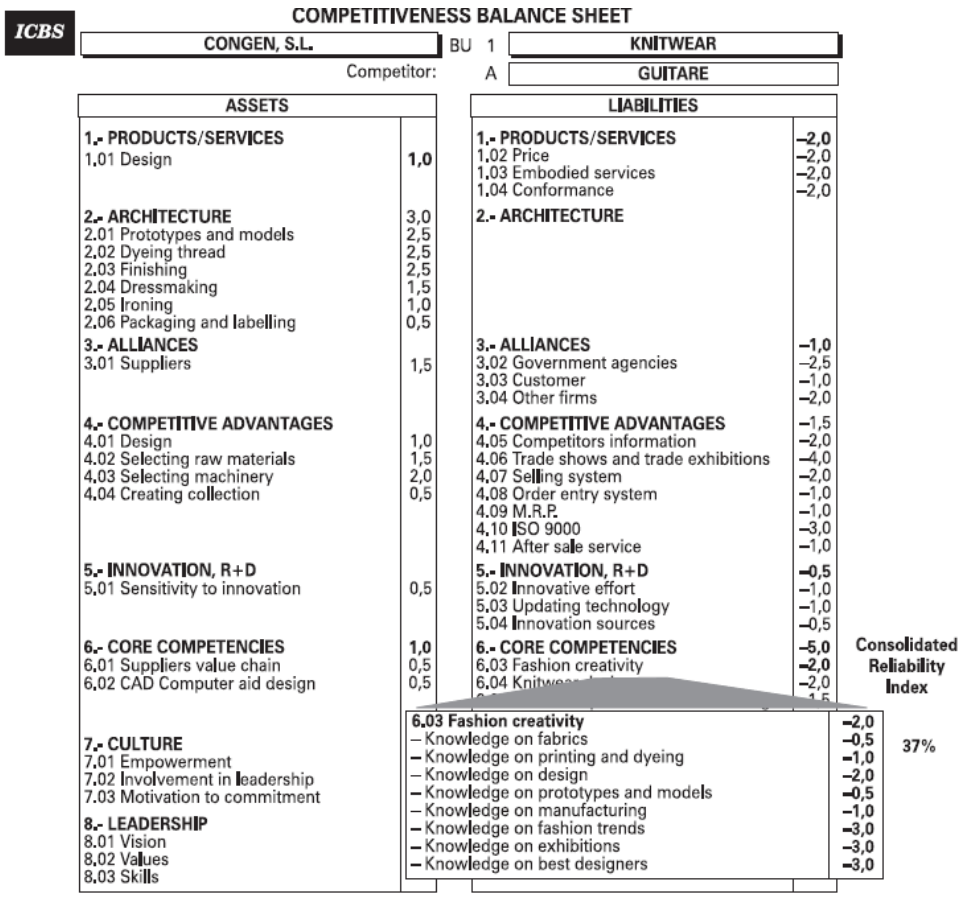


Figure 8. Example competitiveness balance sheet from using ICBS[6]

Benefits and disadvantages of using ICBS, both in general and in this thesis context, are listed in Table 6.

Table 6. ICBS - Advantages and disadvantages

Advantages	Disadvantages
Produces a measurement/relationship between IC and competitiveness	Though explained, difficult to replicate study
Systematic approach – lessened risk of subjectivity	Fairly subjective appreciation
Identifies key areas and core competencies, which are a company's main source of CA, and can be useful for future activities	Authors only provide benefits of model – does not add any critique or limitations on their model
ICBS competitiveness factors can be modified according to business context	Do not provide recommendations from results

[6] Image retrieved from: Marti, J. M. V., 2001. ICBS - Intellectual Capital Benchmarking System. Journal of Intellectual Capital, 2(2), pp. 148-165.

Model 5: Knowledge assessment from a manager perspective

In Wilcox and Zeithamls article on measuring organisational knowledge (Wilcox King & Zeithaml, 2003), they apply theory from the resource based view and from epistemology. Their aim is to add to theory by presenting a four-step approach to measure organisational knowledge from the perspective of managers. In their approach, they first define their scope by selecting two industries; textile and hospital, in which a number of companies were selected according to size and profitability. Following, they performed interviews with experts to build the study. Third, interviews were carried out, with managers in the selected companies, to identify the knowledge's or skills thought to provide a competitive advantage for the firms. From these interviews, 36 knowledge resources in the textile industry, and 30 from the hospital industry, were found and then brought into two separate surveys. In these surveys, various managers from the firms ranked the identified knowledge resources stating whether they were at an advantage of disadvantage compared to their competitors see Figure 9.

−3	Very significant competitive *dis*advantage
−2	Moderate competitive *dis*advantage
−1	Slight competitive *dis*advantage
0	Neither an advantage nor disadvantage
+1	Slight competitive advantage
+2	Moderate competitive advantage
+3	Very significant competitive advantage

Textile	Hospital
Benchmarking competitors' processes to speed adoption of valuable practices	Attracting and retaining top nursing and support staff
Developing differentiated innovative products	Attracting and retaining top physicians
Developing innovative processes	Clinical capability of physicians
Developing new end-uses that expand the market for our products	Clinical capability of the nursing and support staff
Flexible manufacturing through quick changeovers	Cost containment
Global sourcing of materials and labor	Health care services outside the hospital (such as home health care and satellite primary care facilities)
Identifying and developing market niches that my company can dominate	Information systems to help physicians manage their practices
Maintaining a corporate-wide 'sense of urgency'	Innovative partnerships
Maintaining an organizational culture of personal dependability, reliability, and integrity	Internal information systems
Making decisions quickly	Knowledge and skills necessary to succeed in an environment of capitation
Making difficult decisions among investment alternatives (i.e., technology, staffing, and capital investments)	Knowledge and skills necessary to succeed in an environment of managed care
	Less invasive surgical procedures

Figure 9. Part of the survey used for the measurement of competitiveness[7]

Advantages and disadvantages of using this managerial assessment approach, both in general and in this thesis context, are listed in Table 7.

Table 7. Advantages and disadvantages of using an RBV and epistemology approach

Advantages	Disadvantages
Measures knowledge importance for competitiveness	Trusts that managers know what knowledge assets provide CA
Simple approach on evaluation	Trusts that managers know their position of named knowledge assets compared to their competition
Includes competitors	Subjective
	Does not present clear results

[7] Image retrieved from: Wilcox King, A. & Zeithaml, C. P., 2003. Measuring Organizational Knowledge: A Conceptual and Methodological Framework. Strategic Management Journal, 24(8), pp. 763-772.

Model 6: Knowledge Assets Value Creation Map

Knowledge Assets Value Creation Map (KAVCM) (Carlucci & Schiuma, 2007) is an approach aiming to show how knowledge assets increase a firm's performance by visualising the link between them. In addition, KAVCM also assesses the knowledge resources according to its significance in the value creation.

To implement the model, first, the firms' objectives, mission and vision must be defined. When this is done, performance objectives from the set strategy should be set, and for each of them, the most important knowledge resources needed to fulfil those objectives should be identified. Following, an Analytic Hierarchy Process (AHP) is applied to set priorities and weights for knowledge assets and their respective performance objectives, visualised in Figure 10.

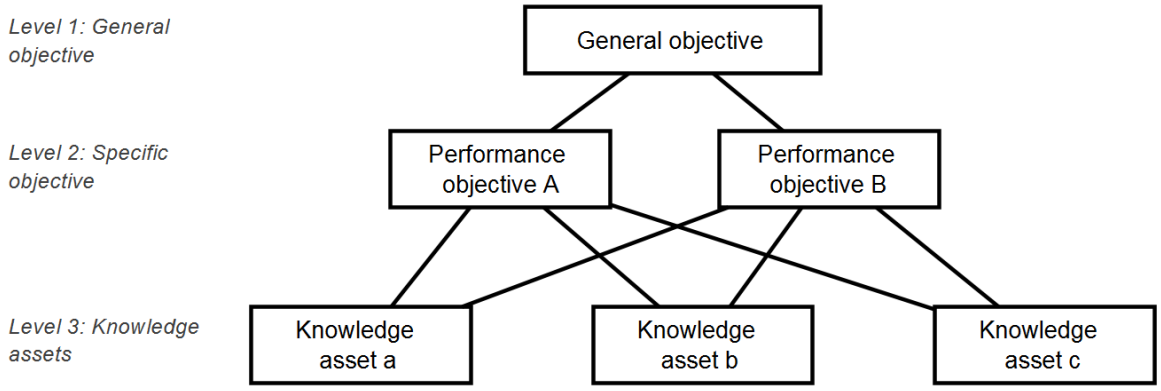


Figure 10. Relationship between knowledge assets and performance objectives[8]

Next, a matrix is used to determine the interrelationships between the knowledge assets, Figure 11.

Performance objective A	Knowledge Element a	Knowledge Element b	Knowledge Element c
Knowledge Element a	□	■	-
Knowledge Element b	■	-	-
Knowledge Element c	-	■	□
■ = Strong importance, □ = moderate importance			

Figure 11. Relationship matrix for knowledge assets[8]

Combining these two, finally the KAVCM is drawn, see Figure 12.

[8] Images modified from original: Carlucci, D. & Schiuma, G., 2007. Knowledge assets value creation map Assessing knowledge assets value drivers using AHP. Expert Systems with Applications, Volume 32, pp. 814-821.

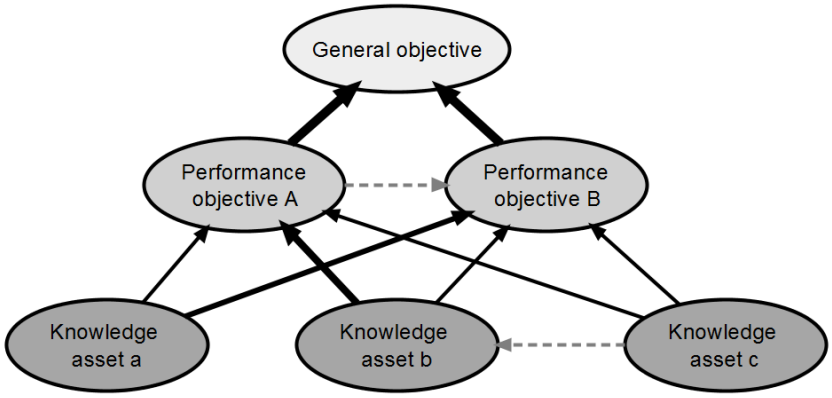


Figure 12. KAVCM mapl; dotted lines show interrelations between elements, and filled lines show links between the elements on different levels (thickness of line visualises importance of link)[9]

Moving on, this model sees competitiveness of a knowledge asset as the relation it has to facilitating a firm's strategic goals. Advantages and disadvantages of KAVCM, both in general and in this thesis context, are listed in Table 8.

Table 8. Advantages and disadvantages of KAVCM

Advantages	Disadvantages
Relates knowledge assets to performance objectives and then to business performance objectives, thus the application of knowledge assets	Does not include competitors
Includes relationship between knowledge assets	
Visual and objective	
Identifies competitive/important knowledge assets	

Model 7: Strategic Knowledge Portfolio Assessment

With the purpose to aid organisations to find key knowledge elements, which allow for competitive advantage, Birchall and Tovstiga designed a framework that maps and assesses the effect of knowledge assets on competitiveness to see which assets need managerial attention (Birchall & Tovstiga, 2002).

Initially, in this model, the businesses core processes (see Figure 13) are mapped to then be separated from the required knowledge creation. Following, the firms key success factors are identified, and the knowledge assets required for fulfilment of the realisation. Subsequently the company's knowledge performance in relation to its closest competitors is performed. Next, the knowledge portfolio is created by identifying, classifying and mapping knowledge resources in four areas; process, content, culture and infrastructure (see Figure 14), this to then rate their level of explicitness or tacitness (Figure 15).

[9] Image modified from original: Carlucci, D. & Schiuma, G., 2007. Knowledge assets value creation map Assessing knowledge assets value drivers using AHP. Expert Systems with Applications, Volume 32, pp. 814-821.

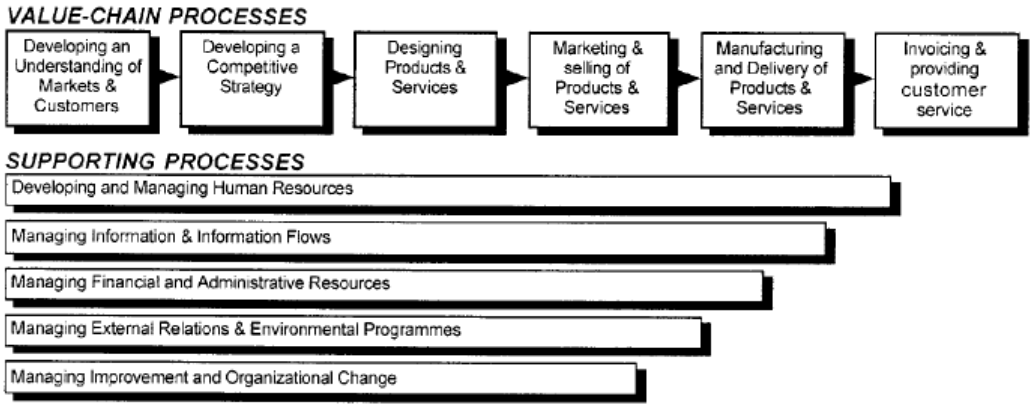


Figure 13. Core business processes of a firm[10]

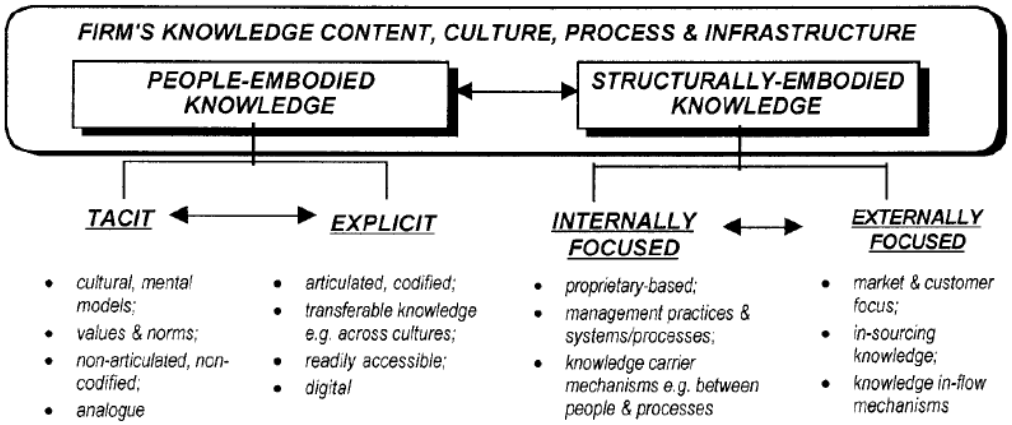


Figure 14. Classification of knowledge assets[10]

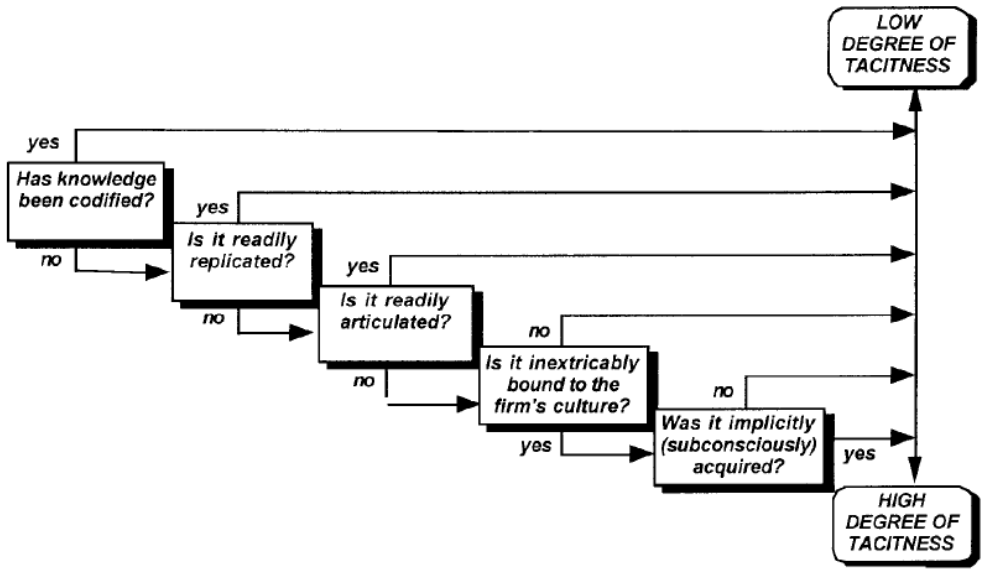


Figure 15. Determining degree of tacitness[10]

[10] Image retrieved from: Birchall, D. B. & Tovstiga, G., 2002. Assessing the firm's strategic knowledge portfolio: a framework and methodology. International Journal of Technology Management, 24(4), pp. 419-434.

