ONSHORE- OFFSHORE DECISION FOR HIGH TECH SHIPBUILDING PROJECTS

Abstract
In this paper, we study Norwegian ship-owners on-shoring and offshoring decisions when building advanced offshore support vessels. Innovative shipbuilding requires a good relationship between partners in the shipbuilding project. Therefore, we focus on the challenges of how social capital in business networks and project characteristics will influence the sourcing decision in shipbuilding projects. The research question investigated is how does partner relationship and project characteristics influence the sourcing decision in shipbuilding projects? Data from a Norwegian owned fleet of 456 vessels are used to investigate the dependence of complexity/ novelty, whether ship-owner are located within the shipbuilding cluster, and previous building experience from building abroad or in Norway on the probability of ship-owners to on-shore their next shipbuilding project. We did find significant effects of such dependency.

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INTRODUCTION

Knowledge and knowledge management play a key role in managing businesses and projects successfully (Perez-Araos, Barber, Munive-Hernandez, & Eldridge, 2007). Effective knowledge management has a potential to improve the effectiveness of project activities by increased learning ability and provide a major source of competitive advantage for project-based firms (Kivrak, Arslan, Dikmen, & Birgonul, 2008). Knowledge management is especially important in *innovative shipbuilding* projects that are relatively complex in design and equipped with advanced onboard systems. These systems are often supplied by multiple vendors with different nationality and culture. Research has shown that innovative shipbuilding projects are comprised of different knowledge-based activities that require different types of knowledge being exchanged between the parties involved (Solli-Sæther & Karlsen, 2012). However, organizations often face difficulties when trying to encourage knowledge sharing behaviours (Wang, 2001). This may be due to international, organizational and technological challenges that innovative shipbuilding projects confront (Berggren, Bergek, Bengtsson, & Söderlund, 2011). The international challenge may include cross border projects, like offshoring, and knowledge integration between companies in high-tech (high-cost) and low-tech (low-cost) countries, as well as cultural differences. The organizational challenge may include project management and control, and alignment of goals and success criteria, as well as social capital in business networks. The technological challenge may include knowledge specialization, complex technologies, issues of intellectual property rights, and clock speed competition.

This paper seeks to study the sourcing decision in building-projects of advanced offshore service vessels. More specifically, this investigation focuses on the onshore-offshore sourcing decision, the impact of partner relationship, and the impact of complex technology. The paper draws on 456 innovative shipbuilding projects with Norwegian based ship-owners, shipyards located onshore or offshore, and four different types of advanced supply vessels.

Shipbuilding requires a good relationship between partners in the shipbuilding project. Therefore, we focus on the challenges of how partner relationship (e.g. social capital in business networks) and project characteristics (e.g. advanced offshore vessels) will influence the sourcing decision in shipbuilding projects. Consequently, the research question investigated in this study is stated as follows: *How does partner relationship and project characteristics influence the sourcing decision in shipbuilding projects?*

THEORY

Prior research has come up with different reasons for global sourcing. Cross-border factor-cost advantages through “low-wage country sourcing” is traditionally the primary reason (Steinle & Schiele, 2008). Other goals may be to offset competitive disadvantages by finding foreign suppliers that offer quality or technology superior to what is available at home (“global technology sourcing”). Purchasing activities in target countries may also be a strategy to pave the way for future sales activities. (Steinle & Schiele, 2008).

Social capital in clusters

Positive externalities of firms within clusters and industrial districts are well documented in the literature (Molina-Morales & Martinez-Fernandez, 2006; Porter, 1998). Cluster literature has changed over time and increased its focus on externalities from social and relational resources (Molina-Morales & Martinez-Fernandez, 2006). This calls for studies which targets social capitals contribution to positive externalities for cluster firms. Social capital theory is a label for diverse theories that share a focus on social relation as a source that can provide benefits to individuals or communities/regions. Definitions of social capital vary in what sources they include in the concept. From a narrow definition, including only the network structure (Baker, 1990; Burt, 2000). To a wider definition, including also social relation factors of the ties or connections (Bourdieu, 1985; Portes, 1998; Putnam, 1995; Woolcock, 1998). The broadest definition includes also potential resources related to actor abilities located in the nodes of a network (Adler & Kwon, 2002; Nahapiet & Ghoshal, 1998).

