Knowledge utilization, communication and innovations in aquaculture in an international perspective

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Abstract: The aquaculture sector worldwide is becoming increasingly important as a provider of healthy food, and production has grown considerably in volume. At the same time, the sector is also facing increasing environmental challenges. The need for innovation has escalated, together with the use of advanced production equipment and high-level biological competence, while at the same time striving for environmental sustainability.

In this paper we focus on how aquaculture now has become a knowledge intensive production. Firms must be able to manage knowledge to fulfil competence demands, often requiring a change in communication patterns. The other main subject is about how innovative developments are related to competence, communication and culture aspects like trust. We have just completed data collection from three firms: two in Norway and one in Chile, where we have studied how knowledge management takes place and how innovations can be linked to drivers like the ones mentioned above.

This paper offer insights about relationships concerning knowledge management and innovations and how this affects the operation of the firms by comparing the production of the same commodity, harvested salmon, in three different firms with quite equal production equipment but different operational frameworks like management styles, knowledge levels and cultural background. We find, like in most studies, links between firm operations and knowledge management, and knowledge and innovations, but these links do not have the same structure in Norway and Chile. Factors like competence and communication structure as well as cultural factors like trust seem to explain most of the differences between the firms.

Keywords: Knowledge management, communication, innovations, harvested salmon, Norway, Chile.

1. Introduction

Knowledge as an essential component of competitiveness for any firm has been recognized for several decades. This was first ascertained for high-tech production firms and knowledge organizations. Prior to the 1990's, aquaculture was viewed as a low-tech industry where feeding to a large extent was done manually and the optimal amount of feed given was based more on experience and intuition rather than on technologically advanced equipment and methods. This picture has now radically changed. To be successful in aquaculture now, firms have to manage three high-tech knowledge intensive processes, feeding, logistics and fish health, and also be able to develop these processes in an innovative way.

The paper will first present a discussion of how knowledge within this framework can contribute to competitiveness and innovations. Then we will introduce an empirical study based on data collection from three aquaculture firms, two in Norway and one in Chile. Here we will analyze the role of knowledge utilization and management in fostering competitiveness and innovative development, and finalize by discussing how the results can be interpreted.

The research questions we will try to answer are:

- What are the consequences of relations between knowledge management and competence, communication and innovative initiatives (like changes in routines) for the operation of aquaculture firms in Norway and Chile?
- How are the relationships between innovations and knowledge influenced by communication, competence and cultural factors like trust?

2. Theoretical background

2.1 Intellectual capital and knowledge-based capital

Sources for the development of the concepts of intellectual capital (IC) are Edvinsson and Malone (1997) and Bontis (1998) and knowledge capital (KC) MERITUM (2002). The definitions and use of the concepts IC an KC are quite parallel and here we use the definitions from MERITUM (2002) where they suggest that the firm's knowledge capital is equal to the sum of three elements:

1. Human capital: defined as the knowledge that employees have and hold, regardless of whether they are in the workplace or not, for example the employees' expertise, education etc.
2. Structural capital: defined as the collection of knowledge that stays in the company, such as formal rights to knowledge, patents, corporate practices, databases, descriptions of routines etc.
3. Relational capital: defined as all human capital and structural capital that is associated with the network of all external business relationships, such as contacts to subcontractors, marketing etc.

The concept of knowledge-based capital (KBC) recently proposed by OECD (OECD 2013) is also designed to measure the intangible assets in which firms invest and develop. The OECD report divides KBC into three categories:

1. Computerized information (software and databases)
2. Innovative property (patents, copyrights, designs, trademarks)
3. Economic competencies (including brand equity, firm-specific human capital, networks of people and institutions, and organisational know-how that increases enterprise efficiency)

2.2 Knowledge and skills

All firms have knowledge capital but the important task for the firm is to develop the knowledge capital into skills. Skills are normally understood as the capacity of the firm to customize the knowledge capital to the needs of the firm and combine that with the physical capital in the optimal way. This understanding can be traced back to Schumpeter (1934) via Prahalad and Hamel (1990) and up to recent work on knowledge in organizations by e. g. Takeuchi et al (2013). The central strength of skills as a result of knowledge is that it can improve in value by learning, unlike physical capital assets. Firms can determine the value of knowledge capital using the following keywords, see e. g. MERITUM (2002) and Westeren et al (2018):

- Identification: Looking at knowledge in relation to the processes that are crucial for value creation in the company – core competences.
- Measurement: Finding a useful set of indicators to measure the knowledge capital as it actually is.
- Management: Developing a management system for the company which takes into account the effects of knowledge capital toward achieving corporate goals.