Once the knowledge resources are classified, they should then be assessed according to their impact on competitiveness (Figure 16). Here, the authors separate between Emerging, Pacing, Kay and Base Knowledge. Finally, an assessment of how much control the company has over the knowledge resource is made (Figure 17).

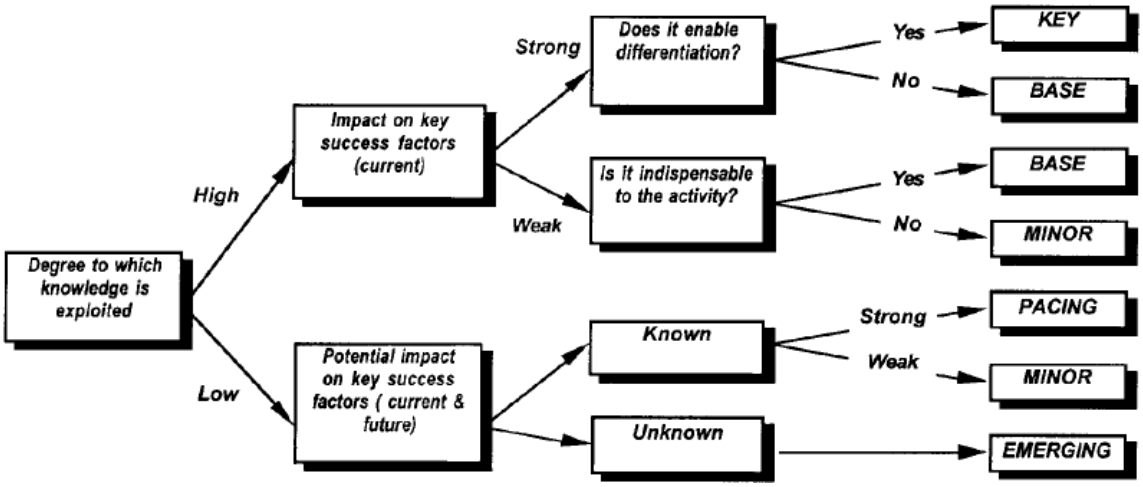


Figure 16. Assessment of knowledge impact on competitive advantage[11]

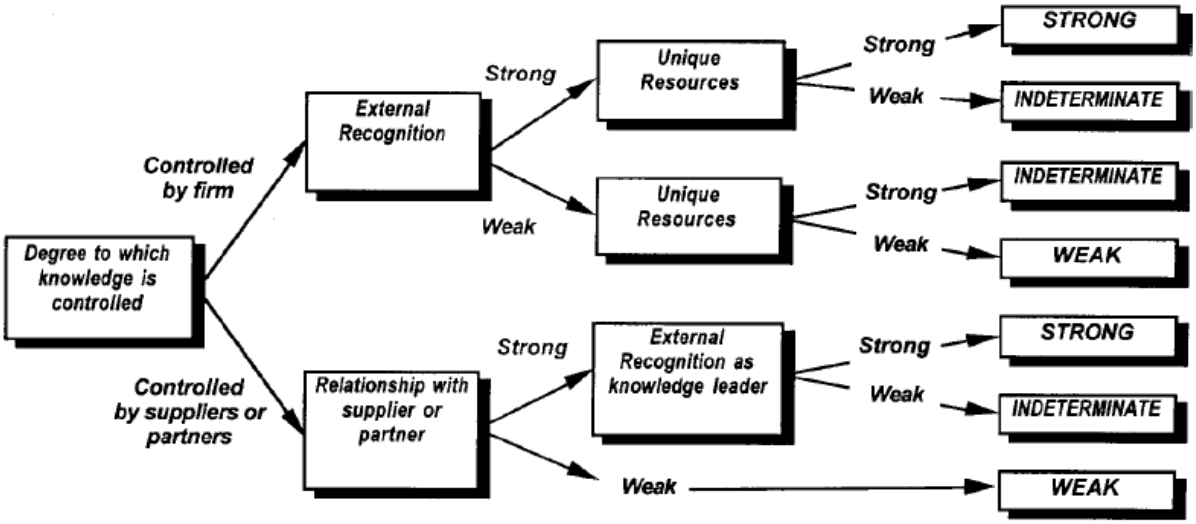


Figure 17. Degree of control a firm has over a specific knowledge asset[11]

The authors conclude with giving strategic recommendations according to the results obtained by the above assessment, an overview of this is shown in Figure 18.

[11] Image retrieved from: Birchall, D. B. & Tovstiga, G., 2002. Assessing the firm's strategic knowledge portfolio: a framework and methodology. International Journal of Technology Management, 24(4), pp. 419-434.

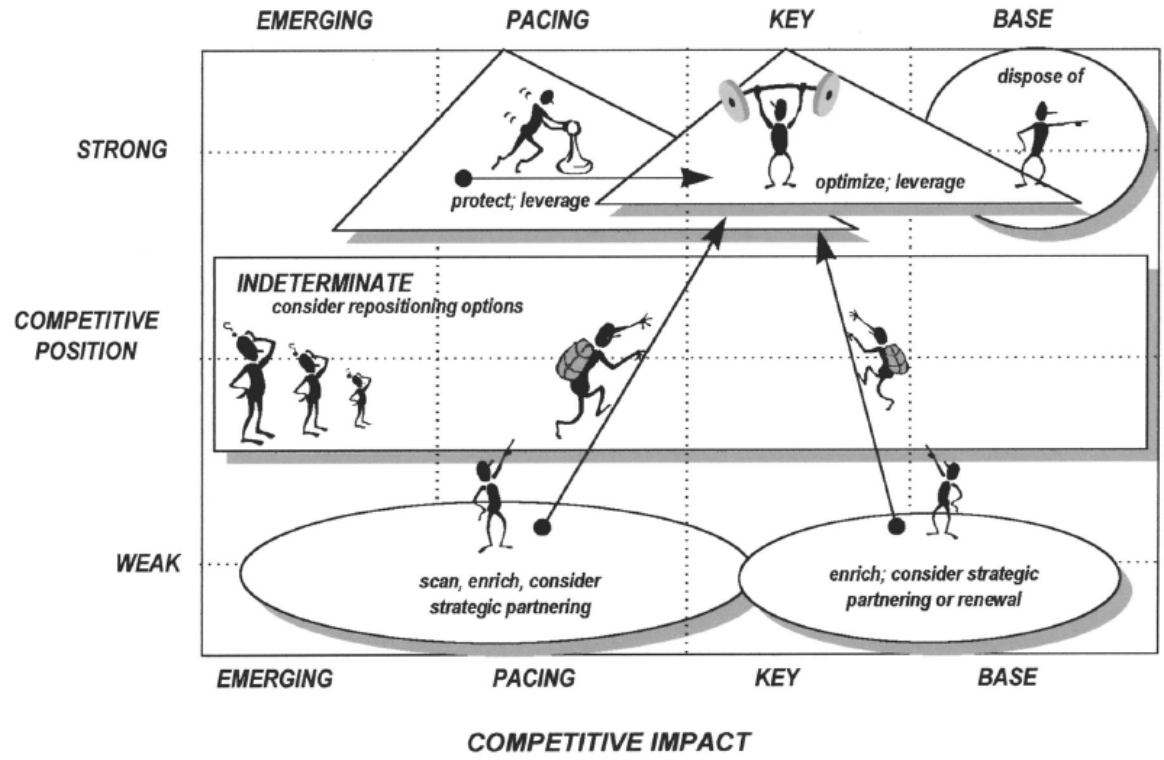


Figure 18. Strategic recommendations from the knowledge portfolio[12]

Competitiveness of knowledge here relates to the imitability, strategic importance and nature of the knowledge asset but also the amount of control a company has over it. Advantages and disadvantages of SKPA, both in general and in this thesis context, are listed in Table 9.

Table 9. Advantages and disadvantages of using knowledge portfolio assessment

Advantages	Disadvantages
Relates knowledge assets impact on competitiveness	No numeric measures
Provides replicable framework	Subjectivity in model
Visual	
Provides strategic suggestions from results	
Includes competitor analysis	

[12] Image retrieved from: Birchall, D. B. & Tovstiga, G., 2002. Assessing the firm's strategic knowledge portfolio: a framework and methodology. International Journal of Technology Management, 24(4), pp. 419-434.

4.2 Selection of model

In the literature review, several models related to the sought evaluation were identified, but none of them included all the sought criteria. A decision was made to try to select the best aspects from the models and assemble a new model. As mentioned before, in the initial stages some criteria for the sought model were set, these were:

1. Relevant criteria should determine the competitiveness of the knowledge asset.
2. Including the application of the knowledge asset in the evaluation.
3. Possible to rate in comparison with competing companies.
4. Available assessment of appropriate application areas of the knowledge.
5. Suggestions of how assessed knowledge can be managed.
6. Objectivity in evaluation.

After summarising and evaluating the found models, the Strategic Knowledge Portfolio Assessment (SKPA) was the most suiting model as it fulfilled several of the above criteria (1, 3, 5). However, it is lacking criteria 2 and 4. The closest to the second criteria any of the models came was in Knowledge Assets Value Creation Map (KAVCM), where the knowledge assets are rated on their importance in the creation of value. Moreover, KAVCM also covers the relation to specific performance goals, and is fairly objective in its assessment. As for the fourth criteria, none of the models incorporated this. It was set as it would help verify the appropriateness of use in PD businesses, but as no found model considered it, that sub-problem will instead be considered in the second literature review and/or incorporated in the testing of the model. Thus, the selected models for this thesis work are mainly SKPA with the incorporation aspects of the KAVCM model.

To verify the usage of the chosen articles they were reviewed by looking at the number of citations made and by using the database Journal Citations Report, see Table 10. As seen in the table the number of citations on the respective articles varies from four to almost two hundred referring's. As for the two chosen models KAVCM and SKPA, the first has one of the higher citation ratings and though the latter has less than half of the citations compared to the KAVCM it still is the median of all of the articles number of citations.

In Journal Citations Report each journals 5-year impact factor was retrieved, this is a measure of the average number of times the journal has been cited over the last five years. This measurement is thought to reveal the credibility of specific journal; however, not many journals were included in this database as can be seen in the table. Though the most important, the ones of the chosen articles were included. Accordingly, articles in the journal Expert Systems with applications (KAVCM) have an average citation of 2.339 whereas articles in International journal of technology management only have an average citation of 0.636. However, International journal of technology management decreased to only nine published articles thus it has rapidly declined in use since its peak years in 2008-2009, whereas, Expert Systems with applications just started to decrease in use and still had 546 articles published in 2012. Thus, even if both journals have begun decreasing in use, they have had a higher standing in the past, when the articles were published.

Table 10. Article citations and journal impact

Model	No. citations on article	Journal	Journal impact factor (5-year)
Importance-Comparative Performance Analysis Maps	4	Journal of Construction Engineering & Management	1.277
Benchmarking the knowledge competitiveness	10	Competitiveness Review: An International Business Journal	Not in database
CRITICAL Knowledge Intense Service Activities	9	Management Research News	Not in database
Intellectual Capital Benchmarking System	134	Journal of Intellectual Capital	Not in database
Measuring Organizational Knowledge	197	Strategic Management Journal	Not in database
Knowledge Assets Value Creation Map	53	Expert Systems with Applications	2.339

4.3 Design of the new model

In large, the two selected models suit the sought model aim to assess the competitiveness of knowledge assets, KAVCM assesses the impact an individual knowledge resource has on performance objectives, and, SKPA reviews the competitive impact of selected knowledge resources. However, for them to be useful in this thesis context, in fulfilling the research questions, the models needed to be merged. Furthermore, an assessment of the models on whether every aspect of them was necessary for the new model needed to be made.

To visualise and clarify the construction of the models, an overview of their schemes was created. First, the SKPA model is shown in Figure 19, where boxes with filled lines are steps in the model and boxes with dotted frames contain notes or suggestions for the respective steps (by model authors). In the illustration, a separation is also shown between the part of the process creating a knowledge portfolio, and the part assessing knowledge competitiveness.

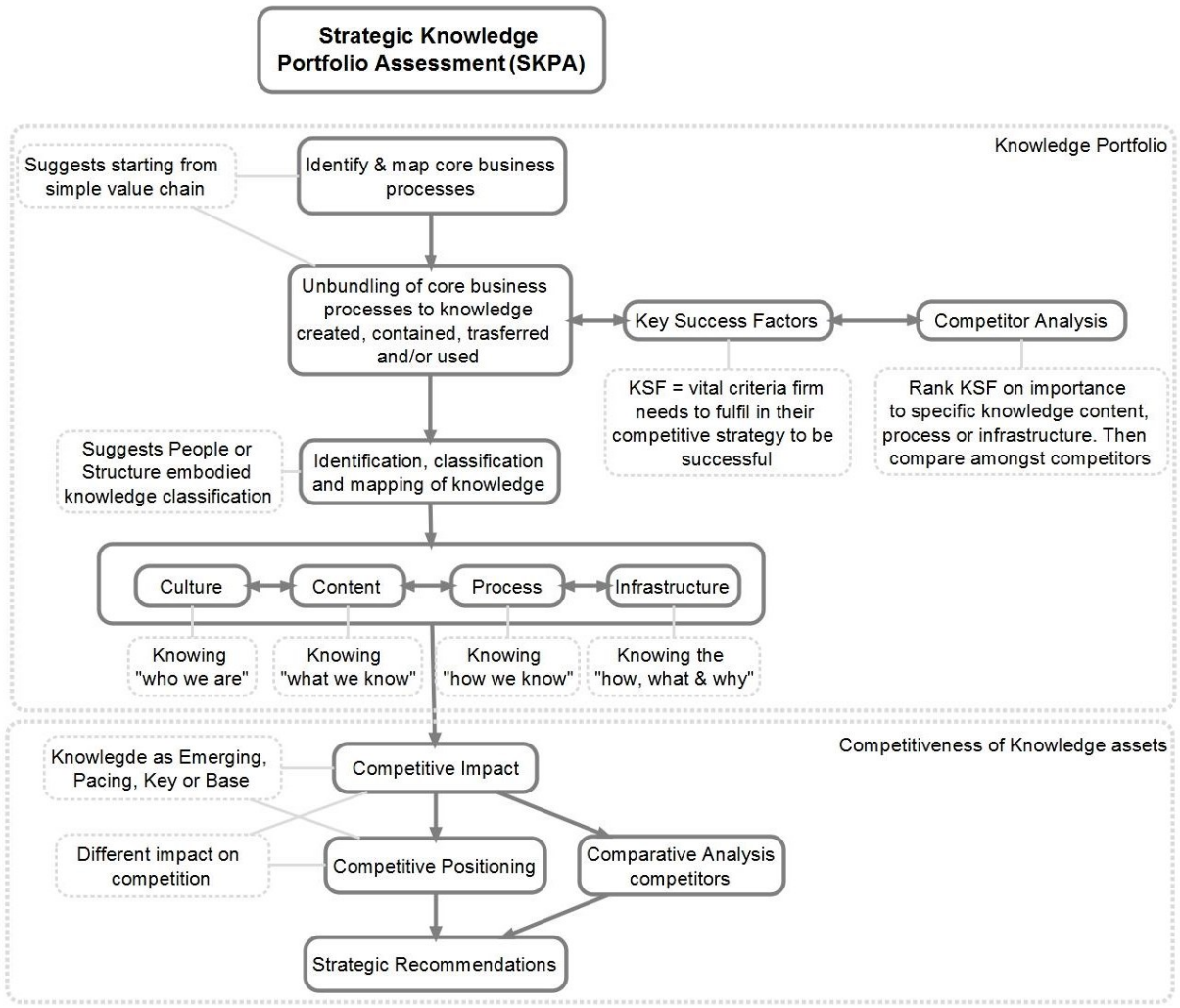


Figure 19. Strategic Knowledge Portfolio Assessment process scheme[13]

In reviewing this model, a backwards approach was used to select the most vital steps in it. This approach was used as the same end-result was sought in the new model; the graph showing the relation of the knowledge's impact on competitive advantage and the firm control, see Figure 18. Thus, the three last steps in the SKPA process, competitiveness of knowledge assets in Figure 19, were necessary in the new model. To produce the final graph as in SKPA, the firms KSF's are needed, thus the step where these are identified and compared to the firm's competitors must be brought to the new model. Furthermore, the forth step where knowledge is assessed according to the explicitness of the knowledge assets, seemed an important part of the assessment, though with a simpler classification scheme as it is not a key part in the model. The three previous steps, where core businesses are mapped and from where knowledge recourses are identified, although important per se, were removed as they do not directly affect the end result.