Nahapiet and Ghoshal (1998)'s working within the field of organizational theory and management proposed the following definition of social capital as: "the sum of the actual and potential resources embedded within, available through, derived from the network of relationships possessed by an individual or social unit. Social capital thus comprises both the network and the assets that may be mobilized through that network" (Nahapiet & Ghoshal, 1998: p. 243). Nahapiet and Ghoshal (1998)'s also separated social capital in a structural, relational and cognitive dimension.

The relevance of geographical concentration has changed its role due to globalization. Firms opens up and interacts with distant markets and resources in combination with exploitation of advantages of local factors (Molina-Morales & Martinez-Fernandez, 2006): "Previously located factors of production becomes globally available and, in consequence, they cannot be considered as the base of local competitive advantage. However, the pattern of specialization is remarkably stable.” (Molina-Morales & Martinez-Fernandez, 2006: p. 506). Proximity as a factor contributing to tacit knowledge exchange, learning and innovation, becomes the new explanation of clustered specialization advantages (Maskell, 1998; Maskell & Malmberg, 1999; Molina-Morales & Martinez-Fernandez, 2006).

The growing complexity of the knowledge bases necessary for innovation increases the importance of external or inter-firm sources for innovation activity and the capacity for absorbing knowledge from outside the firm is important for innovative firms (Fagerberg et al., 2005). Pavitt (1984), introduced a taxonomy separating two high tech sectors; ‘science based’ and ‘specialized suppliers’. The first where characterized by high levels of formal R&D and strong links to scientific knowledge where the second where characterized by capabilities of engineering and close interaction with users. The factors leading to innovation differs strongly between these two sectors (Pavitt, 1984), where tacit knowledge and relational strength seem to be more important for specialized supplier projects.

CONTEXT

The maritime cluster in Møre and Romsdal consists of at least 215 firms; 19 ship-owners, 14 shipyards, 13 design companies and 169 ship technology suppliers. Together these firms employ about 20,000 workers within a county with a population of about 250,000 and most firms are located in agglomerations within the county where the maritime clustering will be higher (Hervik, Oterhals, Bergem, & Johannessen, 2012). The county of Møre and Romsdal enjoys a strategic position close to the North Sea with rich fishing, oil and gas resources, which have contributed to a concentration of maritime industry in the county. Large investments in the oil and gas industry, which enabled the exploitation of oil in deep waters and harsh weather conditions made way for expensive and innovative offshore service vessels (OSV's) in a local maritime industry. Sailing officers and crewmembers have interacted with ship owners, shipyards and ship technology suppliers to develop experienced based innovations for high-end offshore vessels. This resulted in great expansion within the Norwegian maritime industry. Reve and Sasson (2012), describes the maritime cluster in Møre and Romsdal as one of the most prosperous in Norway during this period. Local ship-owners suggests that the way companies in the maritime cluster cooperate is contributing to competitive advantage for the local maritime cluster in building the most complex innovative shipbuilding projects. Since mid- 2015, the ship- owners in the offshore segment have found themselves in deep trouble due to overcapacity, and new contracts in this segment are rare. Less activity in the oil and gas industry means that shipyards and suppliers in the shipbuilding value chain has adapted to a new situation by focusing on other segments of shipbuilding such as fisheries, offshore wind and cruising. According to the Norwegian Ship-owner Association the Norwegian offshore fleet, is the worlds second largest, and its most modern. It has been specializing in deep-water operations, which demands larger vessels with capabilities to operate in harsh weather conditions.

Different actors has taken different roles within the maritime cluster network and has different characteristics of their network structure. *Ship technology suppliers* may choose to operate within rather closed communities with shipyards within the cluster or engage in external ties with customers operating all over the world. *Shipyards* have both a network of closed ties with suppliers and may have a more open network with design companies and ship owners. *Design companies* can take the role of brokers or boundary spanners between ship-owners, shipyards and ship technology suppliers. *Ship-owners* supply offshore services in a global marked with customer ties spanning the boundaries of the local maritime cluster. Some cluster actors has developed strong relations from working together in previous projects and probably also share a common identity.

