# Technological innovation capability and interaction effect in a Scandinavian industry cluster


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**Abstract:**
How do innovation ecosystems affect the technological innovation capabilities (TICs), as defined by Yam et al. (2004), and company performance? Empirical data was acquired through a survey of 75 maritime equipment suppliers in an industry cluster in Norway. Regression analysis was supplemented with partial least square methods in order to compensate for the low number of respondents. Significant effects were found for manufacturing and marketing capabilities on company performance. The results for organizational capability were method dependent. Learning, R&D, resource allocation and strategic capabilities were identified as insignificant. These results conflict with other studies that identified manufacturing capabilities as the only insignificant TIC construct. However, the findings are partially in line with studies that have questioned learning, organizing, and resource capabilities as drivers for competitive advantages. The moderating effect of cluster interaction and manufacturing capability on performance is coherent with prior research, but further research is needed for a deeper understanding of these interaction effects.



**Keywords:** Technological innovation capabilities; cluster companies; company size; cluster interaction, manufacturing capabilities

## 1 Introduction

How do innovation ecosystems affect technological innovation capabilities (TICs) and company performance? Traditionally, investment in R&D is considered as the main indicator of the innovation capabilities of companies. However, recent studies show that successful technological innovation depends on a range of capabilities (Azubuike, 2013; Yam et al., 2004; Yam et al., 2011). This indicates that no single-dimension scale can measure the TICs of a company. In Yams' framework, seven types of TICs are identified: R&D capabilities, learning capabilities, manufacturing capabilities, marketing capabilities, resource capabilities, organizational capabilities and strategic capabilities. However, the framework does not show which of these are most important for the performance of a company.

What influence does the geographical and industrial surroundings have on a company? Industrial clusters are recognized as one of the main elements in an innovation ecosystem (Mercan & Goktas, 2011). Porter (1998) argues that proximity in a cluster improves the innovativeness of a company by facilitating the creation of knowledge and skills. The aim of this study is to explore how cluster interaction and company size affect the various technological innovation capabilities and company performance.

The survey data are drawn from maritime equipment suppliers in a Scandinavian region and were collected in spring 2016. This cluster is a world leader in design, construction, equipment and operation of advanced offshore vessels. The companies are export-oriented and they compete on global markets. The dramatic drop in oil prices from USD 100 per barrel autumn 2014 to below USD 40 spring 2016 has created a severe crisis due to an almost complete halt in new offshore-related projects. This has created a new pressure and focus on innovation capabilities.

There are a limited number of studies related to TICs and firm performance in various industrial settings. The available studies range from plastic producers in Africa, manufacturing companies in Australia and China, to high tech companies in China. The findings from these studies diverge. Several authors report the positive moderating effect of cluster interaction on company performance (Dhewanto et al., 2012). Most of these results relate to clusters within the high tech sectors, such as ICT and biotechnology. However, Rogers (2004) found that a moderating effect was strongest for small manufacturing firms, whereas medium and large non-manufacturing companies had no positive effect from cluster interaction. The literature reports that the positive moderating effect of company size on innovation capabilities is likely to be strongest for larger organisations. Therefore, this study aims to answer the following research questions:

*RQ1: How do the seven TICs (R&D, learning, manufacturing, marketing, resource allocation, organization, and strategic capabilities) affect firm performance?*

*RQ2: Does firm size and cluster relations moderate the relationship between TICs and firm performance?*

## 2 Theoretical framing

Innovation systems exist and are discussed in the literature for at least three different levels: regional, national and global, but also as sectoral innovation systems (Asheim & Isaksen, 1997). In this respect, the innovation system is similar to the way in which we define an industry cluster. Porter (2000, p. 16) defines cluster as "[a] geographic concentration of interconnected companies, specialized suppliers, service providers, firms in related industries, and associated institutions (e.g., universities, standard agencies, trade associations) in a particular field that compete but also cooperate." Numerous researchers provide valuable insight into how clusters enhance competitive advantage and promote innovation. According to Porter (2000), innovation is as equally an important cluster advantage as growth in productivity.