[13] Modified from originals in article: Birchall, D. B. & Tovstiga, G., 2002. Assessing the firm's strategic knowledge portfolio: a framework and methodology. International Journal of Technology Management, 24(4), pp. 419-434.

Succeeding, an overview of KAVCM can be seen in Figure 20, where boxes with filled lines are steps in the model and boxes with dotted frames contain notes or suggestions for the respective steps (by model authors). The KAVCM has a similar first approach as the SKPA, in the notion that it begins by defining strategic aspects on a high level to then identify strategy objectives and from them define key resources.

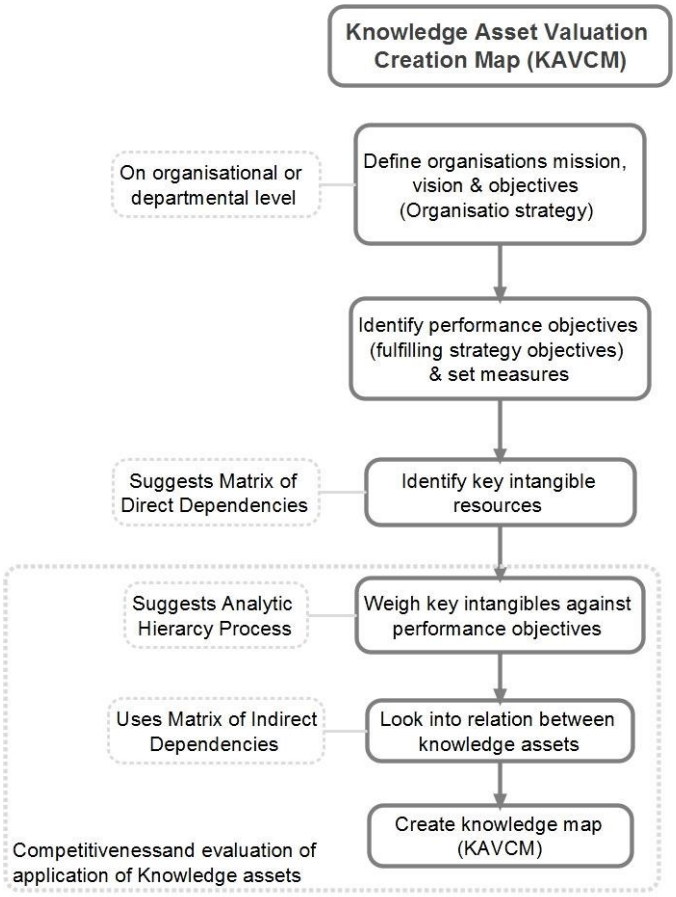


Figure 20. Knowledge Assets Value Creation Map process overview

In assessing the steps of the KAVCM, once again, a backwards approach was used; the KAVCM map was sought as an end result, thus the steps needed for this had to be brought in. The KAVCM map visualises the relationship between knowledge assets and their performance objectives, and between the knowledge assets themselves. As the first of these relationships, between assets and objectives, can be related to a firms performance it was viewed as important. However, the internal relation between the knowledge assets was though less important as it does not relate either to the actual competitiveness evaluation or to the application of knowledge. Hence, a revised KAVCM map was made. This means that the fifth step in the KAVCM scheme was not brought to the new model. Whereas, the first four steps of the KAVCM are vital for producing the final map, consequently, they were included in the new model.

One important difference between both these models, and the basing research articles for this thesis, is the approach to identify knowledge assets. These models start on an organisational and strategic level to identify knowledge assets, whereas, the researchers seeking this model (Schmidt, et al., 2014) (Schmidt, et al., 2013) start by identifying available knowledge assets to then assess them. How the knowledge is identified plays an important role in any evaluation model because it determines which object actually will be assessed (Lerro, et al., 2012). Often, due to its intangibility, it is a difficult task to identify the knowledge and also to make a rational valuation of it (Lerro, et al., 2012). There are benefits with both approaches; however, to obtain more relevant knowledge assets to start with the approach as in KAVCM, to identify knowledge assets from targeted performance objectives, was selected for the new model. A risk with this is that some important knowledge assets might not be identified; however, limiting the identification as in KAVCM gives structure and scope to the evaluation.

Furthermore, another significant difference between the two models, SKPA and KAVCM, is that SKPA evaluates knowledge on an organisational level, whereas, KAVCM evaluates on a departmental level. A risk when working on the entire company is that the evaluation becomes too abstract; in addition, it might include unnecessary aspects and demand more resources than needed. Therefore, the new model will focus its evaluation on a departmental level, of course including vital aspects from a firm level but then narrow the scope down to be able to make a more relevant assessment. This is supported by Haas and Hansen who claim that for knowledge to be reviewed appropriately, it has to be done within its contextual use (Haas & Hansen, 2005).

4.4 Model evaluating the competitiveness of knowledge

Finally, the new model scheme for evaluating the competitiveness of knowledge was produced (Figure 21); building on the KAVCM and SKPA models. Each step of the model is explained below.

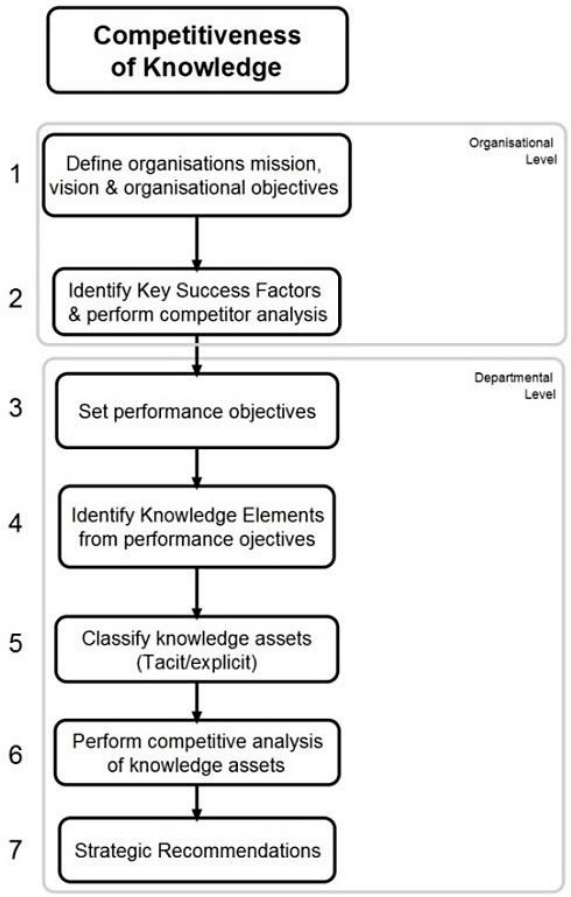


Figure 21. Model scheme for assessing the competitiveness of knowledge

Step 1. State mission, vision and organisational objectives

As in Carlucci and Shiuma's KAVCM model, this model starts by identifying the mission, vision and objectives of the company. Here, not only to identify performance objectives as in their model, but also to identify Key Success Factors for the company in its industry.

A vision is a statement visualising the overall future and direction of a company, it should communicate the organisations philosophy and motivate people to embrace challenges in order to be successful. Often the vision statement is short and answers what the company wants to be. (Hitt, et al., 2007) (Grant, 2010) The mission of an organisation states the businesses in which it means to compete and what customers it means to serve. (Hitt, et al., 2007) This statement should include the "who", "what", "why", "for whom" and "how" of the company. (Grant, 2010) Finally, the organisational goals, needed to fulfil the vision, should be identified in order to set measurable objectives. A few objectives for each goal should be set, and, they should be measurable and feasible. A summary of how to perform this step is shown in Table 11. As information of this sort often is provided on companies' websites, this step does not necessarily require interviewing. This step could be helpful for identifying performance objectives later on; however, it is not an indispensable step in the model, as it is not directly affecting the actual evaluation of competitiveness of knowledge.

Table 11. Summary of how to identify/set mission, vision and objectives

Method for collecting data:	Targeted research within company, on website and by collecting, or verifying, knowledge from an appropriate manager in the company. Together answering the following questions: • What does the company want to be? (Vision) • To who will the company provide offers, what will their offer be, why will they provide the offer and for whom, and finally how? (Mission) • How will the company accomplish their vision? (Goal, for example improve profitability, employee training, or customer relations) What and in what timeframe? (Objective, for example to increase market share by X % within the next Y years) Estimated interview time: 20 min
Outcome:	A vision and mission statement along with clear objectives on an organisational level, this to determine organisational Key Success Factors and departmental performance objectives later on.

Step 2. Identify Key Success Factors

Key Success Factors (KSF) are competitive components that a company has to master and control to be successful in their industry. These KSF are the same within an industry are defined by the competing market place, a set of KFS are what determines whether a company is leading or losing the competition. Example of a KSF could be "ability to provide excellent customer service" or "maintaining long-term customer relations". To formulate KSF, three factors need to be considered; industry time frame and scope, its macro environment and its stakeholder profile. (Birchall & Tovstiga, 2002)

Grant presents a simple framework for identifying KSF (Grant, 2010), including these three factors, which will be implemented in this model, see Figure 22. In this part of the model the aim is to identify a few well formulated KSF that relate to the company strategy, this to enable a competitive impact analysis of the knowledge elements later on, thus, this step of the model is vital for the assessment to be able to be executed. In addition, identification of KSF is to aid in the selection of which department to focus the future evaluation on.

At this stage Birchall and Tovstiga suggest a competitor analysis to assess the company's position on its KFS. The firms' performance on KSF compared to its main competitors should be assessed; either the company is leading, average or lagging. This step is done both to retrieve a competitive overview, and to verify the chosen KSF and to get an insight of their relative importance. Moreover, from the found KSF's a suitable department of the company should be selected for evaluation, thus a department that have a clear impact on KSF's should be chosen, otherwise an evaluation will not be possible. These KFS found this selection as they are vital later on in the process when evaluating the actual competitiveness of knowledge For relevance to be insured this selection should be done in discussion with a manager. A summary of how to perform this step is shown in Table 12.

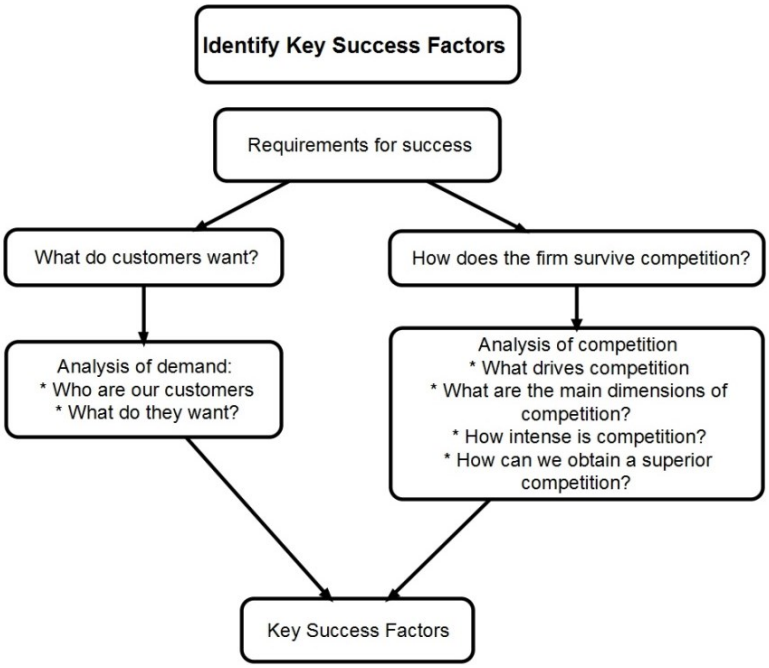


Figure 22. Identification of Key Success Factors[14]

Table 12. Summary of how to identify Key Success Factors

Method for collecting data:	Targeted research online, reviewing competitive elements in a specific industry, and collecting or verifying knowledge from an appropriate manager in the company. Together answering the following questions: • Who are the customers and what do they want? (Diversity, low prices, quality, convenient location, or, reliable supply for example) • How do firms survive competition? (High fixed costs, cost efficiency, premium offers through differentiation, or, fast imitation for example) From the above questions, formulate KSF, and: • For each identified KSF, determine the firm's comparative status in its industry (leading, average or lagging). Estimated interview time: 40 min
Outcome:	A few, well formulated, KSF later used to determine competitive impact of knowledge assets and the company's competitive position according to the KSF's.

[14] Modified from original in book: Grant, R. M., 2010. Contemporary Strategy Analysis. 7th ed. Chichester: John Wiley & Sons Ltd.

Step 3. State performance objectives

Once a department has been chosen, appropriate performance objectives for this company function should be set. These objectives should be set by a manager in the department; they should be measurable and relate to the organisational objectives, thus working toward the company vision. In addition, the objectives should be relevant to the activities performed by teams and individuals in the respective department, and relate to the identified KSF. This step of determining goals is vital for identifying knowledge assets and, thus, for the pending evaluation. A summary of how to perform this step is shown in Table 13.

Table 13. Summary of how to obtain performance objectives

Method for collecting data:	Interview with department manager to obtain performance objectives. Found objectives should answer what needs to be done, be measurable and ideally include a timeframe. Estimated interview time: 20 min
Outcome:	A few, well formulated, performance objectives for the specific department.

Step 4. Identify knowledge elements from performance objectives

As a foundation to being able to assess knowledge, the knowledge first has to be identified. There are several ways of identifying these, for example questionnaires, interviews and storytelling, where the latter two is used in the knowledge evaluation performed in the founding article for this thesis (Schmidt, et al., 2013) in which they start their evaluation by identifying tasks and from them knowledge assets. In contrast the model KAVCM uses the set performance objectives to identify knowledge resources fulfilling them, thus, going the other way around. This way not all available knowledge elements are identified, however, the most relevant ones are, as they are ones contributing to the objectives. Depending on the company and study size, specific methods might be more or less sensible, however, as this model focuses on a departmental level further interviews with its respective manager is proposed for this step (in accordance to the KAVCM approach).

