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A system dynamic approach to competitive advantage: the petro-industry in Central Norway as a case study

*Maria Sandsmark**

Molde Research Institute,
Britveien 4, N-6411 Molde, Norway

Abstract

The aim of this paper is to study the interplay of factors described in the literature of industrial clusters, business-to-business branding and industrial organization and how these influence firms' competitive advantage over time. To structure and facilitate the interdisciplinary analysis, I chose a system dynamic approach. The applicability of the theoretical study of competitive advantage is discussed using a case study of the development of global brands within the petroleum industry in Central Norway.

Key words: Industrial clusters; B2B branding; industrial organization; system dynamics

* Tel.: +47 71214284; Fax.+47 71214299; E-mail: maria.sandsmark@himolde.no

1. Introduction

The objective of this paper is to use a system dynamic approach to perform an interdisciplinary study of the factors that underlie sustainable competitive advantage. The petroleum industry located in Central-Norway will serve as an empirical case when discussing the system dynamic approach. This industry is part of a maritime cluster that has been studied frequently the last 15 years, see Hervik et al. (2009) and the references therein. The scope of these studies has so far been to identify successful cluster effects in terms of cooperative patterns and knowledge sharing, c.f. Bjarnar (2008). However, besides the literature on industrial clusters (Porter, 1990 and Krugman, 1991) there are at least two distinct strands of the international academic literature that deal with the topic of competitive advantage. The ones I have in mind are the industrial organization literature (Tirole, 1988 and Shy, 1995) and the literature on brand building (de Chernatony and McDonald, 2003).

Although having somewhat different scopes, the abovementioned literature uses *innovation* and *product differentiation* as core concepts to explain competitive advantage: The cluster literature studies the effects of innovation and differentiation that relate to firm localization; the industrial organization literature studies how market structure influences incentives to innovate and bring forth differentiated products, whereas the branding literature studies how potential customers' emotional associations with products or services motivate product differentiation to build brand identity and to keep a constant focus on innovations to maintain customers' loyalty over time. Moreover, causes and effects are interlinked: for example, localization and market structure influence the potential for establishing successful industrial brands and individual incentives to pursue branding strategies affect the level of innovation within an industrial cluster.

Therefore, the purpose and novelty of this paper is to use a system dynamic approach (see Barlas, 2002) to facilitate the joint application of the insights from the three above mentioned literature strands to illuminate our research topic, motivated by the following questions: *What characterize the global brands already established within the petroleum industry in Central Norway? Has the market structure and localization within an industrial cluster influenced their market position/brand equity? Also, is there a scope for new global brands due to increased globalization, and if so, wherein lays the potential for successful brand building?*

System dynamics was developed during the 1950s and has now become an advanced method for describing a system's basic structures through causal loop diagrams and simulation, for example in resource planning, c.f. Ford (1996). Apart from Lin et al. (2006), Dangelico et al. (2010) and Ma and Huang (2008), examples of system dynamic analyses that study competitive advantages and regional growth are few. Lin et al. (2006) consider four dimensions of industrial competitiveness that may affect cluster effects, Dangelico et al. (2010) use system dynamic modeling to describe the relationship between knowledge and proximity and analyze how these elements can affect the success and survival of technology districts, using the aerospace district of Seattle as an example and Ma and Huang (2008) use system dynamics to better understand the evolution of logistics clusters.

In the present paper I extend the interdisciplinary study by Bremnes and Sandsmark (2010) to include system dynamics. The system dynamic approach combines and structures feedback loops that facilitate a long-term dynamic perspective. Particularly relevant for the purpose here is the property that both quantitative and qualitative data are applicable. Although a computational analysis or data simulations lie outside the scope of the present paper, practical applicability is part of the motivation and will be the objective of further research. Although

the petroleum industry in Central Norway is used as a reference industry, I believe that the topic has relevance beyond this narrow focus.

The rest of the paper is organized as follows: In the subsequent section I present the literature background that serves as a basis for the interdisciplinary feedback modeling of factors that influence sustained competitive advantage. Section 3 contains the system dynamic feed-back loops and Section 4 discusses the appropriateness of the interdisciplinary dynamic approach to understand the development of the petroleum industry and in Central Norway and the global brands within this industry. Section 5 concludes.