Industrial clusters are driven by competition, cooperation, innovation-pressure and knowledge exchange. In industrial clusters companies are closely related; they are located close to each other, which increases the possibility of a rich exchange of information that in turn stimulates innovation. According to Reve and Jacobsen (2001), three upgrading mechanisms at cluster level – innovation pressure, knowledge sharing and complementarities – influence the value creation potential. Accordingly, the industrial conditions will be decisive in how companies succeed.

Technological innovation is an essential component of competitiveness and is rooted in the organizational structure of a single company. Traditionally, investments in research and development were considered by industry and academics to be the primary measure of technological innovation. Teece (1986) introduced the term innovation assets and proposed to split innovation assets into core innovation assets and complimentary innovation assets. Christensen (1995) criticizes the one-dimensional focus on R&D capabilities and suggested a division into four main types of asset profiles for technological innovation: scientific research assets, process innovation assets, product innovation application assets and aesthetic assets. Adler and Shenbar (1990) further divided firm assets into technology – and organizational assets. However, recent studies show that successful technological innovations also depend on capabilities in the areas of learning, resource allocation, manufacturing, marketing, organization and strategy (Yam et al., 2004). Guan and Ma (2003) suggested including R&D, manufacturing and marketing in the concept of core innovation assets. Likewise, they suggest that supplementary innovation assets contain a capability set of learning, organizational, resource and strategy capabilities.

Several authors have been puzzled by the fact that high innovation activity does not necessarily lead to higher profitability (Koellinger, 2008). This has also been discussed by Teece (1986), who underlines the necessity of complimentary innovation assets in order to reap the fruit of core innovation assets. The same authors also stress the central role of manufacturing capabilities; "Innovating firms without the requested manufacturing and related capacities, may die, even though they are the best at innovation" (Teece, 1986, p. 285).

Companies in strong industrial clusters have better development opportunities than individual enterprises. Empirical evidence suggests that both the degree of knowledge sharing and competition among companies are important factors in explaining economic performance (Morosini, 2004). The rationale is that a higher degree of knowledge integration and competition between member companies stimulates cost-efficient product and process innovation. Porter (1998) further argues that proximity improves a company's innovativeness and performance by facilitating the creation of knowledge and skills.

The size of a company is viewed as an important predictor of innovation and competitive performance as it is argued that technological change is most likely to be driven by large firms due to economies of scale or scope (Schumpeter, 1942). In their study of TICs and export performance Guan and Ma (2003) find that larger firms perform better than smaller. Damanpour (1992) finds that firm size is positively related to innovation due to a higher level of implementation capabilities.

The concept of technology innovation capability can be related to company performance as described above, influenced by the industrial environment and the size of the organisation. In this study, we address all three antecedents of company performance, but we focus in particular on the technology innovation capabilities of maritime equipment suppliers in a Scandinavian region.

*Characteristics of the maritime cluster*

Norway has historically been one of the world's leading maritime nations. In the late 60s, the petroleum sector started to develop and eventually became the most important industry in Norway. During this period of time the maritime industry in the north-western part of Norway gradually built up a maritime cluster of companies supporting the petroleum sector. Today this cluster is a world leader in design, construction, equipment and the operation of vessels for the global oil industry (Froystad & Nesset, 2015). The cluster consists of 15 ship consultants, 14 yards, 165 equipment suppliers and 19 shipping companies. In addition the region also hosts a fishing fleet with more than 80 vessels and other marine-related firms (GCE Blue Maritime, 2015, 2016).