Thus, for each performance objective the interviewee has to identify knowledge elements needed to fulfil them. In the KAVCM the Matrix of Direct Dependencies is used to sort this relationship, in the matrix target performance objectives are listed in columns, whereas, knowledge assets are listed in rows and then marked according to their relationship (no relationship " ", partially related "□", strongly related "■"). From this matrix a basic Analytic Hierarchal Process (AHP) map is drawn, illustrating the relationship between a performance objective and its knowledge objectives. An AHP could be a basic map (as proposed in this model) where all the elements have the same weight, or, a more traditional map where each performance objective have different weights thus a more advanced but more thorough projection. Here only the simpler version is proposed as this is only one part of the evaluation and more focus will be put on the further evaluation steps. Of course this step is essential for the evaluation as it actually identifies the knowledge resources to be evaluated. A summary of how to perform this step is shown in Table 14.

Table 14. Summary of how to identify knowledge elements from performance objectives

Method for collecting data:	Interview with department manager to identify knowledge assets needed to fulfil set performance objectives, the knowledge should be on a level relevant to the work by individuals/teams within the department. This relationship is then sorted (by interviewer) by use of a Matrix of Direct Dependencies. From this matrix an AHP map is created (by interviewer). Estimated interview time: 60 min
Outcome:	A list of knowledge assets and a AHP showing the relationship between the knowledge assets and their performance objectives.

Step 5. Classify knowledge assets

As a prelude to the coming competitiveness evaluation, Birchall and Tovstiga also recommend making a classification of the identified knowledge assets, this to get a better perspective of the available assets. Of the suggested classifications, one was chosen to be included in this model - the level of tacitness, which, is very relevant for this evaluation as the level of explicitness relates to knowledge imitability (thus competitive advantage) (Haas & Hansen, 2005) (Grant, 2010). In their model, Birchall and Tovstiga provide a simple Yes/No question approach to determine tacitness of a knowledge element. This will be applied also in the new revised model, see Figure 23. That is, for each knowledge element a level of tacitness can be identified by interviewing the department manager. A summary of how to perform this step is shown in Table 15.

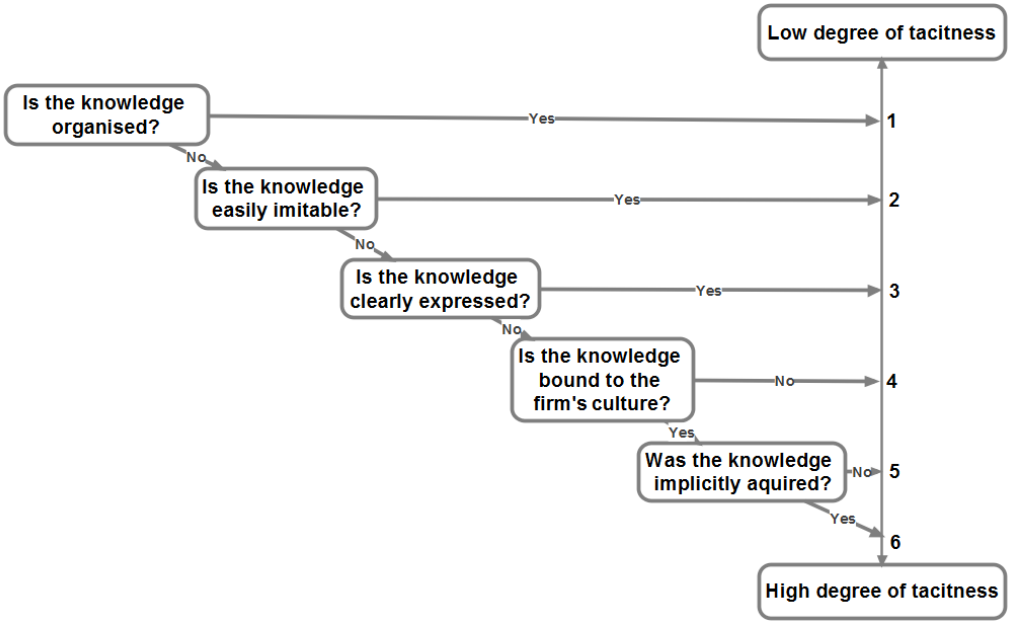


Figure 23. Determining level of tacitness[15]

[15] Modified from original in article: Birchall, D. B. & Tovstiga, G., 2002. Assessing the firm's strategic knowledge portfolio: a framework and methodology. International Journal of Technology Management, 24(4), pp. 419-434.

An evaluation of the tacit/explicitness of resources is a way of determining how imitable knowledge resources are. This, in turn, is important as the more imitable an asset is (and the more valuable it is) the more likely it is that someone will try to copy it. Part of the success in many companies is due to their tacit resources, the ones their competitors cannot grasp and copy. Although this step of the model scheme is interesting, it is not necessary for the assessment of knowledge competitiveness, thus it is an important but not indispensable step in the model.

Table 15. Summary of how to classify knowledge assets

Method for collecting data:	Interview with department manager to classify knowledge assets, each knowledge asset will be ranked according to the question sequence in Figure 23 (a numeric scale will be added for easier understanding and a faster evaluation process). Estimated interview time: 20 min
Outcome:	Specific knowledge assets level of tacitness.

Step 6. Perform competitive analysis of knowledge assets

For the assessment of knowledge's competitive impact and positioning Birchall and Tovstigas approach was decided to be used in its full, this as they provide a manageable, and replicable, framework for assessing competitiveness of knowledge. This is the final and most crucial step of the evaluation/interviews; the last step is performed by the interviewer depending on the interview results.

First in assessing the competitiveness of a knowledge asset, it is classified to determine its competitive impact. Here there are five types of knowledge, where only four has a competitive impact. The different classifications are shown in Table 16.

Table 16. Knowledge types for assessing competitive impact (Birchall & Tovstiga, 2002)

Type	Description
Emerging	A knowledge asset with low exploitation and with unknown impact on KSF, thus, a yet unknown impact on competitiveness.
Pacing	A pacing knowledge asset has shown potential to change the basis of competition, it is not highly exploited but its potential is known, and strong.
Base	Knowledge that is classified as base is common amongst all competitors and only adds little value to the company.
Key	A company's key knowledge has major influence in the company's value creating process and is often embedded in its products, processes or services.
Minor	No, or close to none, impact on competitiveness or value adding.

To determine which kind of knowledge a specific knowledge is the suggested decision-tree from Birchall and Tovstiga was used, see Figure 24. Moving on, the degree of control a company has over their knowledge assets should also be evaluated. Such an evaluation might not say too much about the competitiveness of the knowledge itself, however, it does reflect on the degree of which a company exploits its knowledge assets. In addition, it is important as a company needs to be able to control its most important assets. For this ranking, Birchall and Tovstigas approach is once again suggested, here another decision-tree is used to identify the company's degree of control of an asset, see Figure 25. In their ranking a firm can either have weak, intermediate or strong control of a specific asset. A summary of how to perform this step is shown in Table 17.

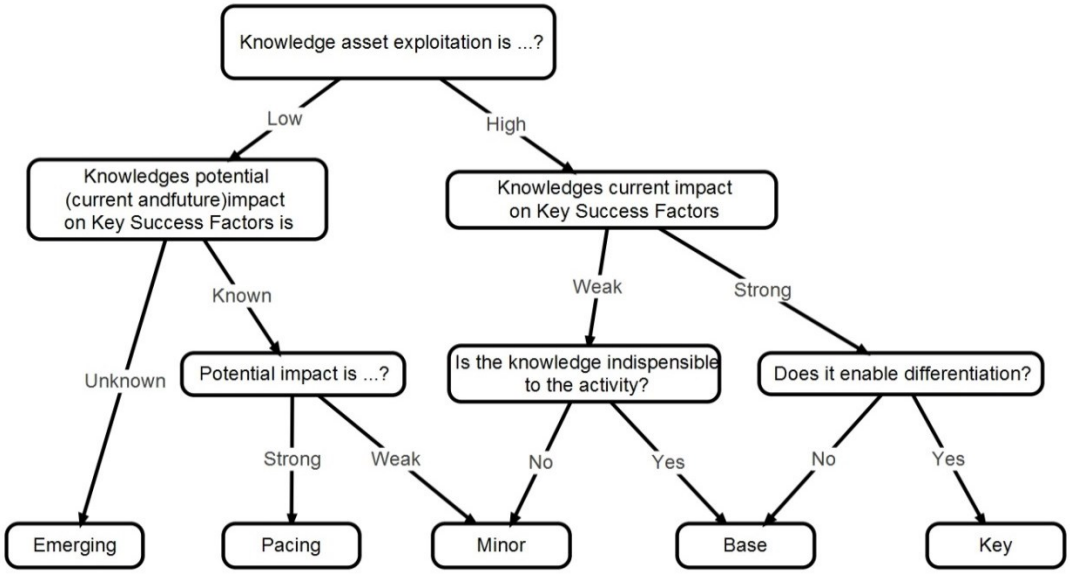


Figure 24. Assessment of knowledge impact on competitiveness[16]

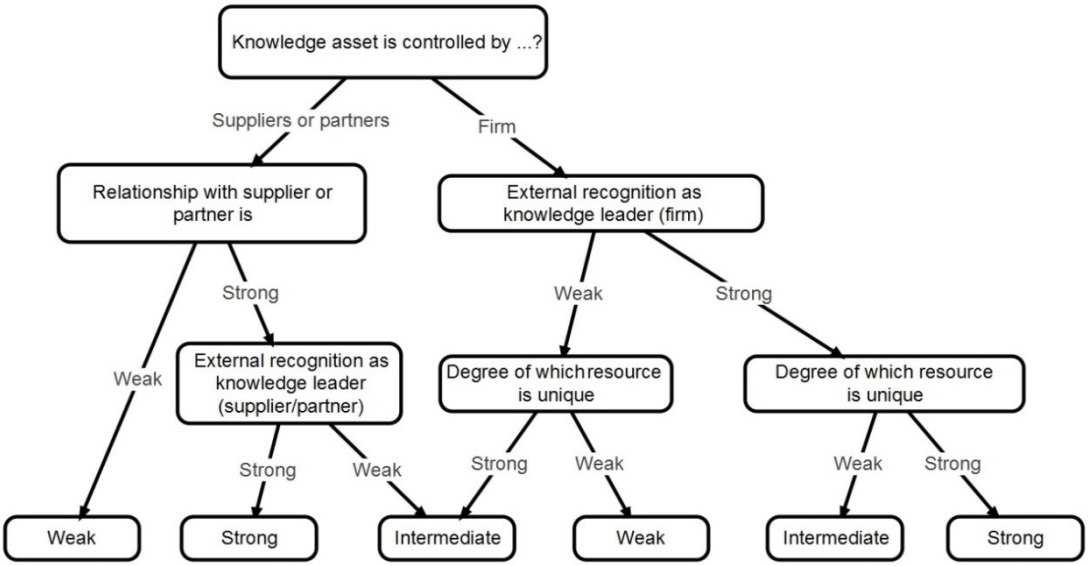


Figure 25. Degree of control a firm has over a specific knowledge asset[16]

[16] Modified from originals in article: Birchall, D. B. & Tovstiga, G., 2002. Assessing the firm's strategic knowledge portfolio: a framework and methodology. International Journal of Technology Management, 24(4), pp. 419-434.

Table 17. Summary of how to assess knowledge competitive impact and firm control

Method for collecting data:	Interview with department manager to; • Classify knowledge assets to determine their respective competitive impact; each knowledge asset will be ranked according to the question sequence in Figure 22. • Rank firm control over knowledge assets; each knowledge asset will be taken through the decision-tree in Figure 23. Estimated interview time: 80 min
Outcome:	Classification of knowledge impact on competitiveness and level of control the company has over the specific knowledge asset.

Step 7. Strategic recommendations from knowledge assessment

As for the strategic assessment, it will follow the framework provided by Birchall and Tovstiga. From the classifications in the previous step a diagram is created, with competitive impact of a knowledge asset on one axis, and, with the firm's control over the knowledge asset on the other axis (see framework in Figure 26). Thus, the two classifications are combined to provide strategic recommendations. The different managing actions suggested in their model are seen in Table 18. A summary of how to perform this step is shown in Table 19.

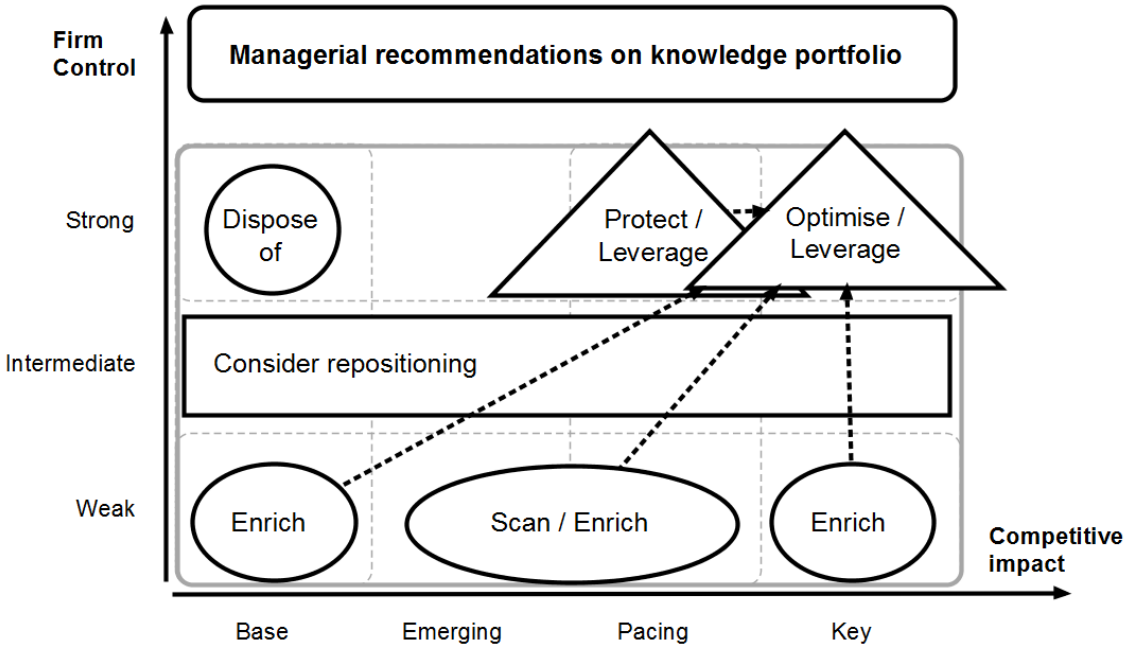


Figure 26. Strategic recommendations from the SKPA model[17]

[17] Modified from originals in article: Birchall, D. B. & Tovstiga, G., 2002. Assessing the firm's strategic knowledge portfolio: a framework and methodology. International Journal of Technology Management, 24(4), pp. 419-434.

Table 18. Available recommendations for managerial actions from the knowledge portfolio assessment (Birchall & Tovstiga, 2002)

Action	Description
Scan	This action is done when realising that knowledge can come from a broad range of sources, thus, a scanning of available information should be made to discover threats and opportunities in the company environment.
Protect	As the name reveals, this action means to protect the knowledge portfolio, both from external and internal sources (competition respective malpractice).
Enrich	Here the most growing part of the business environment is to be nurtured; this could be done by forming strategic alliances, acquisitions, or internal competency building.
Optimise	By refining knowledge assets to meet contemporary needs and increasing the company's control over it, the asset is optimised.
Leverage	Here the goal is to exploit the knowledge asset to its fullest; this could be done by focusing or recycling the knowledge, but also by converging with current assets.
Dispose	Simply to remove all, or parts of, a knowledge asset.

Table 19. Summary of how to create a strategic recommendation map

Method for collecting data:	For each knowledge asset, use the provided strategic recommendations in Birchall and Tovstigas article and framework, see Figure 26.
Outcome:	Recommendations of suitable managerial actions to improve the knowledge portfolio.

Estimated interview time required for the entire evaluation was 4h; however, this number is merely approximate and will vary depending on available prerequisite information and on evaluation scope.