2. Literature background

Firms with opportunities and incentives to innovate may be able to differentiate their products or services from those of their competitors. Moreover, such a setting constitutes a potential for establishing a brand identity. Relevant questions are then: To what extent does a firm have a realistic option, in terms of economical capacity, to carry out research and development (R&D) activities? And what are the determining factors that decide whether firms chose to engage in these kinds of activities? In my opinion, these questions are best answered if highlighted by insights from different academic traditions, outlined in the following. The literature study presented here, starting with industrial organization, followed by industrial brand building and geographical clusters, is to a large extent a summarized version of Bremnes and Sandsmark (2010), which will serve as the underlying theoretical basis for the system dynamic loop flow diagrams presented in Section 3.

2.1 Industrial organization

Industrial organization theory assumes that consumers in a market for a homogenous product are indifferent to the origin of the product and will choose the supplier with the lowest price. Thus, the established market price will equal the cost of producing one additional unit, the marginal cost, and the opportunity to earn positive net profit is limited. Therefore, firms would wish to alter the attributes of its product to make it stand out from its closest substitutes. Thereby the firm may endogenously decide the price (or equivalently the quantity) that yield the highest profit, i.e. where marginal cost equals marginal revenue, and be able to earn a positive net profit, see e.g. Varian (1992). Altering a product's attributes does, however, require financial resources to undertake R&D activities. Schumpeter's (1943) creative destruction process implies that firms with successful innovations increase their market shares. Schumpeter's hypothesis further suggests that an efficient economic development encompassing technological changes and innovations requires a market structure that is dominated by few large firms. In contrast, Arrow (1962) shows that the incentives to invest in order to obtain innovations may be weaker for a monopolist compared to a firm who operates in a perfect competitive market. The reason is that the monopolist will only replace itself whenever it realizes successful innovations, whereas innovations that take place in a competitive market will result in the owner capturing market shares. But, as noted above, firms in a competitive environment will not be able to realize a profit above a normal return on the input factors, implying that the possibility to engage in complex R&D activities is limited compared to the monopolist. The discussion above indicates that two conditions are central in relation to the innovation rate within an industry. Firms must be able to achieve sufficient revenue to manage initiation of R&D projects and the right incentives must be present, meaning that there must be a certain competitive pressure.

Successful product differentiation thus implies that the competitive environment changes as the firm establish market power to some degree and in the short run the market power position will yield a certain extra profit. However, this market adjustment is not a long term equilibrium. The extra profit will constantly be challenge by the competing firms who eventually reduce the extra profit. To what extent the firm is able to maintain the monopoly profit over time depends on how easily rival firms manage to imitate the invention or how fast new firms can enter the market. But the question still remains: Which firm, who both has the option and incentives to innovate, is able to transform a decision to innovate into a differentiated product that will increase the owners' competitive advantage, and how? Answers to these questions are better found in the literature on industrial brand building.

2.2 B2B branding

Industrial marketing practice has traditionally emphasized measurable product characteristics when communicating with potential customers, thus most of the literature on branding has been focusing on consumer goods or services. However, an increasing literature is evolving around business-to-business (B2B) branding, see for example Shaw et al. (1989) and Kotler and Pfoertsch (2007). Other relevant studies include Walley et al. (2007), Roberts and Merrilees (2007) and Blombäck and Axelsson (2007). Yet, the literature reveals differences between business brands and consumer brands, c.f. Beverland et al. (2007). The relationship between buyer and seller is often personal in business markets compared to consumer markets as buyers are fewer and have more specific needs. Therefore, the degree of confidence in a certain product is typically tied directly to the producer or firm rather than the product or service. Moreover, heavy expenditures on advertising do not contribute to brand identity and

brand awareness in the same degree in business markets as in consumer markets where personal selling is more important (Davis et al., 2008). Also, Gordon et al. (1993) shows that industrial brand loyalty tends to be of a more global nature, extending across all the firm's product lines. Furthermore, industrial brands have the emotional benefit of reducing perceived risk and uncertainty whereas consumer brand management relates more to self-expressive benefits of brands, c.f. Mudambi (2002) who examines to whom B2B branding is important and in what situations. She finds that the branding receptive buyer descriptor was “large volume” and “sophisticated” and the purchase descriptor was “highly important” and “risky”.