This delineation establishes the concept of core competencies which Prahalad and Hamel (1990, p. 81) have defined in this manner: “Core competencies are the collective learning in the organization, especially how to coordinate diverse production skills and integrate multiple streams of technologies.”

2.3 Knowledge management

Knowledge management has been linked to the interpretation of the knowledge concept and the definitions of IC and KBC. Schiuma et al (2012) defined Knowledge Management (KM) as “the set of management activities that enable the firm to deliver value from its knowledge assets”, Schiuma et al (2012, p. 618). Hansen et al (1999) looked at KM strategies using two points of departure, codification and personalization. This is developed further by Hislop (2005) where he analyzes KM from the objectivist perspective and the practice-based perspective. The objectivist perspective is grounded in a positivist philosophy of science where codification of knowledge is the central aspect, and this implies that knowledge can be stored and retrieved and made operational in such a way that hypothesis testing is possible. Personalization means that we do not assume a subject-object split and is based on a hermeneutic and/or constructivist philosophy of science and here the concept of tacit knowledge, see Polanyi (1962), can be handled with scientific seriousness.

Hussinki et al (2017) have several examples showing how KM is defined by its practice. A more Scandinavian-oriented model, Irgens and Wennes (2011) looks at KM as:

- Resources, such as intellectual capital, representing the knowledge base of the firm.
- Knowledge processes as generic activities, such as the acquisition, sharing and creation of knowledge.
- Purposeful organizational and managerial practices aimed at managing both resources and processes to create organizational benefits.

KM practices can be divided into categorizations and Heisig (2009) compared 160 KM models and proposed grouping the most studied KM success factors into the following categories:

- human-oriented,
- organization-oriented,
- technology-oriented and
- management process-oriented

Within the category of human oriented KM, supervisory work is central to establishing favorable conditions for KM in an organization. Empirical studies, like the one in this project, have revealed that supervisors who participate, inspire, delegate, and support are valuable organizational members, as their involvement is linked with positive firm performance. Supervisors also pave the way for any KM agenda by creating a trustful, respectful atmosphere and creative culture by coordinating knowledge integration within a firm. The effect on firm performance may be more pronounced if supervisory work is combined with sufficient technological support and a KM-specific training regime. Another human oriented KM process is enhancing learning mechanisms like improving the quality and increasing the amount of organizational knowledge and competence. We see in this project that firms emphasizing learning invest in transferring knowledge from experienced employees to less experienced employees through activities like mentoring, apprenticeships, and job rotation.

Technological proficiency has emerged as a basic competence in a modern firm. In today's world, practically all codifiable knowledge is available through various digital channels; thus, firms adopt new IT practices, as technological solutions can facilitate better leverage over the firm's knowledge resources and enable organizational learning. Recently, the phenomenon of "big data" has become increasingly important to KM, as firms have access to more data from internal and external sources, which they can combine and utilize in their value creation.

2.4 Knowledge and innovation

The links between knowledge and innovations have been well established at least since the 1990's and in 2017 a book by Bathelt et al (2017), "The Elgar companion to innovation and knowledge creation", presented 47 chapters about innovation and knowledge and had more than 5000 references about this subject. One conclusion from the book is that this subject still needs more research, but it also has gotten extensive attention in later years. In relation to the focus of this paper it is interesting to notice that the ideas of Schumpeter about "new combinations" and "creative destruction" Schumpeter (1934; 1942) are still very relevant and frequently discussed, as also in Bathelt et al (2017). The choice of keywords for the innovation process: intention, spark, social construction, and landing, gives a framework for the innovation processes we study in this article. The process of knowledge association and recombination, Mumford et al. (2009), has important parallels to the innovation processes we are studying in the empirical part here.

Ideas need to be implemented and require networking skills, Baer (2012), and translation processes. Normally firms can only to some extent plan for this and are often dependent on the assumption that tacit knowledge processes are converted into explicit knowledge. After some time, the innovative idea has gained sufficient maturity and thereby gained trust, so the organization is willing to invest resources in actual development of a spark that now has become a project. Westeren (2017) and Westeren et al (2018) show that cultural differences may play an important role in how successful the organization is to convert an innovative idea into a project. Innovation management has turned into a science of its own, see e. g. Tidd and Bessant (2018). They posit that knowledge requirements often change in structure and content in the innovation management phase, but still there seems to be a large need for a more holistic view on knowledge.