4.5 First implementation test of model

To verify the steps of the model, the estimated time for performing each step, and remove flaws before the actual company test, a general-rehearsal for the model was made with the help of a student colleague. This student evaluated his own knowledge assets from when he performed a thesis for a company a year back. Though he did not possess the knowledge that a manager (ideal case for the evaluation) would have, it was thought enough for this initial evaluation of the model. Below, the results from this student test are presented. For each step, the methods described above in the explanation of them were used. To keep the company of which the interviewed student had worked in anonymous, some company specific information has been modified, this is visualised with ‘’ marks.

Step 1. State mission, vision and organisational objectives

Vision:

> *"Increase access to and consistency of 'positive results from offered goods and services' everywhere."*

Objective:

> *"Together make 'our industry' technology more impactful and accessible to 'customers and lead users in our industry'"*

Required time for this step was 3 minutes of explaining and 2 minutes of actual interview time, thus 5 minutes in total.

Step 2. Identify Key Success Factors

Identified Key Success Factors of the example firm within its industry (also firm position in industry; leading, average or lagging) are shown in Table 20.

Table 20. Key Success Factors for firm in the general rehearsal of model

Key Success Factor	Positioning
Access to 'lead users'	Lagging
Products that are; easily useable, have a steep learning curve, and, save time	Average
High accuracy of 'specialist products in our specific sector'	Average
Balance between effort and outcome	Average

Required time for this step was 5 minutes of explaining and 10 minutes of actual interview time, thus 15 minutes in total.

Step 3. State performance objectives

This section and further steps are to be done on a departmental level. However, in this test case they are investigated on an individual level. The student participating in the test wrote a thesis at the example company and the evaluation was made from his point of view, thus, the performance objects for his thesis work are stated here, in Table 21. Required time for this step was 5 minutes of explaining and 10 minutes of actual interview time, thus 15 minutes in total.

Table 21. Performance objectives for student's thesis

Performance Objective (PO#)
PO1. Test accuracy and compatibility of different CAD models
PO2. Review found failures manually
PO3. Write and present internal reports, firm guidelines
PO4. Write thesis, according to scientific guidelines
PO5. Keep correspondence with suppliers

Step 4. Identify knowledge elements from performance objectives

For each performance objective, knowledge elements needed to fulfil the objectives were identified by the interviewee. In total 10 elements were identified, simultaneously the elements relation to the performance objectives was assessed by the interviewee.

The resulting Matrix of Direct Dependencies, also including the relationship between the knowledge assets and the objectives is showed in Table 22, and, an AHP map illustrating the same is shown in Appendix 2. The matrix was done simultaneously as the interview, whereas, the AHP was done afterwards. Required time for this step was 5 minutes of explaining and 20 minutes of actual interview time, thus 25 minutes in total.

Table 22. Matrix of Direct Dependencies of the identified knowledge assets and their performance objectives

Performance objective/ Knowledge Element:	**PO1. Test accuracy and compatibility of different CAD models**	**PO2. Review fails manually**	**PO3. Writing internal report and present**	**PO4. Write thesis**	**PO5. Correspondence with suppliers**
KE1. How 'industry specific' procedures work	□	■		□	
KE2. How software works (that uses the CAD models)	■	■		□	□
KE3. What defines the CAD models - which measurements that are important, what accuracy means in relation to the 'products'	■	■	□	□	■
KE4. How to write thesis well (scientific standards)				■	
KE5. How to write firm reports (qualitative management tools)			■		□
KE6. How CAD file formats work and differ	■	■	□	□	
KE7. How to use a CAD software		■	□	□	□
KE8. Knowledge in basic geometry and math	□	■		□	
KE9. Word processing and image processing			■	■	□
KE10. Theoretical scientific background (research)		□		■	
** Knowledge object formulation has been modified to keep test company anonymous*	■ = Strong relation, □ = moderate relation, " " = no relation				

In both the matrix and AHP visualisation, the complex relations between the knowledge assets and their performance objectives can be seen. Or rather, how a knowledge element relates to several performance objectives in strong or moderate fashions. In the two, the performance objective with the most directly/strongly related knowledge elements (6/10) was to "review fails manually". That is, a performance objective is demanding actual application of knowledge as well as evaluation of results, and, individual decision making. The performance objective relating to most knowledge elements, with no consideration of the strength of the relation, was the actual writing of a scientific thesis – the only element it did not relate to was how to write internal documents.

Looking at the matrix from another perspective, the knowledge element with strong correlations to the most performance objectives was element 3 (What defines the CAD models), it related to all the performance objectives though only strongly to three (out of five). This element was closely followed by number 2 and 6 (how software works, and, how CAD file formats work and differ, respectively). Hence, the elements correlating to more performance objectives were the ones of a more applied nature. That is, they were theoretical but applied in the sense that they were specific for the set task. In contrast, the elements with the least number of correlations to the performance objectives were number 4, 5 and 10 "How to write thesis well (scientific standards)", "How to write firm reports (qualitative management tools)", and, "Theoretical scientific background (research)". Where the first two consist of guidelines to follow and, the third consist of the ability to gather information.

Step 5. Classify knowledge assets, and Step 6. Perform competitive analysis of knowledge assets

The final part of the interview, the classification and competitiveness assessment of the knowledge assets are summarised here, see Table 23. First, the level of tacit or explicitness was examined. For this evaluation the provided decision tree (Figure 23) was used, where 1 is high degree of tacitness whereas 6 is explicit (low tacitness). What was interesting in the test was that only one of the elements, number 2 "How software works (that uses the CAD models)", was highly tacit, therefore bound to the firm. The other elements were all either fives or sixes, thus explicit and obtainable for all who sought to obtain them.

Following, the decision trees determining a specific knowledge's competitive impact, and, the degree of control the firm had over it, were applied. For the competitive impact the alternatives were; emerging, pacing, key, base, and minor (as explained in chapter 4.4 Step 6). This of course related to the decision tree considering the firms KSF's. Within the students thesis work, several knowledge elements with a "key" impact were found (number 1-4, 10), that is they had a major impact on the firms value creating process. All the other (5-9), had were base or minor knowledge, meaning they had minor or no impact on the competitiveness. As to the degree of control the firm had over the assets, it could be strong, intermediate or weak. Amongst the identified elements, the firm only had strong control of one of them (number 2) and intermediate control of one (number 10), as for number 10 is was thought of as intermediate as the firm could control the amount of energy put into research, and, not in the aspect as it provided the research or was a leading contributor.

Table 23. Knowledge elements level of tacit, competitive impact and firm control from student test

Knowledge element:	Tacit/ Explicitness:	Competitive impact:	Firm control:
KE1. How 'industry specific' procedures work	6	Key	Weak
KE2. How software works (that uses the CAD models)	1	Key	Strong
KE3. What defines the CAD models - which measurements that are important, what accuracy means in relation to the 'products'	6	Key	Weak
KE4. How to write thesis well (scientific standards)	6	Key	Weak
KE5. How to write firm reports (qualitative management tools)	6	Minor	Weak
KE6. How CAD file formats work and differ	6	Base	Weak
KE7. How to use a CAD software	6	Base	Weak
KE8. Knowledge in basic geometry and math	6	Base	Weak
KE9. Word processing and image processing	6	Minor	Weak
KE10. Theoretical scientific background (research)	5	Key	Intermediate
Time required for interview:	4 min	8 min	6 min
** Knowledge object formulation has been modified to keep company anonymous*			

7. Strategic recommendations from knowledge assessment

From the summarised knowledge portfolio, in Table 23, a graph founding strategic recommendations on managerial actions was drawn in accordance with the model by Birchall and Tovstiga (SKPA), see Figure 27.

Of the ten identified knowledge elements needed for the student to write his thesis, as many as six were key or base with a low amount of company control. Base knowledge is on the limit to uselessness and key is necessary for adding value in the products/service development. Though, when these types of knowledge have a low firm control, they ought to be enriched. Thus, the knowledge should be nurtured to increase the value adding to the company's offer. This cultivation can be done via internal competence building, acquisitioning or forming of strategic alliances.

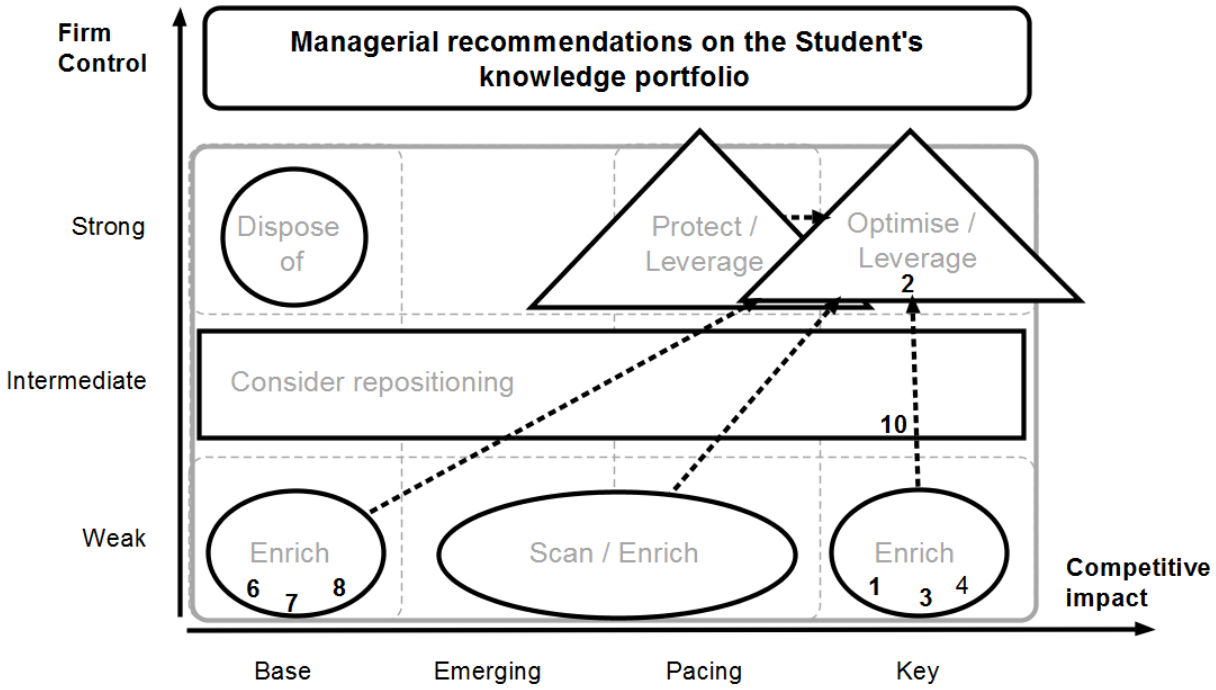


Figure 27. Graph of the students' knowledge portfolio

However, by looking individually at each knowledge element, which is more sensible, a better, more accurate observation can be made. For example, number one and three are highly important for the company yet under low control as it is public information, thus enrich seems a good recommendation. Whereas, number four, "how to write thesis well" is on an individual level, and, though it might need enriching only the student himself can impact this element and therefore it is quite irrelevant for this evaluation. Especially since the company will never be able to control this, as interns only stay a short time, and, as knowledge on how to write a thesis will always be a key knowledge only for the individual never for the company.

Knowledge element 6-8 are also in the enrich section, and are all base, thus, not having any mentionable impact on competitiveness. But, they were needed for finishing the thesis work. As the company deals with tasks in CAD, they are all necessary though they are likely to remain base knowledge, and, although the company might increase control over them by providing in-house learning they are so basic they are not likely to ever provide much impact on the competitive advantage of the firm. Furthermore, as one can see in Figure 27, if the knowledge is base and reaches high firm control, the amount of energy put on this asset is too high making the effort obsolete (as the recommendation would be to dispose of the knowledge).

Moving on, elements five and nine are minor with weak firm control, thus even outside of the graph. Reasons for this is that they are competences possessed by the individual and no in-house training was given for the intern/student on arrival. Even though these elements would were not included in the SKPA illustration, they were included here as they were believed to increase in potential. For example, though element nine "Word processing and image processing" could be developed into a base/key knowledge, as proper word and illustrations might improve the level of communicativeness, thus aiding the selling of an idea or enabling of understanding of a concept. The same goes for element five, "How to write firm reports", a better report might increase likeliness of understanding by the reader for example.

Next, element number ten "Theoretical scientific background" refers to the students' ability to gather research for the thesis, and with the portfolio status being to "consider repositioning". However, for this question the proper answer on firm control was difficult for the student to determine. If looking at the question individually, the level of control the student himself had over the performed research was high; however, from the view of the company it would have a low control of the students performed research. Thus, the answer resulted in the middle, intermediate, which might not give an honest view of the situation. If focusing on the individuals thesis work, the level of control is high, thus the recommendation would be to optimise or leverage the knowledge instead. As for if the perspective was from the firm, the proper recommendation would be to enrich it, perhaps by increasing use of lead user feedback.

Finally, element number two "How software works", lies in an ideal position in the graph, the leverage/optimise triangle. With this, Birchall and Tovstiga mean to continuously refine the knowledge asset so that it better meets the current requirements; in addition, by leveraging they mean to increase control and retrieved value from the knowledge by recycling, concentrating, or converging with work in different areas of use. With this, the firm would increase its control over strategically vital knowledge assets.

Furthermore, from this test run of the model, some feedback on the execution was given. First, the student recommended using a sound-recorder to minimise time required for the interview – thus eliminating part of the need for note taking. Furthermore, when asked the questions in the last steps, the ones containing decision trees, the student was given illustrations of the schemes to increase understanding and efficiency. This was something positive according to the interviewee. Required time for the entire test was approximately 80 min.

4.6 Model implementation at Test Company

For the actual test of the model, at a company, a number of firms in the area of Munich working with some version of PD were contacted, mainly via email. In the end, a company branch working in the general media industry, decided to participate in the application test of the model.

In the general rehearsal for the test, approximately 80 minutes were necessary, and for the real test an approximate of the double of required time was made. This assumption was made as all steps could not be covered completely by the student in the previous test, also as his project was quite small when comparing to the work of a department, thus identifying less knowledge elements needed to reach the objectives. However, a demand from the test company's interviewee was that the interview could take maximum 90 minutes. Therefore, more preparations, with questions more specific to this company were prepared; also, some information was gathered in advance. In addition only the necessary steps of the model were decided to be used to rationalise the interview, thus, the shortened model scheme in Figure 28 was used.

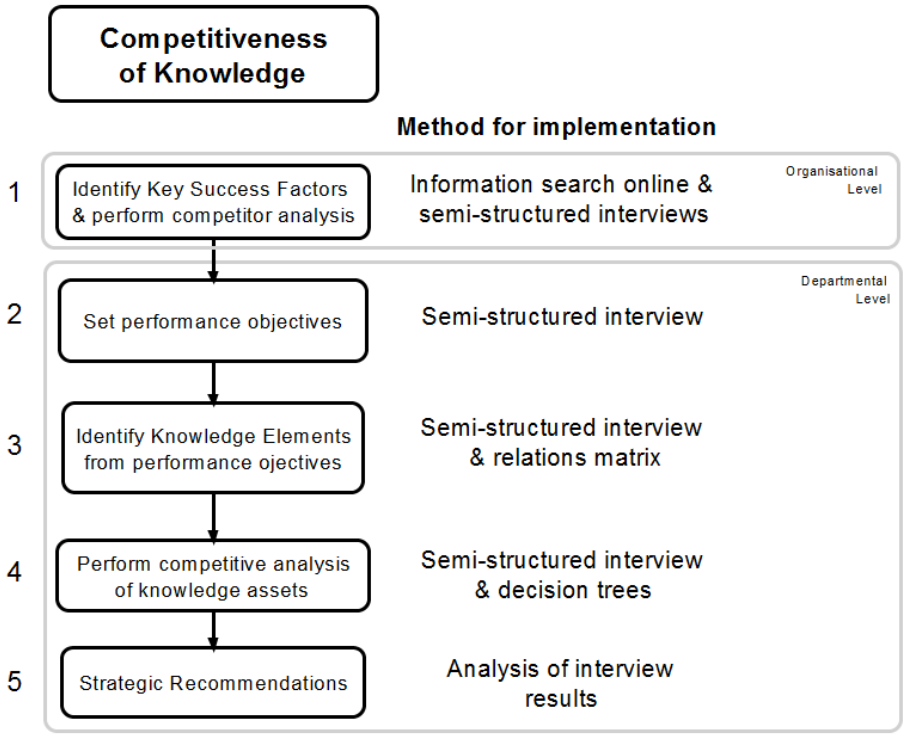


Figure 28. Model scheme for evaluating competitiveness of knowledge, shortened version for company test

Introducing the test company, the part of the company used for the test application of the knowledge evaluation model works with general media solutions. For this evaluation a specific department was evaluated, this department stand for a certain product family in the company. Their offers are produced by a Research and Development (R&D) team, consisting of less than ten members, which was the team evaluated here. The team offers individual consulting, and customisation or modularisation, to provide the customers with exactly what they need.