Knowledge base

The local maritime cluster has evolved over decades in an environment with many actors and firms involved in activities at sea and the development of new solutions based on their demands and ideas for improvements and novel solutions. Today the county of Møre and Romsdal has a high concentration of persons using equipment, vessels and performing multi-actor operations related to deep-sea oil and gas operations. Firms involved in development and production of tailored solutions for maritime use has evolved and clustered in the area providing a concentration of individuals and firms with engineering and production skills related to this industry. Experience from previous projects has contributed to organizational knowledge useful in multi-firm interaction in new projects. Table 1 illustrates how engineering and experience based knowledge from operations at sea and previous projects has become core knowledge for shipbuilding projects. From a situation where standardized vessels mainly involved welding of hulls and installation of components, advanced shipbuilding projects demands other knowledge bases. Ship-owners estimates that complete hull structures constitutes only about 20 % of the value creation in new vessels, and several yards choose to locate this task in shipbuilding projects to lower cost countries. System integration yards seem to have exchanged traditional welding work, with other more complex tasks related to system integration. Increased complexity in new one-of a kind projects tailored for new tasks, calls for innovative solutions where sharing of tacit knowledge and social capital like trust, common codes and established networks may be more important to obtain project goals in an effective way.

Table 1

The onshore-offshore decision

Each shipbuilding project constitutes a temporal project network formally regulated by contracts between customer (ship-owner) and shipyard based on a conceptual design and contract design. Shipyards take the role of system integrator and subcontracts both complex coordination intensive tasks and standard purchases. The temporal limitations of contracts contributes too frequent renegotiations of contractual relationships, but collaborating firms tend to continue relationship when entering new projects.

This paper builds on the assumption that ship-owners is economizing on core project goals (cost, quality, time and uncertainty) when choosing to build in Norway (on-shoring) or abroad (offshoring). Ship-owners decision depends on specific offers from shipyards, which again depends on factors like macroeconomic environment of shipyard (wage costs, financing opportunities, aggregate supply and demand in segment); cluster environment; social capital from previous partner experience and/ or cluster localization; specific yard qualifications and yard capacity.

Project complexity and novelty increases the degree of innovation in new projects and proximity as a factor contributing to tacit knowledge exchange, learning and innovation is a key factor explaining to explain clustered specialization advantages (Maskell, 1998; Maskell & Malmberg, 1999; Molina-Morales & Martinez-Fernandez, 2006)

Cluster theory and social capital theory assumes a knowledge sharing advantage in knowledge based clusters. Hourly wage cost is high in Norway, compared to most available offshoring locations and potentially collaboration advantages from social capital within the cluster must outperform cost disadvantages from higher wage costs for on-shoring to be preferable. Potential collaboration advantages will probably increase with the level of complexity or novelty of a shipbuilding project. We assume therefore that a Norwegian shipbuilder located within the maritime cluster have more social capital in relation to the maritime cluster than a ship-owner located in other parts of Norway.

Table 2 illustrates the anticipated causal relations between distance, complexity and performance. Collaboration advantages from low distance relationships has probably contributed to the development and survival of a Norwegian shipbuilding industry, where some ship-owners has seen these advantages as outperforming other cost advantages abroad.

Table 2

The on-shoring offshoring decision is as a selection where ship-owners try to economize on overall project goals and we expect the probability of building in Norway to depend on variables like project complexity, cluster location and previous experience.

METHOD

We identified the fleet of Norwegian owned offshore support vessels and collected information of ship-owner location, shipyard location, building year, vessel design and category by document studies on the Internet. The sources where web pages from the following actors; Norwegian ship-owners association, cluster organizations, ship-owners, shipyards, naval architects, class companies and articles from baptizing ceremonies in maritime magazines. We then added new constructed variables describing the number of vessels previously built abroad and number of vessels previously built in Norway based on the collected data. Norwegian ship-owners location where coded as either within the maritime cluster of the county of Møre and Romsdal or elsewhere in Norway. Each vessel in the Norwegian owned offshore support fleet in 2015 is the unit of analysis. We then performed a logistic regression to test the effect of ship-owners location, project complexity, previous building history in Norway and abroad and building year on the probability that Norwegian ship-owners choose to onshore their shipbuilding projects.