3. Empirical part

3.1 About the data collection and the firms in the study

The empirical part is based on a study of three aquaculture firms, Midt-Norsk Havbruk in Norway, Marine Harvest (now renamed MOWI) Region North in Norway, and Marine Harvest in Chile. Data collection is based on a questionnaire and took place from the beginning of 2017 to the end of 2018. We collected 37 responses from eight sites for Midt-Norsk Havbruk (MNH), 52 responses from six sites from Marine Harvest Region North (MH Nord) and 35 responses from ten sites from Marine Harvest Chile (MH Chile). Each site has a site manager and 3-7 operators in the working team. The data collection has a representative distribution of answers from site managers and operators.

3.2 Competence

Competence is an important part of the knowledge that the individual possesses and in this study we have analyzed competence from three perspectives: basic education, competence gained during work on the sites, and course participation. We have registered the educational level of everyone who participated in the survey and it is classified according to international standards (World Economic Forum, 2015) by using a grouping where the lowest level is 1: Not completed 9-year primary school and the highest 6: University education.

Based on this information we have calculated an average level of education at each site and the results are shown in Table 1. The other indicator for examining competence is the individual's understanding of the technology used at the site. This has been investigated by asking all at the sites for understanding technology based the following four options:
1: Must have special training and long (more than 30 minutes) explanation
2: Must have more than 10 minutes but less than 30 minutes explanation
3: Understand with a short (less than 10 minutes) explanation
4: Understand immediately without explanation

The results in Table 1 show that the Norwegian sites score higher on all competence variables.

Table 1. Results of competence variables for MH in Chile and Norway and MNH.

		Average educational level	Understand technology	Attended courses last year	Attended courses last month
MH Chile	N	35	35	35	35
	Average	3.34	2.80	3.07	0.57
MH Nord	N	52	52	52	52
	Average	4.43	3.73	3.46	1.00
MNH	N	37	37	37	37
	Average	4.27	3.73	3.62	1.30

N: Number of answers (This abbreviation is used for all tables)

3.3 Communication

In the data collection we have asked site managers and operators about the communication they have upwards in the system, about the communication they have with each other, and about the communication there is between the manager at the site downward to the operators. Communication is also dependent on group size and at MH Chile the average is 6.14, MH Nord is 5.02, and for MNH the number is 3.92. Another contextual consideration is that the technological equipment is more advanced in Norway than in Chile, like underwater camera equipment, computers for feeding and other communication equipment. Another difference in production routines is a higher degree of rotation of work assignments in MH Nord in Norway. At MNH the management of feeding was centrally controlled, but there was communication between the location and the central management. In Chile the manager of the site and the assistant manager were responsible for managing the feeding, with other operators rarely involved. These differences in the organization of the work had influence on the communication patterns. Table 2 shows that the average number of initiatives for communication in general are higher in Norway than in Chile.

Table 2 . Communication pattern at the sites in Chile and Norway.

		The number of initiatives to talk to leads one level up	Number of initiatives to talk to member in own group	The number of initiatives others in your group took to speak with you
MH Chile	N	35	35	35
	Average	4.40	6.63	5.57
MH Nord	N	52	52	52
	Average	8.06	11.33	11.31
MNH	N	37	37	37
	Average	8.73	13.16	12.76

3.4 Changes in routines

Being able to maintain and develop routines is crucial for firms where some stability in production is needed. Changing routines are seen as an indicator of the extent to which a firm has a potential to develop competitiveness and stimulate the innovation. In order to achieve this, the firm has to change and develop routines, but also must keep a certain stability in routines because this is often looked at as the firm's organizational glue. When we investigated the routines in the firms, we asked about the frequency of changes in routines and the extent to which changes were implemented. Table 3 shows the main results from the questions asked about changes in routines with the following answer categories:

1: Never
2: Earlier than you can remember
3: The last 3 months
4: Last month
5: Last week

Table 3 . Changes in routines.

		Changes in routines	Formal changes in routines
MH Chile	N	35	35
	Average	3.86	1.34
MH Nord	N	52	52
	Average	3.65	3.25
MNH	N	37	37
	Average	4.11	3.84

Since higher numbers show greater frequency of submitting proposals, the results show large differences in the process of formalizing proposals for changes in routines at the sites in Chile compared to Norway, which means clearly higher implementation capacity in Norway. By formal changes we mean the routine must be documented in a written and/or IT-based way. Regarding the extent to which the proposals have been followed up, there is also a relatively large difference between Norway and Chile in the sense that around 94% answer yes to follow-up in Norway while the corresponding figure is 63% in Chile, see Table 4.