1. Identify Key Success Factors and perform competitor analysis

Initial step, of this shortened evaluation model was to identify factors that are vital for the company in its industry, what it needs to survive the competition, its KSF's. Below, in Table 24, is the resulting list of crucial elements. The firms' performance on KSF compared to its main competitors was also assessed; either the company is leading, average or lagging. This step was done both to retrieve a competitive overview, and to verify the chosen KSF and to get an insight of their relative importance.

Table 24. KSF's of the Test Company and firm positioning in industry concerning set KSF's

Key Success Factor	Positioning
Ability to generate innovative and individual solutions, in an appropriate time period and to a reasonable cost, to create intimate customer relations	Leading
Agility in organisation (ability to follow market and technology trends)	Lagging
Flexibility in production (ability to handle a heterogenic production base)	Average
Complexity management in handling product portfolio, optimisation, organisation, business plans, production, procurement	Lagging
Ability to have attract and place the right people in the right places, especially in sales and production (Human Resource and recruitment capability)	Average
Interview time: 20 min	

From the table, one can see that the firm is lagging behind its competitors on two of its identified KSF's. Concerning the KSF "Agility in organisation", they have a lagging position in their ability to follow industry trends. As for the KSF regarding "Complexity management in handling…", it is lagging due to reorganisations in the company. A couple of years back they moved from having independent business units, with separate personnel, product design, production departments and more, to finding synergies and creating a matrix structured organisation with integrated business units. So far they are still in the beginning steps of this reorganisation, thus, a KSF specific for the firm is their ability to get through this complex change, create transparency and fully commit to the new structure. Also to make use of the change and optimise benefits.

The leading KSF concerns innovation, customer intimacy and product individualisation. Most of the firms' innovation is on an incremental level, taking an idea changing it slightly, or taking an idea from a different industry and giving it a new area of use. Especially in the team, to which the interviewee belongs, the customer intimacy is high as they provide precisely what their customer needs, thus contributing to the leading positioning. Another contributing aspect here is the high employee spirit and motivation, really believing in the firm and its goals.

By “Flexibility in production” the interviewee means the firm’s capacity to handle production with numerous materials and different set-ups, which is necessary for the company. For this KSF, the firm is in between leading and average, however average was chosen due to the rapid developments in the industry and though the firm is keeping up fairly at the moment, the situation tomorrow could be different due to set up times. In the average KSF about recruitment and Human Resource Management, the intricacy lies in the variation of the firm’s customers; all from large Key Accounts standing for large parts of the firm incomes to small customers hardly giving any revenue, but that might provide foundation for future innovation.

2. Set performance objectives

The performance objectives identified by the interviewee were both for the team, and for the entire company, and were what the interviewee thought needed attention in a near future; the three identified objectives are listed in Table 25.

Table 25. Performance objectives of Test Company

Performance Objective (PO#)	Comment
PO1. Realise technology projects	Fulfil project portfolio
PO2. Optimise project management abilities	Prioritisation and follow through of projects is currently lagging, needs more optimising
PO3. Optimise business processes between business units in company matrix	The firm is still accustoming to the new matrix organisation of the company
Interview time: 5 min	

3. Identify knowledge elements from performance objectives

From the set performance objectives, knowledge resources required to fulfil the objectives were listed. By considering one objective at a time, 17 objects were identified, and then their relation (strong, moderate or none) to the objective was determined. Result from this step is shown in Table 26. From this table, an AHP map was made, see Appendix 3.

Table 26. Knowledge elements, performance objectives, and their relation in the Test Company

Performance objective/ Knowledge Element:	**PO1. Fulfil project portfolio, realise technology projects**	**PO2. Optimise project management abilities**	**PO3. Optimise business processes between business units in company matrix**
KE1. Project management skills	■	■	□
KE2. Communication skills	□	■	■
KE3. Supplier relations management	□		
KE4. Programming skills	■		
KE5. Decision making skills	□	■	■
KE6. Prioritisation	■	■	□
KE7. Ability to work with project management software	□	■	
KE8. Resource management	■	■	□
KE9. Project portfolio management abilities	■	■	□
KE10. Ability to use external training resources	□	■	□
KE11. Ability to use internal training resources	■	■	■
KE12. Consequent implementation of concepts	□	■	■
KE13. Overcoming "not invented here" syndrome	□		■
KE14. Clear separation of tasks	□	□	■
KE15. Industry specific technical knowledge *	■	□	
KE16. Industry specific material knowledge *	■		
KE17. Industry specific product knowledge *	■		
Interview time: 35 min			
** Knowledge object formulation has been modified to keep test company anonymous*	■ = Strong relation, □ = Moderate relation, " " = No relation		

4. Perform competitive analysis of knowledge assets

With aid from the decision trees for determination of competitive impact and firm control of knowledge assets, characteristics for each asset was determined according to the list in Table 27. For the competitive impact the alternatives were; emerging, pacing, key, base, and minor), which, related to at what extent the asset contributed to the firms value chain and thereby its KSF's. As to the degree of control the firm had over the assets, it could be strong, intermediate or weak.

Table 27. Competitive impact and firm control of knowledge elements at Test Company

Knowledge element:	**Competitive impact:**	**Firm control:**
KE1. Project management skills	Key	Weak
KE2. Communication skills	Base	Intermediate
KE3. Supplier relations management	Key	Strong
KE4. Programming skills	Pacing	Intermediate
KE5. Decision making skills	Pacing	Weak
KE6. Prioritisation	Pacing	Weak
KE7. Ability to work with project management software	Key	Weak
KE8. Resource management	Pacing	Weak
KE9. Project portfolio management abilities	Pacing	Weak
KE10. Ability to use external training resources	Pacing	Strong
KE11. Ability to use internal training resources	Pacing	Strong
KE12. Consequent implementation of concepts	Base	Weak
KE13. Overcoming "not invented here" syndrome	Base	Intermediate
KE14. Clear separation of tasks	Pacing	Weak
KE15. Industry specific technical knowledge*	Key	Strong
KE16. Industry specific material knowledge*	Key	Weak
KE17. Industry specific product knowledge*	Key	Weak
Interview time: 30 min		
** Knowledge object formulation has been modified to keep test company anonymous*		

Most elements were identified as Key (six components) or Pacing (eight components), which of course relates to the method for identifying knowledge elements. When first, identifying KSF's to then identify goals, to then find object, only the important resources will be identified. With some exceptions, three base knowledge elements were identified.

However, what seemed to surprise the interviewee more was results from the next step; the degree of firm control. Whereas, strong resources had just been identified, the level of control the firm had over them surprised the interviewee. In total the firm has weak control over ten elements, of these; nine were also either Pacing of Key, thus, vital.

5. Strategic recommendations

From the resulting characteristics of the knowledge elements in Table 27, a recommendations map was drawn, see Figure 29.

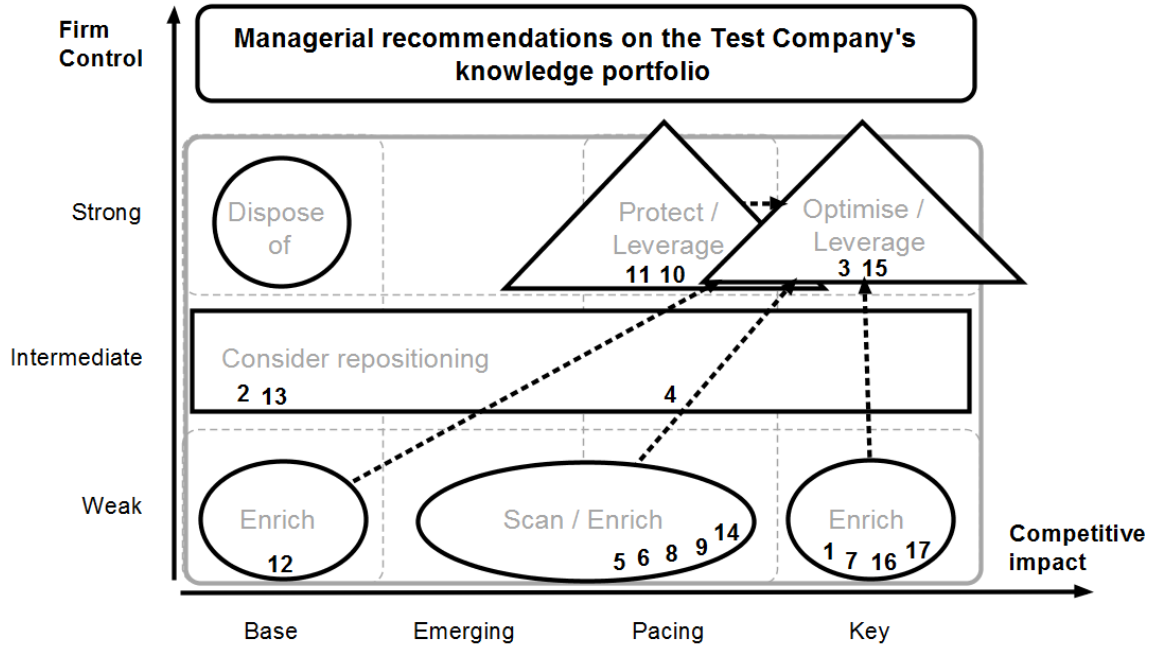


Figure 29. Knowledge portfolio recommendations map for Test Company

Starting on a positive note, object number 3 (Supplier relations management) has an optimal position together with object 15 (Industry specific technical knowledge), meaning they should be optimised or leveraged. Returning to the definitions of these, from the model by Birchall and Tovstiga, optimise refers to increasing control of and refine assets to fulfil current needs, thus, keeping up the good work and keep the knowledge up to date. Which I believe, specifically applies to number 15, hence, continually improving and developing the knowledge that creates leverage for the firm.

Moreover, the action leverage refers to exploiting the knowledge completely, either by recycling it or by adjusting it to contemporary needs. This leveraging, I consider, especially applies to number 3 (Supplier relations management), this as the interviewee implied that this is a strong capability of the team in the assessed department, but perhaps not as strong in other business units of the company. Therefore, promoting learning from the best, within the company, would be an appropriate action. Furthermore, by also including the relations to performance objectives, number 3 is only moderately related to one of the performance objectives (PO1. Fulfil project portfolio), thus its importance could be questioned, if it was not for the first KSF ("…to create intimate customer relations"). Continuing, number 15, contributes highly to the value creating process and has a strong impact on especially the first KSF ("Ability to generate innovative and individual solutions…"), it also has a strong correlation to the first performance objective (Fulfil project portfolio) and a moderate relation to the second concerning project management abilities.

Moving on, knowledge elements 10 and 11 focusing on exploitation of training opportunities (external and internal respectively), fall under the managerial actions protect or leverage. By protect what is meant is to conceal aspects from competitors or to prevent mismanagement within the company, where the latter of the two is more applicable to the situation here. However, for both of these knowledge elements the second recommendation, leverage, might be more suitable. Meaning higher exploitation of what the company has, really using its knowledge in training and the available resources. According to the interviewee there are many training opportunities available for the firm's employees and much knowledge available as well, however partially due to the recent reorganisations the knowledge is not exploited, as the old boundaries between the businesses units still linger.

Together these two training elements strongly relates to especially the KSF concerning complexity management, creating transparency throughout the organisation. In addition, they relate to the all the other KSFs as well. Moving down a level in the organisation, the use of internal training resources (element 11) strongly relates to all of the set performance objectives, whereas, the external training object (number 10) only has a strong correlation to the second performance objective and moderate to the other two. This, as the first (fulfil project portfolio) and third (optimise business processes) performance objective mainly are internal problems that cannot involve much learning from the outside (due to specialisation and firm privacy), whereas learning from external sources in project management simply means learning from best practice.

For the elements 1, 7, 12, 16, and 17, the recommended action is to enrich the knowledge. This part of the knowledge portfolio, is thought to be the most growing (Birchall & Tovstiga, 2002) and therefore the part in most need of nurturing. Essentially all of them need a stronger degree of firm control but there are several ways of approaching this.

Considering the elements in need of enrichment individually, the first (Project management skills) could for example be enriched by internal competency building. Closely related to this is element number seven (Ability to work with project management software), which, also mainly requires more internal training to exploit resources to the fullest. In addition, acquisitioning recognised programs, with appropriate training, could be considered. Both of these elements, of course, relates strongly to the second performance objective (optimising project management abilities), and slightly to the other (see Table 26). Moreover, both are Key knowledge's as they relate strongly to the KSF's regarding innovation and product/offer development but also the one about complexity management.

Subsequent, element 12 (Consequent implementation of concepts), which referred to the current inconsistency in project implementation, also relates more to the internal processes of the enriching recommendation, thus, requiring better availability and implementation of qualitative management tools to create a synergy in the company. Overall, not only the firm control over this asset needs improving, also the exploitation of it to ensure it fulfilling its value creation potential.

Succeeding, elements 16 and 17, industry specific knowledge in materials and products respectively, are also in need of enrichment, this as they are Key knowledge's and, thus, vital in the value creating chain, but the firm control over them is low. This low control has to do with ownership and origin of the knowledge, they are controlled by suppliers (which also are partners depending on the situation) and the relationships with them are weak. Hence, the larger solutions for enriching the knowledge, such as forming strategic alliances or acquisitioning, should be applied here to strengthen the level of firm control.

For the elements 5, 6, 8, 9, and 14, they all relate to judgement making in projects/teams and the recommended action is to enrich and/or scan the knowledge. As explained earlier, enrich focuses on nurturing the knowledge, whereas, to scan the knowledge means to review available sources of information to discover opportunities or threats. In general what is sought for these elements with low firm control and high potential impacts on KSF's is increasing control and fully investigate future potential to exploit it.

Element number 5 (Decision making skills) and 6 (Prioritisation) are more on a know-how level and could be improved with better in-house training, knowledge/experience recycling or better guidelines and/or spreading of guidelines within the company rather than scanning for new potential sources of information. That scanning could however be applied for the elements 8 (Resource management) and 9 (Project portfolio management abilities) as information and experiences from other branches, or literature, could be helpful in improving these, possibly in combination with enriching by in-house training. As for element number 14 (Clear separation of tasks), it is also an in-house activity, that more requires better communication and guidelines within the firm, than training or scanning per se.

Succeeding, elements 2, 4 and 13 all fall under the "consider repositioning" recommendation. Here the recommendations from the original model are scarce, the only advice it provides is to consider each element individually and review the possibilities for altering their position. First, element 2 (Communication skills) is a base knowledge and is likely to remain as such, as it is common for most companies, teams and individuals, though still a necessity. Moving on to number 13 (Overcoming "not invented here" syndrome) the case is similar. Both number 2 and 13 focus on communication and here the relevance of the objects being used in the model can be question rather than the elements actual value, as not many companies have a status as knowledge leaders in communication or overcoming internal barriers. Some companies are good at this, no doubt, but for determining the competitiveness of the knowledge assets it is quite irrelevant whether these specific assets make the firm a knowledge leader. Finally, number 4 (Programming skills) has a status as pacing, but with intermediate control. The intermediate status here was set as the firm's suppliers control the knowledge, and though the relationship to the supplier is strong, the supplier is not recognised as a knowledge leader. In this case, an overlook of which supplier to use might be relevant, also consider using in-house competence and/or recruiting people with this knowledge instead could be considered.