A brand building strategy is shown to serve as a point of differentiation among industrial firms' products or services and brand equity provides a powerful source of sustainable competitive advantage in industrial markets, especially in B2B service markets (Berry, 2000 and Davis et al., 2008). But sustaining a service brand's competitive advantage is particularly difficult as competitive responses can very quickly appear, c.f. Chernatony and McDonald (2003). Then, how can firms manage a brand identity to keep customers loyal or, alternatively, how to maintain a competitive advantage? The added value of product differentiation lies at the heart of brand building strategies and from the literature we learn the importance of continuous innovations (Berry, 2000 and Varadarajan, 2009) and the management of the intangible aspects of products and services (Levitt, 1980) to achieve and sustain a competitive advantage. The choice of geographical localization can serve as a strategic means to making the intangible tangible – to attract customers – and also to increase the chance of innovation successes over time – to help keeping them. Thus, individual brand building strategies may strengthen the perceived feedback effects of industrial clusters.

2.3 Brand building and industrial clusters

There is an extensive literature on industrial clusters highlighted from a wide range of disciplines such as economic geography, sociology and regional planning. A review of different strands of the cluster literature is presented in De Maritno et al. (2006). Our focus here is the literature founded on the works of Marshall (1948) who analyzed industrial districts and the potential for external economies of scale and reduced transaction costs due to agglomeration of firms. According to this theory there are three key factors that influence localization: First, a common market for skilled labor/offered jobs; second, a market for specialized inputs or services; and third, information spillover. This theory is further, but differently, developed by Porter (1990) and Krugman (1991), among others.

Porter (1990) analyzes the development of clusters by emphasizing the interlinkages between firm strategy, its competitive environment and the characteristics of demand and factor conditions, which stimulates innovations. Thus the firms in the cluster gain a competitive advantage compared to similar firms outside the cluster. Krugman (1991) formalizes the theory by using models and techniques derived from theoretical industrial organization and study the interaction between economies of scale and transportation costs and the effects on geographical concentration. The externalities that may lead to an agglomeration of firms are associated with either demand or supply linkages (pecuniary externalities), rather than technological spillovers, implicitly assuming imperfect competition and increasing returns. Firms will therefore locate in a limited number of sites, and due to the minimization of transportation costs, the most likely places are those with large nearby demand. Further, a market is large where production is concentrated. Whether this circular causation process will

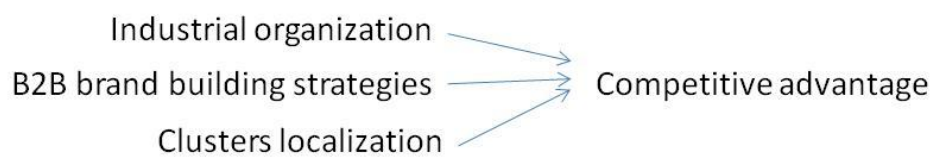
start feeding on itself or not depends in this model on the critical threshold of transportation costs, economies of scale and the share of goods produced with modest use of land. We claim that individual brand building strategies, and in particular actions to make the intangible tangible, may reinforce any positive feedback effects of established industrial clusters.

According to a study documented in Hall (1992) firms' most important intangible resource is company reputation, followed by product reputation and employee know-how. As shown in the study conducted by Blombäck and Axelsson (2007), buyers who considered potential subcontractors sometimes discussed the matter with their competitors or suppliers to subcontractors to limit the time and resources spent on evaluating and selecting a suitable supplier. Therefore, choosing localization within an industrial cluster may increase the likelihood of successfully creating and conveying a favorable company reputation, for example via the informal network of the cluster. Being localized within an industrial cluster may also serve as a signal for quality since producing value-added products or services require a positive net profit, which could be needed to afford to be operating in an area with higher input prices. However, when buyers have become familiar with the brand, its reputation is less important. Then the anticipation of future performances will influence potential re-purchases. Being associated with an industrial cluster may then benefit the process of accumulating brand equity as firms in clusters are expected to innovate more, see Baptista and Swann (1998), due to fore example technology spillovers, c.f. Fosfuri and Rødne (2004). Thus, by choosing a location within an industrial cluster, the intangible resources *reputation*, *perceived quality* (supporting brand identity) and *expected future performance* (supporting brand loyalty) may become tangible.

