

HOW TO DEFINE AND MEASURE KNOWLEDGE FOR THE ANALYSIS OF COMPETITIVENESS

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Abstract: The main purpose of this article is to give a framework for an analysis of how we can link creation, use and transfer of knowledge to a company's economic performance. The article builds on the MERITUM project where the aim was to find standards to measure intangible assets. This is important because a company has a need to measure and identify intangible assets like knowledge and thereby increase the company's competitive situation. In this paper we use Aker Verdal as a case study. This company is situated in Trøndelag in peripheral Norway and produces steel jackets for the offshore industry. The company has about 600 employees and an annual production value of about 200 million USD. The company wants to acquire and develop knowledge capital by looking at three factors: 1) Identification: What are the central knowledge processes that take place? 2) Measurement: What kind of indicators can be used? 3) Management: How is management of knowledge integrated in the general management of the firm? The article discusses how this can be done on the basis on an ongoing project.

Key-Words: Knowledge capital, Measurement, Enterprise performance.

COMO DEFINIR E MEDIR O CONHECIMENTO NA ANÁLISE DA COMPETITIVIDADE

Resumo: A finalidade principal deste artigo é dar uma estrutura para a análise de como nós podemos associar a criação, o uso e a transferência do conhecimento ao desempenho econômico de uma companhia. As configurações do artigo no MERITUM projetam-se onde o objetivo seria encontrar padrões para medir recursos intangíveis. Isto é importante porque uma companhia tem a necessidade de medir e identificar recursos intangíveis como o conhecimento e, desse modo, aumentar sua competitividade. Neste artigo foi utilizado a Aker Verdal como um estudo de caso. Esta companhia é situada em Trøndelag na Noruega periférica e produz revestimentos de aço para as indústrias próximas (ou sobre) do mar. A companhia tem aproximadamente 600 empregados e um valor anual da produção de aproximadamente 200 milhões de dólares. A companhia quer adquirir e desenvolver o capital do conhecimento observando três fatores: 1) Identificação: Quais são os processos centrais do conhecimento que ocorrem? 2) Medida: Quais indicadores podem ser usados? 3) Gerência: Como a gerência do conhecimento é integrada na gerência geral da empresa? O artigo discute como isto pode ser feito tendo por base um projeto em curso.

Palavras-chave: Capital do conhecimento, Medida, Desempenho Empresarial.

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INTRODUCTION

In the research literature and in the public debate there have been many attempts to define what can be included in the concept of a knowledge based or a knowledge driven

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economy. From one point of view knowledge can be looked upon as a commodity that can be bought and sold within a market economy. Another perspective is how knowledge is created and exchanged within a company, between companies, between companies and research institutions, and between companies and other parts of society. A third perspective frequently applied is how the spread/dissemination of knowledge actually takes place and how the development of information and communication technology has an impact on the speed, volume and content of the exchange of knowledge.

The systems of production both in the private and public sectors have developed in such a way that it has become increasingly important to investigate more closely how the concept of knowledge, as a factor of production, has developed compared to other factors such as physical capital, labour and raw materials. In 1996 OECD published a study that analyses trends in the historical development of knowledge based economies over the last 20 years. Here, knowledge economies are defined as:

“Economies which are directly based on production, distribution and use of knowledge and information” (OECD 1996).

In earlier analyses of growth in developed countries one of the main results has been that labour and capital played a central role in explaining economic growth, while other factors of production such as organisation, technology and knowledge also played a part. One assumption made was that the producers combined the factors of production in the best way and that the necessary knowledge on how to do this was available.

In traditional macroeconomic growth theory little emphasis was put on the analysis of the creation of knowledge until 1990, when Romer (1990) first introduced his concept of endogenous growth theory. This shift in perspective had a great influence on growth theory as well as on the analysis of regional growth and how to stimulate regional growth.

Schumpeter (1943) made new developments in innovation theory emphasizing the ability and possibilities of the entrepreneur to create new development. Schumpeter used the concept of innovation related to:

- New products
- New production processes
- New materials
- New organisation of the production process
- New markets

Schumpeter pointed out that new knowledge often was important for innovation, but that this was not the situation for every new innovation. He also stressed that it was vital for the ability to innovate how existing knowledge could be distributed and developed further. This line of thought is picked up again in the 1990s where emphasis on networks, facilitated by information and communication technologies (ICT), was focused in theoretical debates and case studies.