Data

456 vessels in the Norwegian owned fleet of offshore vessels is registered with information of owner, design company, shipyard, year of build and vessel categories. This covers more than 90 % of the total stock of Norwegian owned offshore vessels.

Table 3 shows a summary of the data for each ship-owner, weather the ship-owner did choose to build in Norway or abroad and three vessel categories; anchor handling tug supply (AHTS), platform support vessel (PSV), and seismic/ subsea vessels.

RESULT

We performed a direct logistic regression and found the following impact of a number of factors on the likelihood that Norwegian ship-owners choose to build a new vessel in Norway or abroad (Table 4). The model contained five independent variables (Cluster localization of ship-owner, year of build, number of vessels built in Norway up to date, number of vessels built abroad up to date, vessel category). The full model was statistically significant, χ^2 (df=7, N=448) = 114,93, ρ=0,000, indicating that the model was able to distinguish between shipbuilding projects where ship-owners choose or did not choose to build in Norway. The model as a whole explained between 22,6 % (Cox and Snell R Suare) and 33,8 % (Nagelkerke R suared) of the variance in selected building location, and correctly classified 81,7 % of the cases (Pallant, 2010; Tabachnik, 2013). As shown in table xx, all variables made a unique statistically significant contribution to the model. The strongest predictor of whether to choose to build domestic was ship-owners location within the maritime cluster of Møre and Romsdal recording an odds ratio of 2,86. Vessel category subsea vessel, which are assumed to be the most complex and tailored vessel category reported an odds ratio of 2,46 compared to platform support vessels which are assumed to be the least complex and tailored vessel category within this segment of offshore support vessels. The probability that a ship-owner chooses to build in Norway more than doubles if the ship-owner is located within the county, which is the locus of this maritime industry in Norway and doubles again when building a subsea vessel. The probability of building abroad increases over time and more than doubles in ten years.

Discussion

Social capital theory suggests that benefits from social capital may have a positive influence on knowledge sharing and innovation. Norwegian ship-owners decisions on building location for 456 shipbuilding projects show patterns which can be explained by high levels of social capital in the local maritime cluster. The model shows a significant effect of ship-owners cluster location and previous experience from building within the cluster on the location of shipbuilding projects. The model also show a significant effect of project novelty on cluster location where high novelty projects are systematically located within the local maritime cluster. An interpretation of the estimated results is that ship-owners located within the locus of the maritime cluster have about three times higher probability (odds ratio= 2,86) of placing their shipbuilding order at a Norwegian yard than ship-owners located in other parts of Norway, when controlled for other factors included in this model. This confirms an expected effect where an assumed stronger social capital within the local maritime cluster contributes to performance when choosing to build in Norway, and an assumed lower social capital when distance between ship-owner and local maritime cluster increases contributes less to performance when building within the cluster. If increased distance between ship-owner and system integration shipyard reduces social capital and performance from partnership between ship-owner and shipyard, it is reasonable to expect an even stronger effect when distance increases from Norwegian shipyards to ship-owners abroad. This would mean that foreign located ship-owners with even greater distance to the locus of this cluster has a disadvantage compared to local ship-owners if they choose to build in Norway. Non-cluster and foreign located ship-owners have different options when optimizing their onshore- offshore decisions. If cluster located ship-owners, have the same opportunities and gains from social relations and networks when building abroad than foreign located ship-owners and still find local shipbuilding more competitive, this might contribute to competitiveness for cluster located ship-owners. If cluster located ship-owners does not have the same opportunities and gains from social relations and networks when building abroad than foreign located ship-owners, their tendency to build locally may be a sign of lock-in in a less competitive relation than ship-owners located abroad.

The model does also show a significant effect from previous building experience both in Norway and abroad. The probability of building a vessel in Norway, increases with 4 % for each vessel previously built in Norway, and decreases with 14 % for each vessel previously built abroad. Previous building experience from building similar vessels in Norway is a measure of relational experience and a possible proxy for measuring social capital between ship-owners and shipyards. Number of vessels previously built abroad is an aggregate of experience from different building locations, and does not measure relational experience from a specific yard or cluster. This variable considered as a proxy for global experience, which we expect to reduce switching costs when considering to offshore later shipbuilding projects. A third variable was also constructed which counted the number of vessels previously built at the same yard as the last vessel. This variable probably was a better proxy for social capital in the relation between ship-owner and shipyard, but we later omitted this variable due to multicolinearity with variables for previously built in Norway, and previously built abroad.