3. System dynamic visualization of competitive advantage

The literature review in the section above presents three distinguished literature strands that all seek to explain competitive advantage, but using different approaches and emphasizing different aspects. Figure 1 illustrates a corresponding static and exogenous model for competitive advantage.

Figure 1 Exogenous, static model of competitive advantage



Our objective here is to extract the basic insights from these three approaches and to extend the understanding of sustained competitive advantage, which could also be translated into brand equity. To do this, we utilize a system dynamic method, c.f. Barlas (2002), which can transform the static cause-and-effect model depicted above, to also include feedback-loops that explain synergetic effects. Then we are able to systematize effects that influence other effects which in different ways affect how industrial firms gain and sustain brand image and how cluster localization can maintain their competitive advantage. Increased knowledge of the dynamic effects that underlie brand equity may benefit both individual firms and policy planners.

Presenting a fully analytical model that can be utilized for simulation with statistical data lies outside the scope of this article. The aim here is to present in a systematic way the complex interaction of dynamic variables that underlie competitive advantage. This will, however, constitute the first stage in a more rigorous model which can encompass real world data to perform simulations of different scenarios, left for future research. One of the advantages

using a system dynamic modeling approach is the ability to use both qualitative and quantitative data in the same model. To make a clear exposition, we first present each literature strand as presented in the literature review section as one dimension of the flows that constitute sustained competitive advantage. Then we present the interdisciplinary loop-flow diagram as a connection of the three single dimensions.

3.1 A system dynamic approach to industrial organization

The industrial organization literature focuses on how the ability to achieve competitive advantage depends on the market structure. Key factors are the ability and incentives to earn a positive net profit to finance R&D activities and innovations. Product differentiation is thus both a result of gained competitive advantage and a means to soften a constant competitive pressure from rival firms, better illustrated using a system dynamic perspective. A casual loop diagram illustrating flows representing the market dimensions underlying industrial organization is depicted in Figure 2.

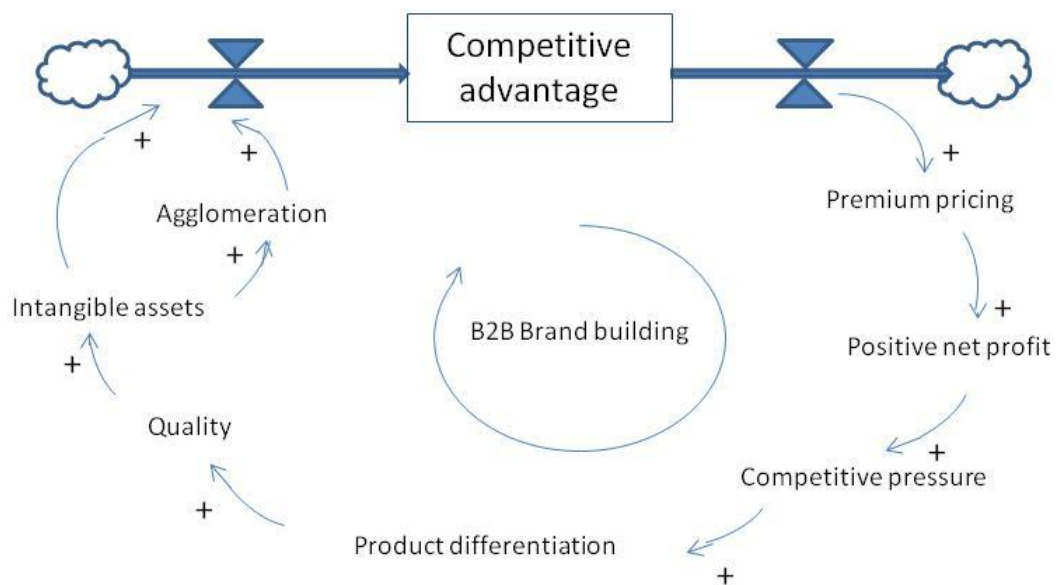
Figure 2 Causal loop diagram of industrial organization flows