The region has been characterised as *'a peripheral manufacturing region'* (Asheim & Grillitches, 2015) operating in global markets, and is particularly vulnerable to negative shocks in the global economy. The innovation capability of the cluster is therefore an important pillar for sustainability and further growth. The severe drop in oil prices from autumn 2014 onward resulted in a situation where there was almost a complete halt in new builds of offshore vessels. This combined with overcapacity has resulted in a massive number of laid-up vessels. As much as 24% of the world fleet for this segment is laid-up, with the percentage for this region at 17% (Norsk Industri, 2016). This situation accentuates the focus on ways of increasing innovation capability. One of the most important modes of innovation within the cluster is assumed to be the "Doing, Using and Interacting" (DUI) mode (Froystad & Nesset, 2015), which is generally a characteristic of Norwegian industry (Cooke, 2016). This mode is experience based, emphasizing learning-by-doing, learning-by-using and learning-by-interacting (Jensen et al., 2007), and is particularly relevant for the upstream part of the maritime cluster (Froystad & Nesset, 2015). In a recent study among firms in Norway, Dahl Fitjar and Rodríguez-Pose (2013) show that collaboration with global agents is more conducive to innovation than collaboration with local partners within the DUI related firms.

The foci of the analysis is thus the effect of TICs on firm performance in a group of equipment suppliers within the maritime cluster in North-Western Norway as well as the possible moderating effect of cluster interaction and firm size between TICs and firm performance. The sample size is small, but the homogeneity of the participating organisations adds another dimension to the data compared to other TIC studies. The relatively small number of respondents creates methodological challenges which we have tried to solve through triangulation of various methods.

## 3 Research method

The survey conducted among the 169 registered maritime equipment suppliers in the maritime cluster was conducted during spring, 2016. A total of 75 complete answers gave an overall response rate of 44.7%.

The seven-dimension TIC framework from Yam et al. (2004), together with constructs for firm performance and cluster-interaction was used. We use the 26 items from Lang et al. (2012), which is an extract from Yam's original 66 items for the seven dimensions. The size of our sample did not allow us to use all the original items. Firm performance was measured using both economic and innovation performance. Confirmatory factor analyses using SPSS® was conducted to make sure that the items suggested by the study measure the correct concepts. Based on the central dimensions of the factor analysed, nine summated scales were created. In order to test the hypotheses, two regression analyses were conducted, one for the TICs on firm performance and one for the moderating effects of cluster interaction and firm size on firm performance.

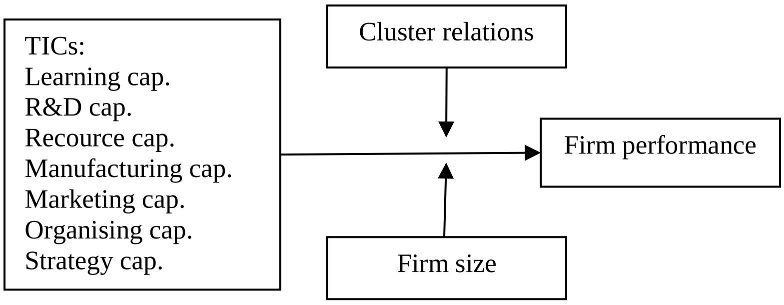


**Figure 1** Research model

*Survey instrument*

The questionnaire comprised four parts. The first part consists of descriptive data for the enterprise (including the municipality to which the company belongs, number of employees, turnover in NOK, etc.). The second part contains the measurement of the TICs, while the third part includes the measures of firm performance. Finally, part four contains the measurements of cluster interaction.

The questionnaire comprises 13 questions, where five are open-ended and eight are closed questions. We used open-ended questions to elicit detailed numerical information from the respondents, such as turnover figures, percentage of R&D personnel, number of employees, etc., whereas closed questions required a greater uniformity in the answers. In accordance with previous literature on TICs (Burgelman et al., 2004; Lang et al., 2012; Yam et al., 2004), the seven TICs were rated on a seven-point Likert scale. In this part of the questionnaire, the respondents were asked to rate the company´s capability on several factors ranging from 1 (very poor) to 7 (very good). The survey was conducted in Norwegian to avoid any possible language barriers for the respondents. An extract of the questionnaire is given in the Appendix A.

The questionnaire was constructed using the web-service “Survey monkey.” The questionnaire was directed at middle and top-level management in order to receive reliable and qualified answers. The questionnaire was first piloted with representatives from three different companies representing small, medium size, and large organizations in the cluster. Feedback from the pilot was taken into account and the questionnaire was amended before the final version was distributed to the population.