2 KNOWLEDGE TRANSFER

Knowledge transfer is a central process taking place in many parts of societal life. We have seen large discussions and a lot of research about how knowledge transfer takes place in education. In economics, Marshall in his “Principles”, spoke about knowledge transfer as an important issue to explain external economics. In neoclassical theory, knowledge, as the other factors of production were assumed to be evenly distributed because of the functioning of the market economy. Economists like Hirschmann and Myrdal, although different points of departure, argued for the doctrine of unbalanced growth. They argued for an uneven development between periphery and centre because factors of production, like knowledge, not

would be evenly distributed in space. It is argued that this type of analysis still is valid to day and applied in NIC countries like Brazil (Santos, Crocco and Jayme 2005).

Knowledge transfer in organizations is by many authors defined as: “The process through which one unit (e. g., group, department, division) is affected by the experience of another”, (Argote and Ingram 2000). Knowledge transfer in organizations, like any other place in society, has to involve individuals. But knowledge transfer in companies also take place between groups, departments and so on. Knowledge transfer is identified when there is change in behaviour. But if this change shall contribute to the improvement of the company’s competitive situation, this change has to be measures in for example saved working hours.

Argote and Ingram (2000) referring to Walsh & Ungson, (1991) use five retention bins or repositories for knowledge in organizations:

- (a) individual members
- (b) roles and organizational structures
- (c) the organization’s standard operating procedures and practices
- (d) its culture
- (e) the physical structure of the workplace

Expressed in another way we can say that the above mentioned bins can be use as categories for the stock of knowledge in organizations. Developing this further one can say that knowledge is embedded in three basic elements (and the subnetworks between them) of organizations like companies:

- Members: the human component of the organization
- Tools: the technological element defined in a wide sense
- Tasks: The organization’s goals, intentions and purposes

In this article we make reference to an ongoing project where we have developed and operationalized the concepts mentioned above to measure how the stock and flow of knowledge influences the competitive situation of a company.

3 HOW TO MEASURE WHAT KNOWLEDGE MEANS FOR THE COMPETITIVE SITUATION OF A COMPANY

This is a field of research where several companies have showed interest but where we have seen few results. One of the best known projects is the so called MERITUM-project, which was a EU initiative. The six countries participating in this program was Spain, France, Sweden, Finland, Norway and Denmark.

MERITUM: MEasuRING InTangibles to Understand and Improve Innovation Management

The conceptual point of departure for the MERITUM project was that when a company produces its commodities, the company’s inputs can be divided into two categories:

- Labour, capital and raw materials
- Intangibles

In the accounts of company we look at:

- Ordinary assets such as machines, buildings etc.
- Financial assets
- Intangible assets

One important part of the work in the MERITUM project was to find standards to measure intangible assets. This is important because the company has a need to measure and identify the level of knowledge and thereby to increase the company's competitive situation. Thus, intangibles are defined as: "Non-monetary sources of probable future economic profits lacking physical substance, controlled (or at least influenced) by a firm as a result of previous events and transactions and may or may not be sold separately from other corporate assets." (Canibano 2004).

One result that has emerged from companies participating in the MERITUM-project was that a method to evaluate the value of intangible assets improved their ability to manage the development and use of knowledge. Another result from the project was clearer rules about how to bring intangible assets into the ordinary bookkeeping. The bookkeeping part of the project is interesting but will not be commented further here. The focus here is how the company can make its management more effective so that the generation and development of knowledge takes place in such a way that it actually improves the company's competitive position.

There is a need to clarify the two concepts 'intangibles' and 'intellectual capital', which are both used about non-physical resources. 'Intangibles' are in most studies more linked to management and accounting while 'intellectual capital' is often used to analyse how the business community develops. In this article we analyse from the company's point of view and will leave out further discussions of 'intellectual capital'.

We use an analysis in three phases to determine the value of intangible assets and knowledge capital:

Identification: Here one must look at knowledge in relation to the processes that are central for value creation in the company.

Measurement: Here one must find a useful and operational set of indicators to measure what the knowledge capital actually consists of.