Variables describing different categories of offshore support vessels has a significant effect on the possibility of building a vessel in Norway. Platform support vessels, has less variation in their function than subsea vessels where the variation in design demands for more tailoring of each vessel to specific purposes. The degree of novelty and therefore project complexity is therefore higher for subsea vessels than for PSV's. We expect therefore the probability for Norwegian ship-owners to build subsea vessels in Norway to be higher than the probability for building PSV’s in Norway. According to the probability of building a subsea vessel in Norway is 2,46 times the probability of building a PSV in Norway. The probability of building anchor handling tug supply vessels (AHTS) and seismic vessels in Norway is less than the probability of building PSV’s in Norway. Possible explanations for this unexpected result may be that seismic vessels have their complexity linked to other knowledge bases, which is not core for this maritime cluster, while AHTS’s are complex vessels with more standard functional requirements than PSV’s. The assumption of subsea vessels being more complex with higher degree of novelty than PSV’s is more certain than the assumptions for AHTS’s and seismic vessels. Better data regarding complexity and novelty for each vessel is necessary to elaborate these suggestions further.

Year of built also show a significant effect on the probability of building in Norway. The estimated probability of building in Norway diminishes by 7,4 % per year, when controlled for other variables. This is the reduction in probability for each vessel category, and the total effect may be reduced if there is built more complex vessels with a higher probability of being built in Norway.

Further work

The aggregate demand for Norwegian built vessels has probably influenced the onshore offshore decision for Norwegian ship-owners. When Norwegian yards was utilizing their full capacity, ship-owners could either delay their building projects, or search new partnerships abroad. Aggregate demand has probably also effected the price level in offers from Norwegian shipyards, which again may have reduced the probability of building in Norway. Norwegian shipyards order reserves could probably be included in the model to control for these effects.

The available dataset only has a limited set of variables. We have used these variables as proxies for vessels complexity, ship-owners social capital from previous projects and cluster attachment. Other variables who may influence the localization decision in general are missing in this analysis. For variables which did not change much during the period when these vessels where built this is of little relevance, like the assumption of lower wage costs when offshoring than when building in Norway is probably valid and not dramatically changed during this period. Other variables like the aggregate demand for vessels in this segment, has probably had a significant effect on ship-owners onshore offshore decision. If there has been situations with full capacity utilization and high order reserves in Norway, ship-owners is forced to offshore new projects.

The collected data also provides information of continuation or breaks in relationships between ship-owner and shipyards for successive projects. If complexity increases the value of close relations, I expect relationships to be stronger, for the most complex vessel categories. Using continued relationship (using the same yard as last time) as dependent variable is one way to test this assumption in later work.

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Table 1 Knowledge base for shipbuilding in the local maritime cluster