*Constructs*

The dependent variable in this study was *firm performance*. Traditionally, firm performance has been measured exclusively by financial indicators. However, recent studies in the field of innovation management argue for a more comprehensive approach (Burgelman et al., 2004; Lang et al., 2012; Yam et al., 2004). We therefore used three performance indicators in this study: innovation performance, sales performance and product performance. Innovation performance was measured in terms of the number of new products or services as a percentage of all products/services offered by the company, over the last three years. Sales performance was measured in terms of the percentage of turnover growth in the preceding year. Product performance was measured through the evaluation of the company's performance concerning three dimensions, compared to their nearest competitor.

The following TICs served as the independent variables in this study: *learning-, R&D-, resource allocation-, manufacturing-, marketing-, organizing- and strategic capability* (as developed by Yam et al., 2004). While the relationship between the independent variables and the dependent variable have been indicated by prior research, there are few studies looking at how interaction between collaborators in a cluster and firm size affects this relationship.

The operationalization of *firm size* was based on a question in the survey asking the respondent about the number of employees. As suggested by previous research (e.g., Damanpour, 1992; Mule et al., 2015; Vaona & Pianta, 2008), large companies may be better equipped to innovate than smaller ones. This is based on the notion that large companies have more resources for implementing large-scale innovations (Damanpour, 1992). Hence, this variable was included to investigate whether larger companies in the sample have a stronger relationship between TICs and performance than smaller ones.

Based on the literature and the preliminary in-depth interviews, it seems apparent that the interaction between firms in a cluster influences innovation and performance. The variable *cluster relations* was measured through two questions. First, the respondents were asked to rate how important other local actors within the cluster were to the economic performance of their organization. Second, they were asked to rate the importance of local collaboration for technological innovation capability. Local actors are defined as organizations (e.g. partners, suppliers, customers, institutions, etc.) with headquarters located in the county. National actors are defined as organizations with headquarters located in other counties in Norway, while international actors are defined as organizations with headquarters located outside Norway. This question was included to investigate the importance of collaboration between companies within the cluster compared with those outside the cluster. According to Morosini (2004), such questions allow the researcher to understand how dependent a company is on local inputs to innovation contra international input.

## 4 Data analysis and results

### *Factor analysis*

This paper aims to investigate whether TICs significantly influence company performance, and whether size of the organization and cluster interaction moderates this influence. In order to answer these questions, confirmatory factor analyses (CFA) were conducted to make sure that the items suggested by the study measure the correct constructs. As illustrated in our research model (Figure 1), there are a total of nine constructs that need to be transformed into summated scales. Company size is not included in the factor analysis as it consists of one variable (number of employees). Items with factor loadings below 0.5 were removed. The reliability and total variance explained for the nine constructs are given in Table 1. The construct firm performance consists of sales performance (one item), innovation performance (one item) and product performance (three items). The factor analysis resulted in a low factor loading for sales performance (<0.5) and in order to raise the Cronbach's alpha, the item measuring innovation performance was also removed in the regression analysis. However, we decided to run a separate Partial Least Square analysis of the results using innovation performance and firm performance as separate variables. The results from these calculations are found in the last section of this chapter.

Based on the central dimensions of the factors analysed above, nine summated scales were created. The scales were constructed by adding the scores for each of the related items, and dividing by the number of questions. The Pearson correlations for the new variables are given in Table 2. All the independent variables displayed positive and significant correlations with the dependent variable; firm performance. Out of these, marketing capabilities displayed the strongest relationship with r=0.745. In addition we also observed that cluster relations were positive and significantly correlated with the dependent variable. On the other hand, number of employees (firm size) showed a negative and non-significant correlation with firm performance. The distribution of firm size is highly skewed towards small and medium sized firms. The mean value for the number of employees is 68, the standard deviation is 234 and the skewness is 7.87.

Finally, no correlation is higher than the recommended values (Pallant, 2013).