Management: Here one must develop a management system for the company that takes care of the effect and relations that knowledge capital has on achieving the company's objectives, which is usually a maximization of profits.

For the company it is crucial that it makes clear what its core competences are and how knowledge capital is related to it. The company also needs to identify the networks in which this knowledge is distributed.

It is vital to make the change between the stock and the flow of knowledge capital of a company:

Knowledge as a stock: That means that a company must be able to identify what it has and can use.

Knowledge as a flow: That means that the company must know how it can influence the creation and development of the knowledge capital.

In general it would have been a good idea to have general criteria to measure both the stock and the flow of knowledge enabling comparisons between companies. Results from the MERITUM project show that it is not easy to develop general criteria because it is almost impossible to define the core competences of a company without going more specifically into the actual production processes.

3.1 FROM INTANGIBLE ASSETS TO KNOWLEDGE CAPITAL

On the operational level the definition of knowledge capital can be as follows:

1. Human capital: Defined as the knowledge the employee has and uses in the operations of the company. Often looked at as the employees' level of education and expertise in the company.
2. Structural capital: Defined as the knowledge that is left in the company when the employees have left, e.g. patent rights, company routines, databases and so on.
3. Relational capital: Defined as all human capital and structural capital that are linked in networks with all external relations the company has, for example contracts with other companies, market channels and so on.

A definition commonly used is then: *The company's knowledge capital equals the total of the human capital, the structural capital and the relational capital.*

3.2 COLLECTION OF DATA FOR THE ANALYSIS OF KNOWLEDGE AS A PART OF THE COMPANY'S COMPETITIVE SITUATION

The MERITUM-project, Canibano (2000) lists 15 indicators under the heading of human capital, 9 under structural capital and 6 under the heading of relational capital. This makes it possible to look at the guidelines from the MERITUM-project and relate them to the core competence of companies, for example the one that will be used as an example in this case, Aker Verdal. These indicators will suggest what kind of knowledge capital the company has and which changes that take place when we look at:

- A change in inputs of goods and services
- New capital equipment
- New relational or operational agreements with other companies
- New recruitment or new developments of labour with new qualifications
- The development of new technologies
- New research and development operations
- New training programs for the labour force

Tacit knowledge will be a central concept in this connection and it is important to study the codifying processes that take place when the workers' tacit knowledge is transferred to explicit knowledge for the company. The concept of tacit knowledge was first developed by Polanyi (1960) and has since become a central concept in many articles and actual projects; see Lundberg and Maskell (2000).

In the case study where we are studying transfer of knowledge and the competitive situation for Aker Verdal we will use Porters definition of a company's competitive situation.

4 AKER VERDAL AS A STUDY OBJECT

Aker Verdal is a company that produces equipment for the offshore sector. The North Sea has been the main market, but in later years Aker Verdal has produced equipment that is used offshore of Canada and in the Gulf of Mexico. The company had a total production value of about \$200 million as an average for the years 2000 - 2006. The main product from Aker Verdal is steel jackets and this market has experienced big changes in the demand situation in recent years. In 1999 there was a sharp downturn in the order situation and about 600 of the

company's 1200 employees were temporarily or permanently without a job. In the year 2000 the market situation changed rapidly to the better and the order situation from 2000 and until 2005 has been reasonably good, with a new upturn in 2005 and a possible downturn again from the end of 2008.

In the problematic period of 1998-2000 the company had extensive educational programs for temporarily laid off employees. These programs have been evaluated as reasonably successful but there has been no extensive analysis of how these programs influenced the company's competitive situation. On this background the central research questions from the company have been:

1. Which processes generate development of knowledge within the company?
2. How can we actually analyse and describe how knowledge leads to reduced costs and/or increased quality in the production?
3. How does this development of knowledge at Aker Verdal spread into the business community in the region?

One of Aker Verdal's most important competitors in steel jackets for the offshore sector is the company Dragados in Spain. Dragados has a wage level that is about the half of Aker Verdal's, but still Aker wins contracts. This has lead the managers of Aker to the conclusion that Aker must have a knowledge component that Dragados does not have. The main objectives of the research project referred in this article are to analyse in more detail what the main content of this knowledge component is and how it can be developed further to improve competitiveness.