Feedback on model

After the interview, the interviewee was asked to give some feedback on the model, likewise, the interviewer realised some areas of improvements during the interview, and these are pointed out here. First, with using this approach of identifying knowledge elements only important elements will be identified (finding key success factors, then important performance objectives, to then find key knowledge elements need to fulfil them). And though this was the purpose with doing it this way, the later stages were not considered enough. For instance, in the company test, most of the elements turned out to be pacing or key, thus important aspects, the less vital were not identified. And as mentioned, this was the idea, however, which means the full recommendation map is likely never to be needed.

Furthermore, the interviewee thought the used decision trees (Figure 24, Figure 25) very helpful for organising thoughts and creating structure in the interview. The same case was for the use of the model overview (Figure 28) that worked as a sort of agenda for the interview. Though, in the decision trees the interviewer noticed some reformulations that could be made to increase understanding and simplify for the interviewee, this could for example be switching “indispensable” for “essential” or “necessary” (Figure 24). Another, more serious, weakness with the decision trees formulations is in the one determining impact on competitiveness (Figure 24), where the interviewee had to determine whether the knowledge had high or low exploitation. For example, there were several cases when the interviewee stated that they had the knowledge, but needed more, thus, the knowledge was highly exploited. However, more focus should have been put on the actual use of the knowledge, and its benefits for the firm, in answering this question. More clarifying questions from the interviewer would also have been appropriate here. Another way of enhancing the evaluation would be to, in the impact assessment step, weigh the knowledge elements against each respective KSF, to really get an overview of their relation.

Moving on, it is worth noticing that the same interview scheme could get very different results when interviewing different individuals, even within the same company. However, this is a common weakness for many qualitative studies. In addition, although of the gathered information in the interview was supposed to be specific for this department; much of it was applicable for the entire company according to the interviewee. A common mistake in knowledge evaluation is looking at the whole firm at once, instead of the resources of individuals or teams (Haas & Hansen, 2005). For the test here, the student considered himself and the test company considered a rather small team, yet they both thought it applicable for larger part of the company. Therefore, the level of evaluation perhaps was a little too abstract. A positive feedback for the model was its gap-analysis, aiding in the identification of what a company is good at, while recognising weaknesses in the handling or control of those competencies.

Finally, even though the model was shortened for this interview, it took longer than anticipated, about 30 minutes. This could also have to do with the level of the interview technique, and consistency in following the set agenda.

4.7 Literature support for model application in PD

In answering the second RQ, another literature review was performed. This to investigate the applicability of the evaluation model could be helpful especially for companies working with PD. And although there is much literature available combining the subjects PD and KM or KE, not many articles combined or evaluated use of the concepts in combination. In this chapter, however, a summary of the results and current discussions in literature is presented.

In general the importance of knowledge management in service companies is high due to the intangible characteristics of services, their high customer involvement, and their knowledge intensity (Edvardsson & Oskarsson, 2011), and their complexity (Evanschitzky, et al., 2007). Subsequently, the same general assumption is correct for PD, as PD also is a knowledge intensive activity (Prieto, et al., 2009). Effective knowledge management could also be a prerequisite for reaching success in service firms with high knowledge intensity (Evanschitzky, et al., 2007). Furthermore, evaluating knowledge assets build to a firm's understanding of its competitive position, and can aid in forecasting future challenges. (Lerro, et al., 2012) In any way, to capture and cultivate knowledge to empower business capacities is a vital activity in this knowledge economy (Wang, et al., 2011).

Sustaining competitive advantage is a process needing constant work. Chaharbaghi and Lynch liken competitive advantage with a journey rather than a destination. This journey alters with market tendencies and the challenge for companies is to identify this process, experience it and exploiting it. A common problem with knowledge management initiatives is that they do not consider the vivacity of a competitive environment, and how companies' constantly need new capabilities and assets as settings shift. (Chaharbaghi & Lynch, 1999) Simultaneously, there are some famous success cases from companies gaining competitiveness by assessing their competencies, employees, and customers. The most noted example might be Skandia, Swedish insurance company that has increased their productivity, improved their image and increased incomes by valuating their intangible resources. Another success example is Abbot Laboratories that significantly increased profitability and productivity by assessing the capabilities of their employees. (Holsaple & Singh, 2001)

The posed research question sought whether the model specifically could have any use in product development processes. According to Prieto et al, product development is a knowledge intensive activity, which, aims to construct new knowledge, or recycle from other areas of use, to innovate and keep up with market fluctuations. In fact, they claim firms success depend on their ability to continuously create and share new knowledge, mainly in product and service development teams. (Prieto, et al., 2009) Experience and know-how in engineering design is, according to Wang et al., the most valuable resource a firm has. Thus making the managing of this information is one of the most important aspects of engineering knowledge management. (Wang, et al., 2011) Moreover, this knowledge intensity has to be a balance between exploration of new knowledge and exploitation of already available knowledge resources. For a firm to gain competitive advantage from knowledge, they have to have an understanding of factors influencing the product developments ability to obtain, construct, and apply knowledge. (Prieto, et al., 2009) Thus, require a more general perspective, than the proposed model in this thesis.

In theory there are five main reasons for measuring knowledge resources; to aid in strategy formulation, to assess strategy implementation, to aid in exploiting decisions in planning and expanding, to use as a foundation for compensation, and to inform stakeholders. (Marr & Spender, 2004) The sought use for the specific model here was mainly in PD, thus in general the purposes fit at least in the strategy formulation and implementation as well as in planning of PD, however, whether this specific model actually is useful need further determination.

5 CONCLUSIONS

The conclusions are based on the implementation of the thesis work and intend to answer the research questions presented in Chapter 1.

In the beginning of this thesis two main research questions were posed. First of all, whether it would be possible to evaluate the competitiveness of individual knowledge assets was asked. After a first literary review, the answer to this question is yes, this as there were several models in literature attempting to do this, with different approaches, see chapter 4.1. However, when initiating the search, some requirements of a model evaluating the sought competitiveness were set (Chapter 4.2). This as competitiveness can mean a number of things in different settings. The models found in the first literature review all evaluated competitive of knowledge or resources somehow, but not all in a relevant manner.

After evaluating the models, some aspects from two of them were chosen and merged for the evaluation to fulfil the sought goals for this research. These were SKPA by (Birchall & Tovstiga, 2002) and KAVCM by (Carlucci & Schiuma, 2007). The resulting model scheme, see Figure 30, corporates parts from the two models and was meant to streamline the two, while merging, and to achieve a relevant assessment of competitiveness. The model is explained in detail in Chapter 4.4.

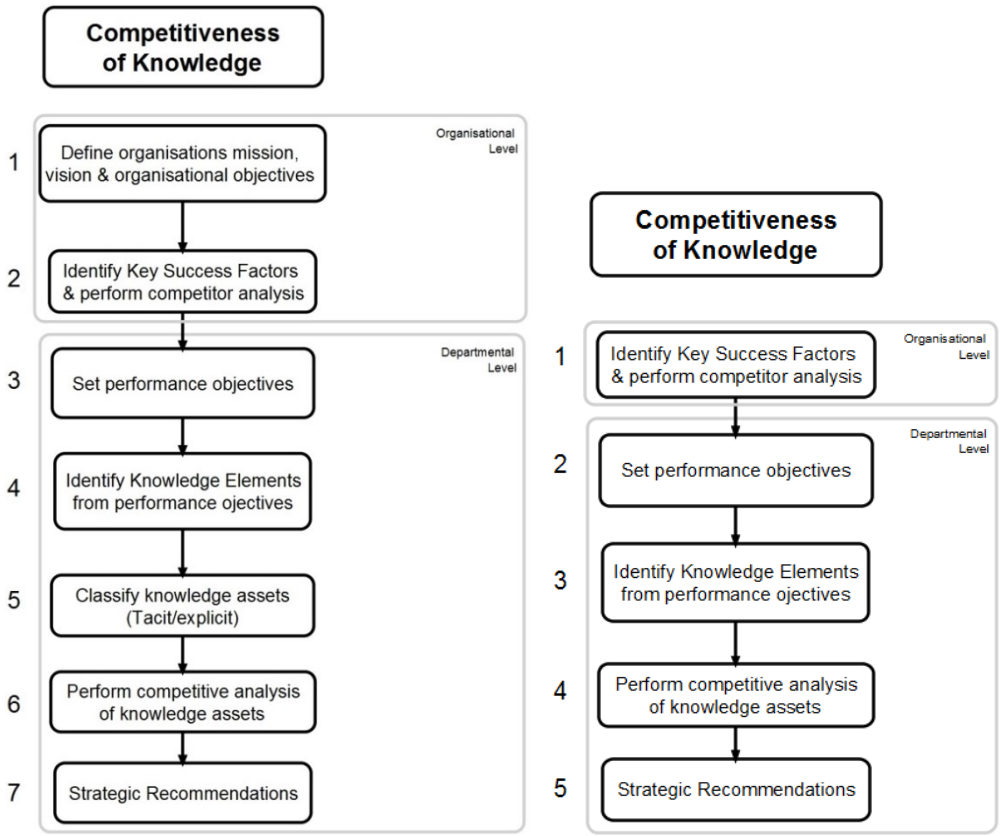


Figure 30. Model scheme for assessing the competitiveness of knowledge resources, full version (left) and shortened version (right)

Thus, it is possible to review the impact knowledge assets has on a firm's competitive position. Following, the first research question also questioned the usability of such an evaluation. Part of this question was answered by implementing the model at a company, second part by reviewing information in literature. This way both a specific and general feedback of the model could be given. First, from the company test, the interviewee identified the model as very helpful as it provided a sort of gap analysis, in identifying both important assets of a company but also as it recognised mismanagement of this knowledge. Moreover, the interviewee thought the model a good way to really think about the available knowledge portfolio, and its exploitation. Second, in literature only very general views on this kind of knowledge evaluation could be found. And, though this literature mostly add support to knowledge management and evaluation in general, feedback for a specific model was nearby impossible to find. Even for the founding models (SKPA and KAVCM).

Succeeding, an attempt to answer the second research question was executed by another search in literature. RQ2 sought actual use for the found model in product development processes. In general knowledge management and PD seem constantly intertwined in literature, this as PD pose high intangibility and requires creation of transparency and a shared knowledge base for the firms to succeed. The same goes for knowledge evaluation, which generally is an accepted approach to work towards this transparency. As to specific uses for the posed model in PD processes, not much could be found more than the identification of PD as a knowledge intensive activity, and such activities are in extra need of knowledge exploitation, thus also sharing and understanding. However, for companies initiating a shift in strategy somehow, where an understanding of the knowledge base and future needs are required, the model could be of special use. This, as it, if implemented correctly, could help identifying the required skill sets for the next steps, thus, allowing management to develop a plan of action.

6 DISCUSSION

A discussion of the results and the conclusions that the authors have drawn during the Master of Science thesis are presented in this chapter.

In seeking a model for the sought evaluation, a number of alternative methods were available. A literature review of some sort had been necessary as building any model requires knowledge of already existing frameworks, to not invent the wheel twice, however once that had been done an alternative could have been to build an entirely new model, whereas, here, the author chose to work from existing ones. Part of this was because of the relative low level of experience in the subject the author had, but also as there is relatively little literature on actually evaluating competitiveness of knowledge, thus making a point of reusing knowledge.

Moving on, the research approach was a mix between a narrative and systematic literature review. A completely systematic review has more use when really summarising all literature on a subject, whereas here, specific models and frameworks, and their reviews, were sought. However, with this mix, a certain level of biasness when selecting articles must be acknowledged.

Succeeding, the model itself, although built on two previous ones, essentially ended up as a shortened version of SKPA (Birchall & Tovstiga, 2002). This especially, as in the step with identifying knowledge and creating a matrix of dependencies an AHP map was to be created. And it was, however, with many knowledge elements the original matrix gave a better overview of the relations between the knowledge elements and their performance objectives. Nevertheless, although one might suggest removing this step, the knowledge identification knowledge from the KAVCM model (Carlucci & Schiuma, 2007) was still kept and incorporated. That is, identifying essential knowledge objects from performance objectives, rather than the process logic presented in the SKPA model, where additionally a preferred knowledge identification method was not presented.

Comparing this model with the founding models (chapter 4.1), SKPA (Birchall & Tovstiga, 2002) and KAVCM (Carlucci & Schiuma, 2007) some benefits and disadvantages can be identified. First, compared to the KAVCM, the numerical factors, rating of performance objectives for the AHP for example, were chosen not to be brought in here which removed some of the analytical aspects, thus increased the qualitative while decreasing the quantitative nature of the study/model. This elimination could be seen as both positive and negative; some research fields hold quantitative studies higher and in that perspective this thesis will have a low credibility, however, in removing this step, and purposely making the study qualitative in nature, no false belief in ratings that essentially are based on subjective data exposed to bias will exist.

Moreover, the new model is definitely less time-consuming than both of the founding models, although mostly from removing steps thought unnecessary, at least for the sought evaluation in this thesis. From the SKPA model, several elements were integrated into this one in their full, or with slight reformulations, however, many elements were also removed. In general, the SKPA model was quite elaborate, and for a complete assessment this might be useful, depending on the depth of the knowledge elements. For example, Birchall and Tovstiga made a point of classifying and placing the knowledge elements in the firm's value creation process, which could be useful, but also extremely time consuming. A classification that might have been interesting to add in the model is a hierarchal separation (Grant, 2010), that is to divide capabilities that are cross-functional, broad, activity-related, specialised or specific for single tasks. This, as it would provide a clearer separation between the identified knowledge elements.

According to Grant, two main factors determine whether a capability can create competitive advantage; scarcity and relevance. By scarcity he refers to the uniqueness of the resource in the competitive industry, this is taken into account in the competitive impact determination, partially in the first decision tree, knowledge exploitation, as well as in the second tree, firm control and resource ownership (Chapter 4.4 Step 6). Subsequent, relevance refers to how significant a resource is for the Key Success Factors in the industry, which is included in the first decision tree (Chapter 4.4 Step 6). Thus, the model proposed here ought to provide a fairly relevant evaluation. However, to sustain the competitive advantage the knowledge also has to have a certain level of durability, transferability, and replicability; none of which aspects are covered in the evaluation model. (Grant, 2010)

Furthermore, comparing the model to the other found frameworks (chapter 4.1), it is definitely more subjective and reliant on one person's knowledge, attitude and perspective than ICPA (Kale & Karaman, 2011), CRITICALKISA (Albors, et al., 2008), and WKCI (Huggins & Izushi, 2008). On the other hand, all three of them assess the knowledge on a much more abstract level, in knowledge clusters or expenditures, thus not going into the level of the knowledge elements themselves. Compared to the approach by Wilcox and Zeithhaml, the level of subjectivity is approximately the same, however with more guidance from the model itself in the one created here, moreover the new models steps (from the work of (Birchall & Tovstiga, 2002)) includes managerial recommendations, thus making the model more applicable, and useful, for non-experts.

Performing evaluations on knowledge assets has many benefits, mostly for managers to get insight and decision material, however also for personnel as tools for individual assessment of professional and personal development, as well as for personnel to see what they actually contribute with to a firm's success. Used the right way, this evaluation can be a motivation for employees to alter routines and focus on important tasks. However, it could also be a stress factor, especially for those employees performing tasks that are not directly related to a firm's key success factors, thus having the opposite effect and discouraging personnel instead. Some knowledge's in a company will always be base, thus not really contributing to the value chain, despite this they are necessary.

An important factor to remember in all this talk of knowledge and resource assessment is that it cannot develop and transfer itself, the firm's human capital, its people are who makes the firm and its knowledge base move forward (Duane & Hitt, 2005). Moreover, this task to transfer, integrating or applying the knowledge can be highly complex for employees and risky for the company (Haas & Hansen, 2005), thus guidance for this process is essential.