**Table 1** Reliability and total variance explained for the constructs

| *Construct* | *α* | *Total variance explained* | *KMO* |
|---|---|---|---|
| Learning capability | 0.826 | 74.8% | 0.668 |
| R&D capability | 0.871 | 72.2% | 0.826 |
| Resource capability | 0.831 | 74.7% | 0.831 |
| Manufacturing capability | 0.831 | 66.6% | 0.775 |
| Marketing capability | 0.885 | 74.6% | 0.885 |
| Organizing capability | 0.782 | 60.6% | 0.722 |
| Strategic capability | 0.848 | 69.4% | 0.747 |
| Cluster relation | 0.821 | 67.5% | 0.628 |
| Firm performance | 0.788 | 50.1% | 0.831 |

**Table 2** Correlation matrix

| *Construct* | *Learn.* | *R&D* | *Res.* | *Man.* | *Mark.* | *Org.* | *Strat.* | *Cluster* | *Size* | *Perf.* |
|---|---|---|---|---|---|---|---|---|---|---|
| Learning | | | | | | | | | | |
| R&D | .789* | | | | | | | | | |
| Resource | .669* | .802* | | | | | | | | |
| Manufacturing | .793* | .857* | .765* | | | | | | | |
| Marketing | .624* | .589* | .550* | .629* | | | | | | |
| Organizing | .686* | .715* | .703* | .782* | .638* | | | | | |
| Strategic | .635* | .687* | .688* | .729* | .602* | .760* | | | | |
| Cluster | .416* | .321* | .392* | .362* | .506* | .411* | .499* | | | |
| Size | -.005 | -.017 | .104 | -.080 | .021* | .077 | .035 | .077 | | |
| Performance | .664* | .646* | .545* | .731* | .745* | .717* | .627* | .515* | -.098 | |

*Sign. at the 5% level

### *Regression models*

The first regression analysis tested the relationship between the seven TICs and firm performance. The results are given in Table 3. The VIF and the Tolerance value in the collinearity diagnostics are well within the critical values, indicating no problems with multicollinearity. Furthermore, inspection of Normal P-P plot and Scanplot of the standard residuals showed no major deviation from normality. The adjusted $R^2$ for the present model is 0.667, indicating that the independent variable explains 66% of the variance of the firm performance. The model also reaches statistical significance with an F-value of 21.906 (p=0.000), indicating a good model fit. The results show that marketing capabilities make the strongest unique contribution to explaining firm performance ($\beta$=0.415, p<0.05), with a 1-unit increase in marketing capabilities leading to a 0.415 increase in firm performance. The other statistical contributions are manufacturing capabilities (β=0.337, $p<0.05$) and organizing capabilities (β=0.250, $p<0.05$).

The moderating effects of cluster relations and company size on the link between the seven TICs and firm performance are tested in the second regression model listed in Table 3. The moderating effects are modelled as interaction terms where the actual (centred) variables are multiplied. In addition, the original independent variables are included in this regression model. We found no significant effect of firm size and the construct was removed from the model. Inspections of the VIF and Tolerance revealed no violation of the multicollinearity assumption. However, the VIF value for the interaction terms, cluster x resources capability and cluster x manufacturing capabilities are rather high. The Normal P-P plot and the Scatterplot indicate a normal distribution of the standardized residuals. A positive moderating effect of cluster interaction is seen as the adjusted $R^2$ increases from 0.667 (Model 1) to 0.688 (Model 2). This means that the new model with the moderating variables explains 68% of the variance in firm performance. The model also reaches statistical significance with an F value of 14.996 (p=0.000), indicating a good overall fit. Cluster interaction has the strongest moderating effect on manufacturing capabilities with a β of 0.902 ($p<0.05$). Furthermore, cluster interaction was statistically significant on resource capability (β=0.380, $p<0.05$) and marketing capability (β=0.380, $p<0.05$). Firm size, on the other hand displayed no moderating effect on the link between the various TICs and firm performance.