5 CASE STUDY AND PRELIMINARY OBSERVATIONS

The main product at Aker is steel jackets for the off shore sector which is structures that are placed on the bottom of the North Sea and with for example production units on the top.

Figure 1 - Steel jacket for the North Sea at Aker (illustration photo of earlier similar project)

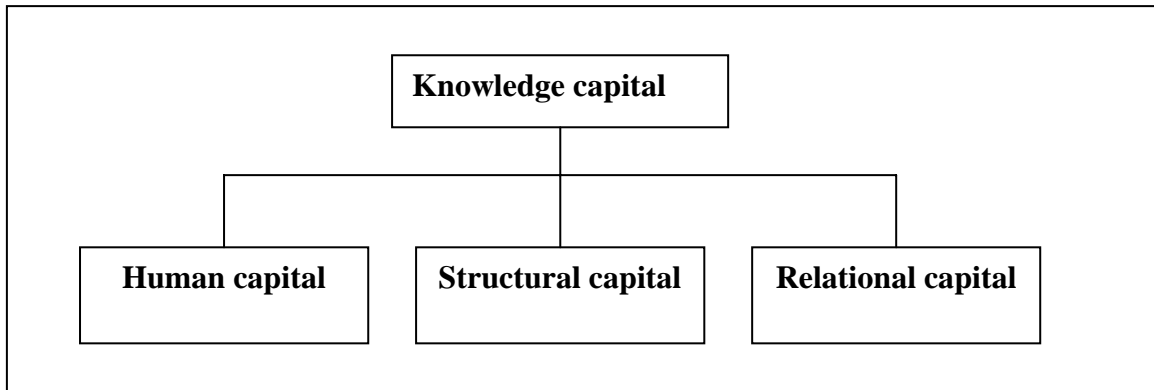


Source: Results of the research.

The Aker company started building the steel jacket in this case study (called Valhall) in May 2008 and it will be finished in July 2009. It weighs about 7000 tons, costs about 100 millions USD and it takes about 500 000 man hours to build it. The project work can be divided into two, engineering and production. In this study we concentrate on the production phase.

In chapter 3 we defined the company's knowledge capital as consisting of: The human capital, the structural capital and the relational capital, and we use this definition in this project.

Figure 2: Definition of the company's knowledge capital



Source: Results of the research.

The central concept in the planning and operational phase of production of the Valhall jacket is **work package**. The production is divided into approximately 600 work packages and each work package has complete drawings of the “piece” that shall be produced and a description of all work processes including what (e. g.) welding technology that shall be used, quality standards and which welding certificates the workers are required to have for producing the specific “piece”. And each work package has a calculated amount of working man hours.

The central assumption of the data collection in the project is that we link knowledge capital to the properties of each work package. This we do by using indicators for human capital, structural capital and relational capital. We have constructed a number of indicators and the most important are the following:

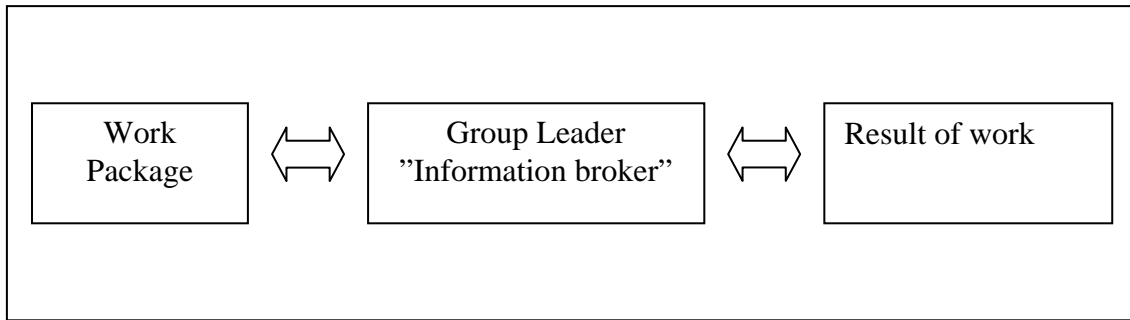
1. Group size
2. Competence level (welding certificate)
3. Average age of persons in the group and average years of work experience in the firm
4. Participated in any training activities specially designed for this project
5. Welding technology
6. Ability to understand drawings
7. Preciseness of measuring steel structures (the work package)
8. Innovations taking place
9. Quality control procedures
10. Communicative skills
11. Collaboration with other departments of the firm
12. Collaboration with outside firms
13. Language problems

The examples above are just some of the indicators we use and they can be related to the following headlines: (1) Indicators relating to workers' competence, (2) Indicators related to technology and (3) indicators related to communication and communicative skills.