3.2 A system dynamic approach to B2B brand building

The literature on B2B branding is focusing on the firms' ability to differentiate its products or services from its competitors' and thus establishing a brand image, including efforts to create intangible assets. A brand image will in turn facilitate premium pricing. A positive net profit is necessary to be able to constantly bringing forth innovations that are relevant for the customers, to keep customers loyal. For subcontractors and suppliers of industrial services B2B branding also implies strategies to make the intangible tangible, as their product name or firm logo is not visible on their customer's final product. Being associated with successful partners or products is therefore valuable. B2B branding strategies that help maintaining a firm's competitive advantage create a dynamic process of brand equity. A system dynamic perspective helps visualizing the laps of time involved in establishing brand equity. A casual loop diagram illustrating flows representing the dimensions underlying B2B brand building strategies is depicted in Figure 3.

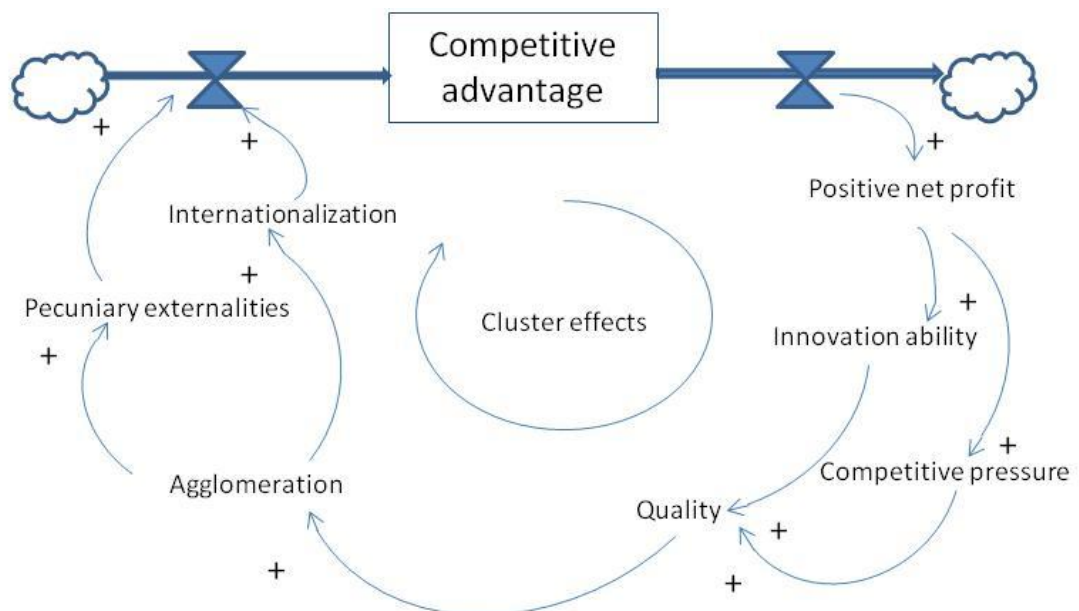
Figure 3 Causal loop diagram of B2B branding flows



3.3 A system dynamic approach to geographical clusters

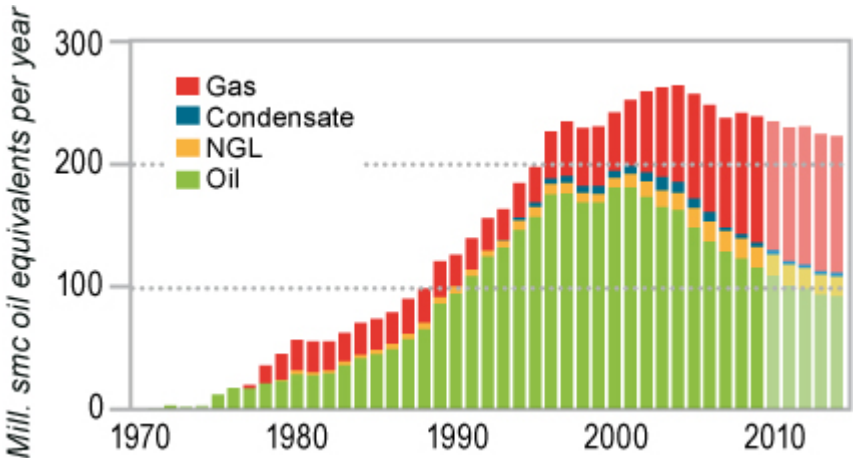
The literature on industrial clusters presented in Section 2, studies how innovation and productivity growth are affected by geographic agglomeration and the economy of scale that is created when a cluster achieves sufficient size. The literature focuses on spillover effects and pecuniary externalities enforced by a competitive pressure and demanding customers. This environment offsets incentives to innovate, which attracts new firms such as global brands interested in specialized products or services. The cluster literature is also occupied with the idea of self-enforcing mechanisms, narrowing any gap to a system dynamic depiction of the process underlying competitive advantage. The corresponding casual loop diagram illustrating flows representing the dimensions underlying industrial cluster effects is depicted in Figure 4.