**Table 3** OLS regression results model 1 and 2. Dependent variable: Firm performance.

| | Model 1 | | | Model 2 | | |
|---|---|---|---|---|---|---|
| | Coeff. | Std.dev. | VIF | Coeff. | Std.dev. | VIF |
| Variables: | | | | | | |
| Constant | -0.497 | 0.453 | | 4.788 | 0.093 | |
| Learning capability | 0.073 | 0.141 | 3.274 | 0.178 | 0.180 | 5.679 |
| R&D capability | 0.032 | 0.170 | 5.211 | 0.084 | 0.166 | 5.357 |
| Resource capability | -0.196 | 0.126 | 3.253 | -0.197 | 0.125 | 3.433 |
| Manufacturing capability | 0.380** | 0.178 | 5.448 | 0.357** | 0.178 | 5.819 |
| Marketing capability | 0.490*** | 0.112 | 1.961 | 0.420*** | 0.113 | 2.134 |
| Organizing capability | 0.311** | 0.156 | 3.437 | 0.348** | 0.150 | 3.510 |
| Strategic capability | 0.014 | 0.131 | 2.849 | 0.043 | 0.150 | 4.400 |
| Interaction terms: | | | | | | |
| Cluster x Resource capability | | | | 0.403** | 0.169 | 9.004 |
| Cluster x Manufacturing capability | | | | 0.697*** | 0.214 | 9.206 |
| Cluster x Marketing capability | | | | 0.279** | 0.129 | 5.710 |
| **Adjusted $R^2$:** | | 0.667 | | | 0.688 | |

*** Sign. at the 1 % level, ** Sign. at the 5 % level

### *The split sample*

To better illustrate the moderating effect identified, the sample was divided into three subgroups based on their level of cluster interactions: low cluster interaction, medium cluster interaction and high cluster interaction. Figure 2 shows the relationship between manufacturing capabilities and firm performance for the different subgroups. It shows that the best linear model fit is found for the high cluster interaction sub group ($R^2$ =0.816). The effect of manufacturing capability on firm performance is also strongest for this group (highest inclination of regression line). The scatterplot shows that the relationship between the two variables, manufacturing capability and firm performance, strengthens proportionally with the level of cluster interaction.