For every indicators we register values and special attention is paid to situations where man hours are saved or lost compared to the standard calculation for the specific work package. This allows us to analyse, based on regression analysis, the relation between lost/saved man hours and for example the level of competence.

The central function of how communication and knowledge transfer takes plan in the production of the work packages can be displayed as in the figure below.

Figure 3: The central position of the Group leader as information broker



Source: Results of the research.

The work packages differ much in size and content, from small jobs with less than 100 man hours to large scale operations of more than 2000 man hours. The table below shows two examples of job packages from the Valhall jacket.

Table 1: Two examples of work packages from the Valhall jacket production

No	Name	Department	Total Man hours
VRN6A15300-01	Valhall jacket - Install Lifting lugs section VR-A-150-30	A2	147,86
VRN5A35001-01	Valhall jacket - Prefabrication of mudmat for cluster section A-350 row A	A2	2 068,96

Source: Results of the research.

The central person in the production process is the group leader. The group leader receives all drawings and descriptions of the work package and he organises and gives instructions to the group of workers that actually do the job. The job doing the lifting lugs was done by a group with six members while the mudmat job was done by a group of twelve. The group leader “translates” all technical and organisational information to the group that does the job and has a central position as an information broker.

The data collection from the project is based on interviews with the responsible group leader and collection on other data for every work package and by November 2008 data are collected for about 300 work packages. The impression so far is that the ability of the group leader to perform his key role as information broker is vital for the productivity. Many articles, e. g. Gourlay (2004, 2006) discusses the central role of transforming tacit to explicit knowledge and in this project we are indirectly able to measure how the communicative skills of the group leader can stimulate the process of transforming tacit to explicit knowledge and thereby enhancing productivity.

6 INNOVATIONS IN TRADITIONAL MANUFACTURING: INDOOR BUILDING OF JACKET COMPONENTS

To develop the effectiveness of the production processes and to work independently of variation in weather Aker Verdal builds many of the important and resource consuming parts of the jacket indoors. Earlier the company had to build up indoor constructions (scaffolds) so the workers could do the welding operations. This was costly and time-consuming and the company was thinking of changing to indoor mobile lifts or different types of mobile platforms that could put the worker in the right position to do the welding operations.

A team was put together with workers from the company (welders) and engineers and this team contacted different producers of mobile lifts and platforms. This resulted in a new

mobile platform being introduced and used in production. A crucial phase of this development was how to identify the workers' tacit knowledge about how things could be done and recode this tacit knowledge to explicit knowledge in the cooperation with a producer of mobile lifts and platforms.

Using Schumpeter's definition this could be labelled as a process innovation. One can argue how big change we must see before we can use the concept of innovation for a cost saving change in the production process and if this example fulfils the criteria. What is definitely interesting is how the company manages the knowledge processes and create an innovative milieu for knowledge transfers, this is also discussed in Cavusgil S.T., Calantone R.J., Zhao Y. (2003).

CONCLUSIONS

The main purpose of this article is to give a framework for an analysis of how we can link creation, use and transfer of knowledge to the company's economic performance. With a fast growing number of articles with theoretical and policy discussions about the importance of knowledge as a factor to develop competitiveness, it is also the time for more empirical work based on extensive data collection.

This article finds the building blocks from the MERITUM project useful as a starting point. It is also important to note that how production is organised in the company is crucial for the possibility to make an analysis like this. Without the descriptions, calculations and drawings forming the work packages it would have been difficult to make reasonably reliable estimations of the connections between factors like knowledge and communicative abilities on the one hand and productivity on the other. In the literature about measurement of intangibles, e. g. Sveiby (1997) and Bounfour (2003), we find clear statements that there is no unique method of evaluation and measurement of intangibles. The same seems to be the case for the analysis of knowledge and communicative abilities at the firm level.

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