Figure 4 Causal loop diagram of industrial cluster flows



industry has gained advanced technical knowledge in many specialized fields. The first oil field, Ekofisk, opened in 1971 and as the Norwegian petroleum industry moved northwards into the Norwegian Sea, it has entered areas containing enormous gas resources, c.f. Figure 6 that displays the historical production of oil and gas from 1971 to 2009.

Figure 6 Historical production of oil and gas from 1971-2009 and production forecast for the next few years

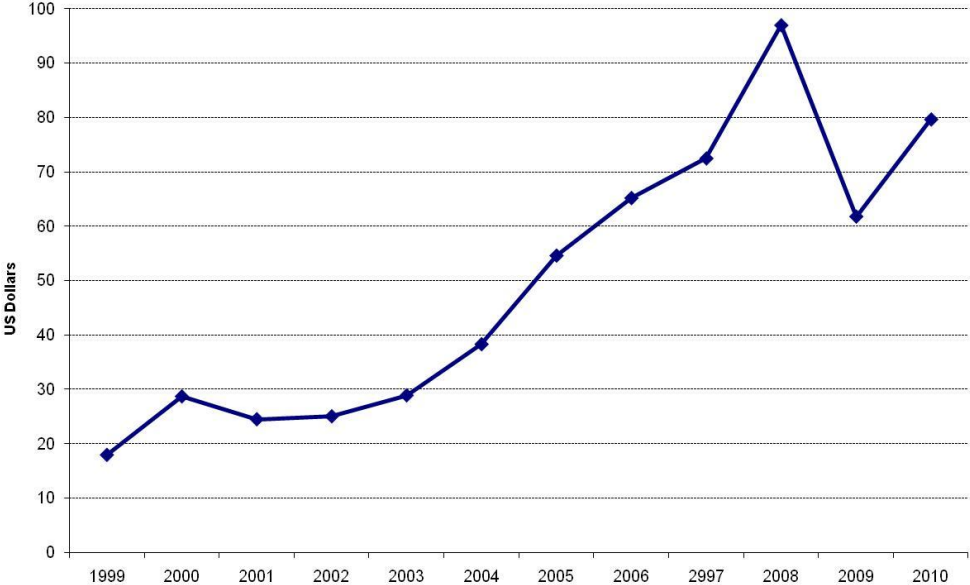


Source: Norwegian Petroleum Directorate

One of the largest gas fields is Ormen Lange outside the shore of Central Norway. Production from this field started in 2007. Gas and condensate from the subsea templates is transported to an onshore facility, where gas is dried and compressed before it is transported in a subsea pipeline to Great Britain. The sea depth in the area varies from 800 to 1100 meters, which made the development very challenging. However, the challenge triggered the improvement of new subsea technology. Thus, the project has become a show window for the companies and subcontractors who were involved, and many of these are companies located in Central Norway. The experience that was gained has opened up possibilities for these subcontractors on other continental shelves, such as the Gulf of Mexico, Brazil and Australia.

Moreover, the development of Ormen Lange coincided with a period of strong economic expansion fuelled by the oil price increase from 2003 to 2008, c.f. Figure 7.