Looking back to the frame of reference presented in chapter 2, the evaluation model here is a mix between Knowledge Asset Measurement Strategy (KAMS) that aims to manage knowledge to achieve performance targets, and, Knowledge Domain Assessment Strategy (KDAS) aiming to assess a firm's competitive position and which knowledge resource need protecting or leveraging to maintain competitiveness. The combination of the both has some benefits, in identifying key knowledge's and enabling the firm reaching its potential. (Lerro, et al., 2012) Especially in this model, as the first part of the model (KAMS) where a knowledge base is created, enables the second (more toward KDAS) in performing competitive and strategic analyses.

Finally, with the aim to evaluate the competitiveness of knowledge a rather diffuse area of subject was approached in this thesis work. For one, what competitiveness is, is something elusive and dynamic, and most of all individual for each company. In the end, the proposed model rather evaluates the impact knowledge elements have on success factors in the firm's industry, than evaluating competitiveness of the elements. Then, whether the identified success factors actually enable competitiveness, or not, is highly reliant on the company having a proper self-image.

7 RECOMMENDATIONS AND FUTURE WORK

In this chapter, recommendations on more detailed solutions and/or future work in this field are presented.

7.1 Recommendations

If the proposed model is to be used in future evaluations or studies, whether or not to use an AHP map should be considered, and if it is used, perhaps in its full with a more numerical approach than suggested here. Also, whether the step considering tacit/explicitness is necessary should be determined before applying the model. In general, perhaps only the shortened model could be a valid approach to make the interviews more efficient.

7.2 Future work

In future research it would be interesting to validate the model further, to really investigate its value. Alternatively, to validate the model by Birchall et al (SKPA), as no work about it was found after its introduction to literature in 2002, and as it is most similar to the suggested approach here.

Moreover, having a more quantitative approach in testing the model and its applicability to PD companies could be interesting, thus actually, reviewing its usefulness in PD processes companies to adjust it more to suit such firms.

8 REFERENCES

Ahamed, Z., Kamoshida, A. & Inohara, T., 2013. Organizational Factors to the Effectiveness of Implementing Servitization Strategy. *Journal of Service Science and Management,* Volume 6, pp. 177-185.

Albors, J., Hervas, J. L. & Marquez, P., 2008. Application of the KISA concept to innovation dynamics and its impact on firms' performance. *Management Research News,* 31(17), pp. 404-417.

Birchall, D. B. & Tovstiga, G., 2002. Assessing the firm's strategic knowledge portfolio: a framework and methodology. *International Journal of Technology Management,* 24(4), pp. 419-434.

Brady, T., Davies, A. & Gann, D. M., 2005. Creating value by delivering integrated solutions. *International Journal of Project Management,* Volume 25, pp. 360-365.

Carlucci, D. & Schiuma, G., 2007. Knowledge assets value creation map Assessing knowledge assets value drivers using AHP. *Expert Systems with Applications,* Volume 32, pp. 814-821.

Chaharbaghi, K. & Lynch, R., 1999. Sustainable competitive advantage: towards a dynamic resource-based strategy. *Management Desicions,* 37(1), pp. 45-50.

Chandrasegeran, S. K. et al., 2013. The evolution, and future challanges of knowledge representation in product design systems. *Computer-Aided Design,* Volume 45, pp. 204-228.

Cronin, P., Ryan, F. & Coughlan, M., 2008. Undertaking a literature review: a step-by-step approach. *British journal of nursing,* 17(1), pp. 38-43.

Crossan, M. :. & Apaydin, M., 2010. A multi-dimansionla framework of organisational innovation: A systematic review of the literature. *Journal of Management studies,* 47(6), pp. 1154-1191.

Denney, A. S. & Tewksbury, R., 2012. How to write a literature review. *Journal of Criminal Justice Education,* 24(2), pp. 218-234.

Duane, R. & Hitt, M. A., 2005. Achieving and Maintaining Strategic Competitiveness in the 21st Century: The Role of Strategic Leadership. *THe Academy of Management Executive,* 19(4), pp. 63-77.

Edvardsson, I. R. & Oskarsson, G. K., 2011. Knowledge management and value creation in service firms. *MEASURING BUSINESS EXCELLENCE,* VOL. 15(No. 4), pp. 7-15.

Evanschitzky, H., Ahlert, D., Blaich, G. & Kenning, P., 2007. Knowledge management in knowledge-intensive service networks: A strategic management approach. *Management Decision,* Vol. 45 (No. 2), pp. 265-283.

Goel, A., Rana, G. & Rastogi, R., 2010. Knowledge Management as a Process to Develop Sustainable Competitive Advantage. *South Asian Journal of Management,* 17(3), pp. 104-116.

Grant, R. M., 2010. *Contemporary Strategy Analysis.* 7th ed. Chichester: John Wiley & Sons Ltd.

Haas, M. R. & Hansen, M. T., 2005. When using knowlegde can hurt performance: the value of organizational capabilities in a management consulting company. *Strategic Management Journal,* 26(1), pp. 1-24.

Håkansson, L., 2010. revisited, The firm as an epistemic community: the knowledge-based view. *Industrial and Corporate Change,* 19(6), pp. 1801-1828.

Hitt, M. A., Ireland, D. & Hoskisson, R. E., 2007. *Strategic Management: Competitiveness and Globalization.* 7th ed. Mason : Thomson South-Western.

Holsaple, C. & Singh, M., 2001. The knowledge chain model: activities for competitiveness. *Expert Systems with Applications,* Volume 20, pp. 77-98.

Huggins, R. & Izushi, H., 2008. Benchmarking the knowledge competitiveness of the globes high performing regions. *Competitiveness Review: An International Business Journal ,* 18(1/2), pp. 70-86.

Johansson, C., Hicks, B., Larsson, A. C. & Bertoni, M., 2010. Knowledge maturity as a means to support decision making during product-service systems development projects in the aerospace sector. *Project Management Journal,* Vol. 42(No. 2), p. 32–50.

Kale, S. & Karaman, E., 2011. Evaluating the Knowledge Management Practices of Construction Firms by Using Importance-Comparative Performance Analysis Maps. *Journal of Construction Engineering & Management,* 137(12), pp. 1142-1152.

Lerro, A., Iacobone, F. A. & Schiuma, G., 2012. Knowledge assets assessment strategies: organizational value, processes, approaches and evaluation architectures. *JOURNAL OF KNOWLEDGE MANAGEMENT,* VOL. 16 (NO. 4), pp. 563-575.

Lightfoot, H., Baines, T. & Smart, P., 2013. The servitization of manufacturing - A systematic literature review of interdependent trends. *International Journal of Operations & Production Management,* 33(11/12), pp. 1408-1434.

Malterud, K., 2001. Qualitative research: standards, challenges, and guidelines. *The Lancet,* Volume 358, pp. 483-488.

Marr, B. & Spender, J. C., 2004. Measuring knowledge assets - implications of the knowledge economy for performance measurement. *Measuring Business Excellence,* 8(1), pp. 18-27.

Marti, J. M. V., 2001. ICBS - Intellectual Capital Benchmarking System. *Journal of Intellectual Capital,* 2(2), pp. 148-165.

McEvily, S. & Chakravarthy, B., 2002. The persistance of knowledge-based advantage: an empirical test for product performance and technological knowledge. *Strategic Management Journal,* Volume 23, pp. 285-305.

Netland, T. H. & Aspelund, A., 2013. Company specific production systems and competitive advantage. *International Journal of operations management & production management,* 33(11), pp. 1511-1531.

Oliva, R. & Kallenberg, R., 2003. Managing the transition from products to services. *International Journal of Service Industry Management,* 14(2), pp. 160-172.

Oliva, R. & Kallenberg, R., 2003. Managing the transition from products to services. *International Journal of Service Industry Management,* 14(2), pp. 160-172.

Prieto, I. M., Revilla, E. & Rodríguez-Prado, B., 2009. Managing the knowledge paradox in product development. *JOURNAL OF KNOWLEDGE MANAGEMENT,* VOL. 13 (NO. 3), pp. 157-170.

Probst, G., Raub, S. & Romhardt, K., 2000. *Managing Knowledge - Building Blocks for Success.* West Sussex: John Wiley & Sons Ltd.

Salunke, S., Weerawardena, J. & McColl-Kennedy, J. R., 2011. Towards a model of dynamic capabilities in innovation-based competitive strategy: Insights from project-oriented service firms. *Industrial Marketing Management,* Volume 40, pp. 1251-1263.

Schenkl, S. A., Rösch, C. & Mörtl, M., 2014. *Literature study on factors influencing the market acceptance of PSS.* München, Elsevier B.V..

Schmidt, D. M., Schenkl, S. A. & Maurer, M., 2014. *Evaluation of knowledge to future-proof the knowledge base.* Dubrovnik, s.n.

Schmidt, D. M. et al., 2013. *Interpreting knowledge maps using structural criteria.* Seoul, s.n.

Shepherd, C. & Ahmed, P., 2000. From product innovation to solutions innovation: a new paradigm for competitive advantage. *European Journal of innovation Management,* 3(2), pp. 100-106.

Strech, D. & Soafer, N., 2012. How to write a systematic review of reasons. *Journal of Medical Ethics,* 38(2), pp. 121-126.

Urgal, B., Quintás, M. A. & Arévalo-Tomé, R., 2013. Knowledge resources and innovation performance: the mediation of innovation capability moderated by management commitment. *Technology Analysis & Strategic Management,* 25(5), pp. 543-565.

Wang, P. P. et al., 2011. Status review and research strategies on product-service systems. *International Journal of Production Research,* 49(22), pp. 6863-6883.

Wilcox King, A. & Zeithaml, C. P., 2003. Measuring Organizational Knowledge: A Conceptual and Methodological Framework. *Strategic Management Journal,* 24(8), pp. 763-772.

Windahl, C., Andersson, P., Breggren, C. & Nehler, C., 2004. Manufacturing firms and integrated solutions: characteristics and implications. *European Journal of Innovation Management,* 7(3), pp. 218-228.

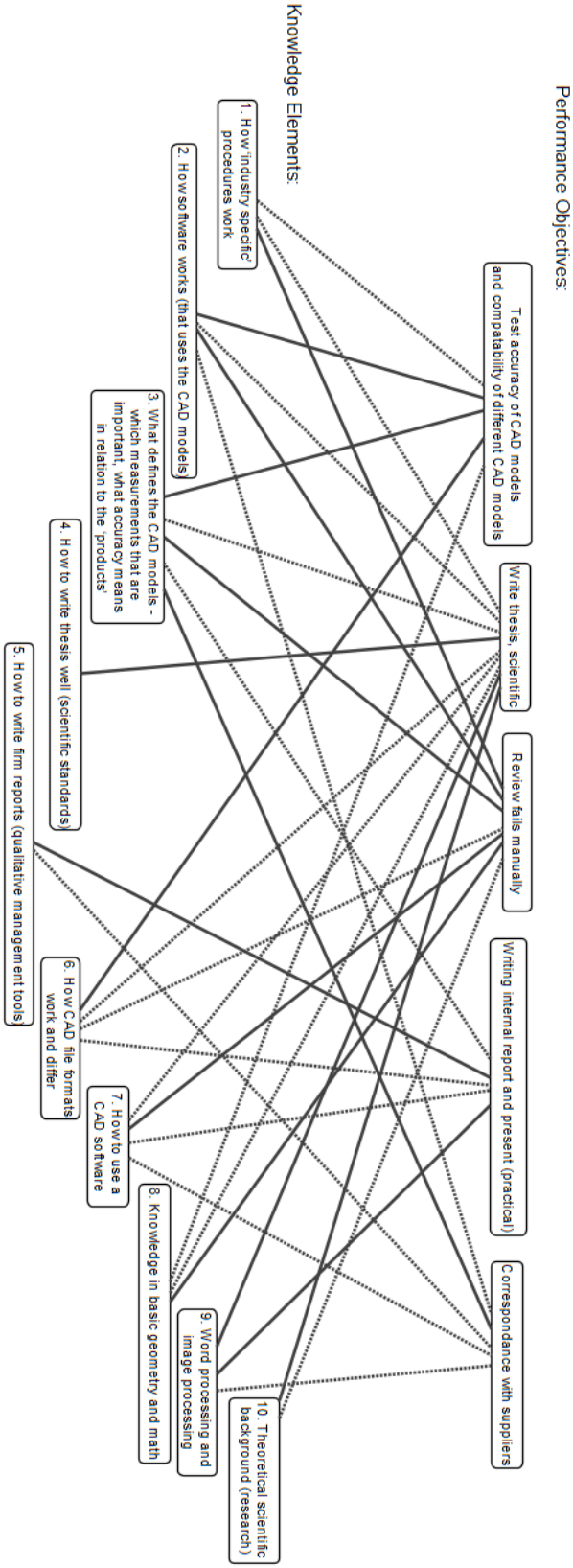
Windahl, C. & Lakemond, N., 2010. Integrated solutions from a service-centred perspective: Applicbility and limitations in the capital goods industry. *Industrial Marketing Management,* pp. 1278-1290.

Appendix 1. List of searches: Literature Review

Made searches	Business source elite		Emerald journals		JSTOR		Science Direct		Web of Knowledge	
Searchstring	Date	No. Results	Date	No.Results	Date	No.Results	Date	No.Results	Date	No.Results
measure competitiveness of knowledge AND (firm OR organisation OR company)	31 03 2014	87	02 04 2014	0	03 04 2014	2	03 04 2014	14	03 04 2014	140
measure competitiveness of knowledge firm	31 03 2014	38	02 04 2014	4	03 04 2014	1	03 04 2014	10899	03 04 2014	40
measure competitiveness of knowledge	31 03 2014	123	02 04 2014	14	03 04 2014	3	03 04 2014	17545	03 04 2014	131
measure knowledge	31 03 2014	7,397	02 04 2014	557	03 04 2014	486	03 04 2014	592835	03 04 2014	86598
how to evaluate knowledge	31 03 2014	727	03 04 2014	22693	03 04 2014	519	03 04 2014	402646	03 04 2014	7908
knowledge (management OR evaluation OR maps OR based view) AND (competitive advantage OR sustainable competitive advantage OR competitiveness)	26 03 2014	3522	03 04 2014	1033	03 04 2014	38	03 04 2014	41294	03 04 2014	2535
knowledge AND (management OR evaluation OR measure) AND (competitive advantage OR (sustainable competitive advantage) OR competitiveness)	26 03 2014	2808	03 04 2014	1078	03 04 2014	33	03 04 2014	62067	03 04 2014	2380
evaluate knowledge competitive advantage	24 03 2014	63	03 04 2014	16	03 04 2014	2	03 04 2014	27401	03 04 2014	172
knowledge (evaluation OR measure) AND (competitive advantage OR sustainable competitive advantage OR competitiveness)	26 03 2014	391	03 04 2014	16	03 04 2014	7	03 04 2014	54709	03 04 2014	525
Knowledge (management OR evaluation OR map OR measure) AND (competitive advantage OR sustainable competitive advantage OR competitiveness)	26 03 2014	3569	03 04 2014	1033	03 04 2014	33	03 04 2014	61021	03 04 2014	2419
evaluate knowledge AND(map OR measure)AND(competitive*)	03 04 2014	9	26 03 2014	1	03 04 2014	8	03 04 2014	36464	03 04 2014	119
intellectual capital OR knowledge evaluation AND competitiv*	03 04 2014	2281	26 03 2014	1017	03 04 2014	121	03 04 2014	7714	03 04 2014	1680
(knowledge map) AND (competitiveness) AND (assess)	03 04 2014	1	26 03 2014	1	03 04 2014	410	03 04 2014	2238	03 04 2014	2

Appendix 2. AHP map of the student's knowledge

Filled line means strong relation, and dotted line moderate relation.



Appendix 3. AHP map of the Test Company

Filled line means strong relation, and dotted line moderate relation.