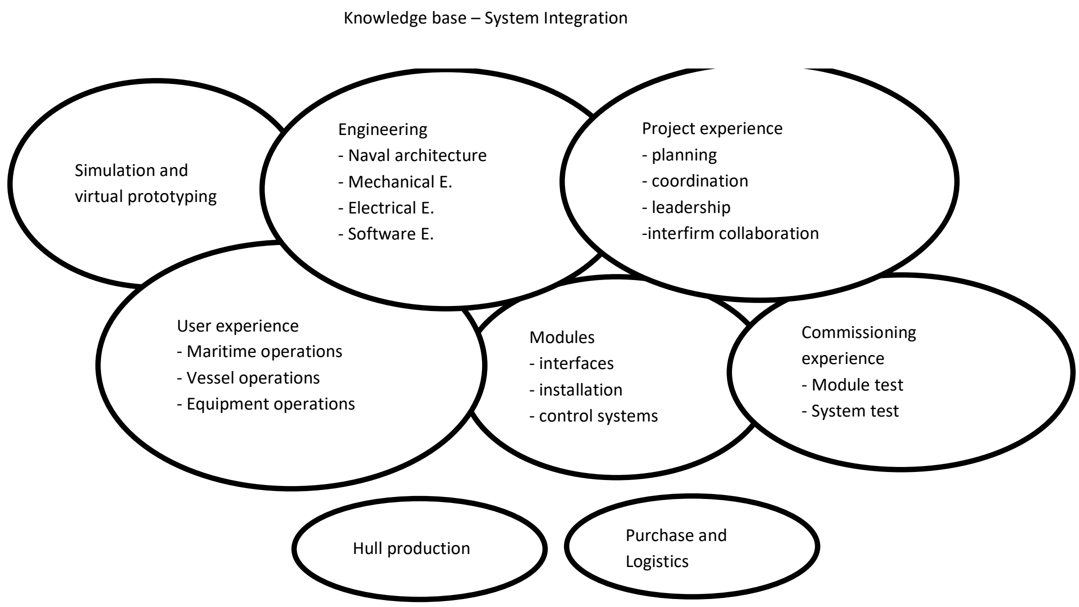

Table 2 Anticipated effects of offshore yard selection

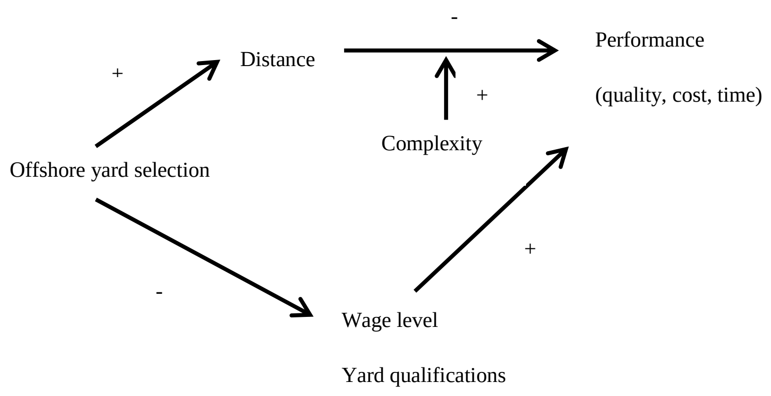

Table 3 Norwegian owned offshore support vessels in 2015

	AHTS		PSV		Seismic	/Subsea	Total
Ship-owner	Abroad	Domestic	Abroad	Domestic	Abroad	Domestic	
Deep Sea Supply	10	5	23	2			40
DOF	13	6		25	5	18	67
Eidesvik Offshore				10	2	14	26
Farstad	5	27	6	20		4	62
GC Rieber Shipping					4	4	8
Golden Energy			4	5			9
Havila Shipping ASA	4	5	3	12		3	27
Island Offshore		3		18	1	10	32
Olympic Shipping		4		8		9	21
Rem Offshore ASA				10		9	19
Sanco Shipping AS						7	7
Siem Offshore			6	10	2	8	26
Simon Møkster		2	5	13		4	24
Solstad Offshore	5	14	1	8	2	16	46
Vestland Offshore			1	4	3	3	11
Viking Supply Ships	4	4		5			13
Volstad Maritime						10	10
Østensjø			3	2		3	8
Total	41	70	52	152	19	122	456

Table 4 Logistic regression Predicting Likelihood of locating shipbuilding project in Norway

	B	S.E.	Wald	df	p	Odds ratio	95 % C.I. Lower	Upper
Ship-owner location	1,050	0,292	12,974	1	,000	2,858	1,614	5,061
Year of build	-0,072	0,026	7,411	1	,006	0,931	0,884	0,980
Number of vessels previously built in Norway	0,037	0,013	7,449	1	,006	1,037	1,010	1,065
Number of vessels previously built abroad	-0,135	0,030	20,084	1	,000	0,874	0,823	0,927
Vessel category			25,495	3	,000			
PSV	0							
AHTS	-1,103	0,310	12,678	1	,000	0,332	0,181	0,609
Seismic	-0,295	0,527	0,314	1	,575	0,744	0,265	2,092
Subsea	0,9	0,402	5,005	1	,0025	2,460	1,118	5,413
Constant	144,70	52,718	7,535	1	,006	7E+62		