Figure 7 Development in Europe Brent Spot price from 1999 to 2010, US Dollars per Barrel



Source: EIA

However, the graph depicted in Figure 7 shows only the average yearly prices. Looking at weekly prices, the Brent Blend peaked at over 139 US Dollar per barrel in mid July 2008. The ship owners, ship yards, ship design consultants and subcontractors who constitute a maritime cluster in Møre and Romsdal – a county of Central Norway – also took part in the petroleum industry boom. A characteristic development of the maritime cluster this period was the transition from traditional maritime products and vessels to highly specialized offshore products and vessels. Some companies within this cluster already had a global brand status, such as Rolls-Royce Marine, Farstad Shipping and the Ulstein Group. Their position served as a stepping-stone for many regional subcontractors in winning international offshore contracts this period, see Bjarnar (2008) for a more detailed account of the history, structure and

cooperate effects of this industry cluster. After the global financial crisis in 2008 and the subsequent drop in oil prices (the price dropped down close to 36 US Dollar at the end of 2008), one expected that the petroleum industry in Central Norway, including the maritime cluster, would experience major problems as demand for offshore equipment and services fell worldwide. Therefore, despite the increase in oil prices during 2009, the Norwegian government launched a support program for ship yards in April 2010 as the order books were close to empty after 2010.

According to the literature on geographical clusters, one would expect that firms with cluster localization improve their ability to sustain a competitive advantage despite business cycles. This literature does not discuss firms' B2B branding strategies, but having the B2B branding literature in mind one would also expect that global brands and their subcontractors would be able to tackle a period of demand shortfall. In the following we present three companies who both have a strong position in the petroleum industry in Central Norway and are members of the maritime cluster. The companies are The Ulstein Group, Brunvoll Thrusters and Rolls-Royce Marine. Based on information displayed on their public websites, we emphasize the company profit through the global financial crisis and potential approaches towards B2B branding strategies and a sustained competitive advantage.

4.2 Examples of global brands in the petroleum industry

The Ulstein Group is a family owned business established in 1917 and the company comprises ship design, shipbuilding, power and control systems, global sales and services and shipping. The Ulstein Group offers ship design package and solutions to offshore support vessels, heavy offshore vessels and short-sea shipping vessels. Technical innovations are main

strategic devices to sustain competitive advantage and one of the latest design innovations is X-BOW[®], a concept that brought a new way of designing and building offshore and specialized vessels inspired by the old Viking style. A priority area during the financial crisis was announced to be R&D activities that aimed at improving the quality of the company's products and services. The annual report from 2009 shows that the operating income has increased every year since 2004 and the profit for the year 2009 was nearly 362 million NOK, close to a 13 percent increase from 2008.

Brunvoll Thrusters was established in 1912 by three brothers and the company is still owned by the Brunvoll family. The company focuses on one product only: The Brunvoll Thruster System. During the petroleum boom from 2005-2008, the company experienced a huge interest in their product and invested 150 million NOK in new equipment. In late 2010 the company has repaid its debt due to this investment program and is planning a new expansion at a cost of 45 million NOK. The expansion will allow the company to produce larger thrusters and rim driven thruster units (RDT). RDT is a Brunvoll invention, a new and revolutionary thruster without a central shaft. Brunvoll has a strategy of keeping the whole value chain in-house. Moreover, the company encourages direct communication between its engineers and its customers enabling the development of innovative tailored solutions. After sales services are also important. This is to secure that there is no cutting back on quality, which is the company's stated brand image. They claim to use only top quality materials and components, believing that the result is lower life-cycle costs for the customers. Failing to keep up with its claimed standards is feared to cost the company its hard-won reputation. So far this strategy seems to have been a success. In 2009 the company experienced a record operating income of 785 million NOK, not expecting 2010 to be equally good, but close. The prospects for 2011 are fairly optimistic.

Rolls-Royce Marine is a division of the Rolls-Royce Group, acquired from Vickers plc in 1999. The previous year, the company was owned by Ulstein, who developed the UT-design. UT-design was developed in parallel with the evolving offshore activities in the North Sea and the first UT-design vessel was delivered in 1975. In 2005 there were 500 contracted UT-design vessels around the world. This number increased to 650 by 2010. In 2009 a UT 761 CD vessel won the “Ship of the year 2000” price. This was the world’s most powerful offshore vessel – a multifunctional Plough/Tug/ Supply/Subsea Service Vessel. Rolls-Royce Marine is the largest ship-designer in the maritime cluster. Revenue and profit before financial costs were £ 2,591 million and £ 332 million in 2010. The revenue was almost the same in 2009, but the profit increased by 26 percent. The local subcontractor ODIM, who produces world-known anchor handling solutions, was acquired in 2010. Rolls-Royce put serious efforts in R&D activities and is working in close relation with The Norwegian University of Science and Technology, situated in Central Norway, among others. This collaboration benefits both actors. Rolls-Royce gains access to qualified R&D personnel who give priority to their problems, whereas the researchers get funding.