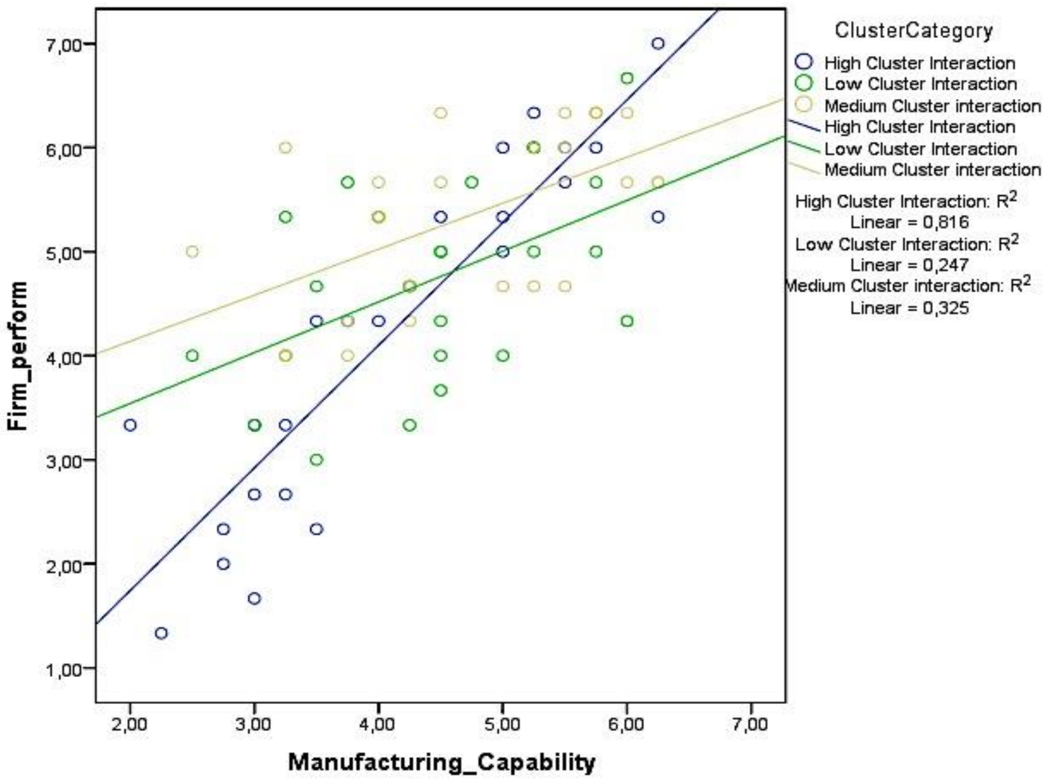


**Figure 2** Moderating effect of cluster interaction on manufacturing capability.

*Partial Least Square (PLS) model*

Based on the results from the regression model, we estimated a restricted and simplified structural equation model with a partial least square path procedure (PLS) by applying SmartPLS (Ringle et al. (2005)). PLS integrates measurement models of unobserved latent variables and structural relationships between the latent variables. The component-based PLS procedure was chosen both because of its possibilities for handling a small data set and because of the explorative nature of this study. PLS has proven to be a powerful method when data samples are small, measurement scales have few items, and/or the distributional characteristics are unknown (Hair et al., 2010). Significance testing of the PLS parameters is based on bootstrapping procedures.

The restrictions imply that only the three significant TICs from the OLS regression (manufacturing capability, marketing capability and organizing capability) are included. A new dummy variable for interaction with global actors is added, and the performance construct is split in two variables: 1) firm performance and 2) innovation performance. Both (local) cluster interaction and global interaction are modelled to have direct effects on firm performance and innovation. In addition, three interaction terms (the product of cluster interaction and the TICs) are also estimated. The interaction between cluster and manufacturing capability is highly significant but with a negative value. The two other interaction terms are far from significant and therefore excluded from the results shown in Table 4. The structure model with standardized coefficients is given in Figure 3. Codes for the items in this figure correspond to items found in appendix A. The complete model with corresponding bootstrapping t-values, based on 1,000 samples can be seen in appendix B. The explained variance for firm performance is as high as 0.731 and for innovation performance 0.276. The variance explained for the PLS model, with direct effect of cluster interaction, is higher than for the two OLS regression models (0.667 and 0.688 respectively).

**Table 4** Structural model results for the PLS model of TICs, subjective performance and innovation: variance explanation and path coefficients.

| | Path Coefficient. | t-value |
|---|---|---|
| Manufacturing capability → Performance | 0.427 | 3.667*** |
| Marketing capabilities → Performance | 0.295 | 3.023*** |
| Organizing capability → Performance | 0.057 | 0.629 |
| | | |
| Manufacturing capability → Innovation | 0.231 | 1.651* |
| Marketing capabilities → Innovation | 0.052 | 0.571 |
| Organizing capability → Innovation | 0.180 | 1.377 |
| | | |
| Cluster interaction → Performance | 0.182 | 2.366** |
| Global interaction → Performance | -0.056 | 0.968 |
| | | |
| Cluster interaction → Innovation | 0.191 | 1.940* |
| Global interaction → Innovation | 0.270 | 2.332** |
| | | |
| Cluster x Manufacturing capability → Performance | -0.177 | 2.698** |
| | | |
| **Variance explanation:** | | |
| $R^2_{Performance}$ = 0.731 | | |
| $R^2_{Innovation}$ = 0.276 | | |

*** Sign. at the 1 % level, ** Sign. at the 5 % level. * Sign. at the 10 % level. Based on bootstrapping with 1000 samples