Table 4 . Follow-up of proposals for changes in routines.

		The proposal for a change in routines has been followed up		
		Yes	No	Total
MH Chile	N	22	13	35
	%	62.9%	37.1%	100.0%
MH Nord	N	49	3	52
	%	94.2%	5.8%	100.0%
MNH	N	35	2	37
	%	94.6%	5.4%	100.0%

3.5 Innovation

In this project a thorough data collection on innovation was done and about 20 questions were asked on this topic. Innovation is currently one of the most discussed topics in economics and about societal development in general, cf. Westeren et al . (2018), where there is a thorough discussion of innovation in theory and practice. It is not easy to interview employees in firms about innovation and innovative suggestions because one must try to distinguish this from suggestions for changes in production more generally. The criteria we used for innovation are taken from the Oslo Manual, OECD (2005), where the central criterion is that the proposal will bring something new to the firm and that the proposal should not have been described as a routine or operation the firm has done before. Most of the suggestions for innovative ideas are linked to the production process at the site. The scope for the proposals is very large, ranging from major changes in feeding systems to smaller proposals on new ways to carry out maintenance and other technical tasks. Of special interest in this analysis is the utilization of knowledge in relation to innovations. Table 5 gives results about whether the innovation needs new knowledge to be implemented.

Table 5. Does innovation need new knowledge to be implemented ?

		The innovation needs new knowledge to be implemented		Number of valid answers	Not answered
		Yes	No		
MH Chile	N	18	12	30	5
	%	60.0%	40.0%	100.0%	
MH Nord	N	39	10	49	3
	%	79.6%	20.4%	100.0%	
MNH	N	30	4	34	3
	%	88.2%	11.8%	100.0%	

It was also asked whether innovation needs new ways of exchanging knowledge (see Table 6). The structure of the answers is clear since there is a preponderance of positive answers in both countries. In Norway, a large majority of the projects need new ways of exchanging knowledge and that proportion is higher than in Chile .

Table 6. Does innovation need new ways of exchanging knowledge ?

		Innovation needs new ways of exchanging knowledge		Number of valid answers	Not answered
		Yes	No		
MH Chile	N	20	10	30	5
	%	66.7%	33.3%	100.0%	
MH Nord	N	42	7	49	3
	%	85.7%	14.3%	100.0%	
MNH	N	28	6	34	3
	%	82.4%	17.6%	100.0%	

Questions were asked about whether the innovation affects the corporate culture (Table 6) and there is some difference in the structure of the answers. The main response is generally negative in all three firms, however in Norway there is a somewhat more even distribution of the answers, while in Chile it is more decisively negative. This is in line with our impression during data collection that corporate culture is more prevalent in Norway than in in Chile, see Table 7.

Table 7. Does the innovation affect organizational culture ?

		The innovation affects the organizational culture		Number of valid answers	Not answered
		Yes	No		
MH Chile	N	4	26	30	5
	%	13.3%	86.7%	100.0%	
MH Nord	N	19	30	49	3
	%	38.8%	61.2%	100.0%	
MNH	N	16	18	34	3
	%	47.1%	52.9%	100.0%	

Table 8 addresses the question of whether there is a need for stronger trust between those working at the site in order to implement the innovation This question generated a clear yes in Norway, while we get a clear no in Chile. One explanation for this in Chile is the more two-tier leadership structure in place there. In Norway, it was stated during the interviews that the innovations could be challenging, especially with regard to new technology, that necessary confidence was important.

Table 8. Does the idea require a stronger network of trust between employees?

		The idea requires a stronger network of trust		Number of valid answers	Not answered
		Yes	No		
MH Chile	N	10	20	30	5
	%	33.3%	66.7%	100.0%	
MH Nord	N	40	9	49	3
	%	81.6%	18.4%	100.0%	
MNH	N	25	9	34	3
	%	73.5%	26.5%	100.0%	

4. Discussion of results and conclusions

There are different possibilities to define outcome variables for fish farming, in this project we have collected data for fish health and asked about the results from fish health control by the veterinarian. This is believed to be an interesting indicator for how the production is going on. The first research questions in this study is about the operation of the firms and how this is related to knowledge capital concerning educational level, understanding of technology, communication and knowledge management, and innovative initiatives. From Table 1 we saw that the Norwegian firms scored higher on the competence variables than the one in Chile. There are different possibilities to analyze how the competence variables statistically can be linked to outcome of production. We have tested different types of statistical models but since the ambition of this paper is to give a broad understanding of possible relationships; we use results based on Pearson correlation coefficients using the SPSS system. The results in Table 9 show that two competence variables, “Understand technology” and “Participated last month in courses” are significantly correlated to the outcome variable. This means that intellectual capital is important, but it is the applied competence that shows correlations. Our impression from the data collection was that the educational level was important as a fundament for the variable “Understand technology”. This indicates that education level is important but statistically influential indirectly through other competence variables.