4.4 Discussion

The three companies presented briefly in the previous subsection all belong to the maritime cluster in Møre and Romsdal county and they have been part of the cluster as it evolved through several business cycles. These global brands within the petroleum industry in Central Norway can therefore not be said to have chosen to establish their businesses within an industrial cluster as part of a strategy for building a brand image. However, based on how the companies present themselves on their web-sites, there are other recognizable elements from the B2B branding literature that one notice. Particularly, strategies that can be said to sustain

competitive advantage or brand equity. We notice that the priority of R&D activities are emphasized, which supports the expectation of new innovations, c.f. “the extended product” discussed in Levitt (1980). Also, the companies stress the importance of personal service, which can be part of a strategy to internalize the brand, c.f. Berry (2000) suggests four strategies to cultivating service brand equity: 1) Create visible different brand profile – defy convention 2) Focus on underserved market needs 3) Make an emotional connection with customers’ core values, and 4) Internalize the brand.

Brunvoll’s articulated strategy of limiting the outsourcing of input factors in order not to jeopardize the quality of their product is supported in Beverland et al. (2007). They point out that the degree of confidence in B2B brands are more closely linked to the producer than the product, contrary to consumer markets. A loss of brand equity associated with one product may therefore pose a negative effect on the company’s entire product range. This is even more important for global brands.

Although the rise in oil prices in 2009 increased the global offshore activities after the financial crisis, the three companies were not severely affected economically by the recession. There is no proof that localization within a cluster or strong brand building traditions were the main cause for this, but we believe that these factors cannot be overlooked. This claim is supported by the findings in the study of Mudambi (2002). The results suggest that B2B branding is most important when purchases are large volume, important and risky, and the products or services supplied are sophisticated and tailored. The associated purchase process is open-minded and thorough. These features, characterize the products and services produced and supplied by the companies constituting the petroleum industry in Central Norway.

5. Concluding remarks

Often different models are used to explain a certain behavior or development, each having a group of supporters. If one look at different theoretical approaches that discuss firms' competitive advantage, one observe that different factors are emphasized differently. I have here studied economic theory of industrial organization, geographical clusters and B2B brand building and found that these distinct models in many aspects work more in terms of complementary than substitutes. However, studying the interplay of theoretical approaches rather than choosing one over the other may increase the insight. The literature on industrial organization emphasizes the necessary conditions for firm to take part in innovations and product differentiation and thereby achieve competitive advantage. Cluster theory emphasize the effect of a firms localization on the degree of innovation and stress that the choice of localization may be a relevant success factor in terms of competitive advantage and internationalization. The B2B branding literature call the attention to the reason why firms should be occupied with innovations and product differentiation and give evidence to the importance of psychological factors in business markets. The three literature strands thus add important and complementary aspects to the development of competitive advantage. Moreover, the different factors underlying competitive advantage seem to interplay, suggesting a dynamic process that explains a successful development from brand identity establishment to brand equity. The system dynamic approach facilitates the dynamic representation.

Illustrating the interplay of factors that influence competitive advantage over time using a system dynamic approach increases the ability to catch sight of hidden courses of action. Also, a systematic presentation of factors that influence competitive advantage via loop-diagrams may add new insight to the effect of political processes, as the accuracy of public

support schemes. Firms and authorities seeking sustained competitive advantage and regional growth would thus benefit from taking an interdisciplinary management perspective. The potential value and information drawn from an explanatory model will of course increase if the model is tested empirically. Such a task will be the basis for subsequent research projects.

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Høgskolen i Molde
PO.Box 2110
N-6402 Molde
Norway
Tel.: +47 71 21 40 00
Fax: +47 71 21 41 00
post@himolde.no
www.himolde.no



Møreforsking Molde AS
Britvegen 4
N-6411 MOLDE
Norway
Tel.: +47 71 21 42 90
Fax: +47 71 21 42 99
mfm@himolde.no
www.mfm.no