Table 9 also show positive correlations between the outcome variable and the communications variables. This is in line with other studies, see Westeren et al (2018). It is interesting to note that more advanced technological equipment seems to a driver for more frequent communication between all levels in the firm. When it comes to routines they have to be formalized to show positive correlation to the outcome variable.

As previously stated, aquaculture has developed in a high-tech, knowledge-intensive environment where production is dependent on successful innovations. We have tested the variable "Innovative idea needs new knowledge" to see how this is correlated with communication variables, competence variables, and variables about changes in routines, see Table 10. Only one of the communication variables is significant when linked to the innovation variable and that is about communication upwards in the firms. This implies that the role of the site manager as the knowledge broker seems to be most important to bring knowledge messages about innovations up to the decision level. Competence is also important for innovations but here the pattern is a little different from the results from the more general operations of the firm. For innovations more basic knowledge like educational level seems to be the most important driver. Understanding of technology is significant but with less strength. The course variable is not significant implying that being able to innovate via new knowledge needs a deeper understanding than just short applied courses. Changes in routines also show interesting results here and it is not enough to be able to come up with the innovative idea, it is also necessary to be able to formalize the innovative idea to get results.

Trust is a key concept in innovative developments. In this study we have looked at one variable "Idea requires stronger network of trust" and analyzed how this variable relates to other innovation variables like "Innovative idea needs new ways to exchange knowledge", "Innovative idea affects organizational culture", and "Innovative idea planned/done". We find positive correlations between the innovation trust variable and the other three variables, see Table 11. Correlation coefficients do not prove anything but the results give us an indication that trust plays an essential role in innovative processes because new ways of exchanging knowledge are dependent on relationships and one thing we know about innovations is that they always to some degree are uncertain. Also, the successful building of organizational culture is in general dependent on trust which we also find from the results here. We find that the ability not just to plan, but also to implement the innovation differs between the firms. The correlations are indications that a higher level of trust increases the firm's ability to complete the innovation process, which is in line with other research like Tidd and Bessant (2018).

A summary of the results shows that intellectual capital and knowledge management play a role for firm operations and innovative activities, but the links work through different mechanisms. This project gives implications about which mechanisms are the most important ones and the results also emphasize context dependency. We will recommend further research based on empirical perspectives taking different contexts of the firms into consideration, We have too many general results that "better knowledge is good for stimulating innovations", without paying enough attention to context, culture, and level of technology, see Bathelt et al. (2017).

Table 9 Correlations between outcome variables and communication, competence and changes in routines

		No talk to leader	No talk to members of the group	Group member initiative talk to you	Average education level	Under-stand technology	Partici-pated last month in courses	Change in routines	Formal change in routines
Result from control	Correlation	.289**	.408**	.368**	0.113	.293**	.196*	0.070	.210*
	Sig. (2-tail)	0.002	0.000	0.000	0.234	0.002	0.037	0.461	0.026
	N	113	113	113	113	113	113	113	113

** Correlation is significant at the 0.01 level (2-tailed). * Correlation is significant at the 0.05 level (2-tailed).

Table 10 Correlations between innovations and communication, competence and changes in routines

		No talk to leader	No talk to members of the group	Group member initiative talk to you	Average education level	Understand technology	Participated last month in courses	Change in routines	Formal change in routines
Innovative idea needs	Correlation	.343**	0.096	0.145	.268**	.200*	0.125	0.042	.296**
	Sig. (2-tail)	0.000	0.310	0.124	0.004	0.034	0.188	0.659	0.001

new knowledge	N	113	113	113	113	113	113	113	113

** Correlation is significant at the 0.01 level (2-tailed). * Correlation is significant at the 0.05 level (2-tailed).

Table 11 Correlations between trust and innovation variables

		Innovative idea needs new ways to exchange knowledge	Innovative idea affects organizational culture	Innovative idea planned/done
Innovative idea requires stronger network of trust	Correlation	.198*	.241*	.228*
	Sig. (2-tailed)	0.035	0.010	0.015
	N	113	113	113

** Correlation is significant at the 0.01 level (2-tailed). * Correlation is significant at the 0.05 level (2-tailed).

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