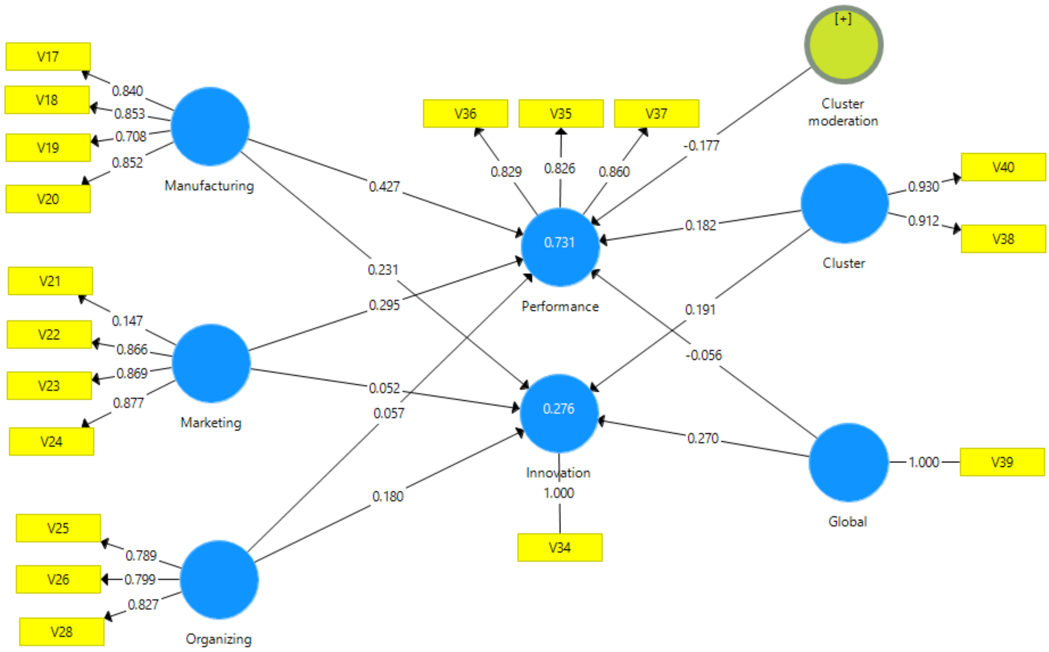


**Figure 3** PLS structural equation model: standardized coefficients.

*Results*

The findings from the regression analysis regarding the first research question can be summarized as follows: marketing capabilities, manufacturing capabilities and organizational capabilities had a statistically significant effect on firm performance. Learning capabilities, R&D capabilities, resource capabilities and strategic capability did not have significant effects.

Regarding the second research question, no statistically significant effect was found for firm size on firm performance. The findings regarding the effect of cluster interaction can be summarized as follows: cluster interaction had significant statistical effect on manufacturing capabilities, marketing capabilities, and strategic capabilities. Learning capabilities, R&D capabilities, strategic capabilities and organizing capabilities were not moderated by cluster interaction.

The findings from the additional PLS calculations are more complex. The direct effects of cluster interaction on firm performance is pronounced. Similarly, the manufacturing and marketing capabilities significantly and positively affected firm performance. Another interesting result is that the dummy for the global firms are positive related to innovation performance, whereas it is negative related to firm performance. Innovation performance is also significant for firm performance. This may indicate that innovation leadership will not necessarily result in high firm performance. When it comes to the moderating effect of cluster interaction and manufacturing indicated in the regression analysis, the PLS calculations show the opposite. While this appears to leave us with a puzzle to explain, the number of observations is limited and when comparing both calculations it indicates that cluster interaction positively moderates firm performance.

The results after splitting the sample into high, medium and low cluster interaction, as shown in Figure 2, point in the same direction: high cluster interaction firms show a strong and linear relationship between manufacturing capabilities and firm performance. The results from the PLS calculations however, show that this relation is not linear.

## *Discussion*

The findings from the three methods above are fairly consistent with our expectations, given the small sample and the chosen industry sector. The significant role of manufacturing capabilities, marketing capabilities and cluster interactions is expected since the firms are equipment manufacturers in maritime offshore industries, usually classified as medium tech.

However, it seems counter intuitive that cluster interaction is important and significant whereas learning capabilities are not. This should be two sides of the same coin. We expect that the reason for this is the number of items we used in the construct. Yam's original constructs are sampled with six to 16 items per construct, whereas we used Lang's stripped down version with three and four items per construct. Lang's justification for reducing the number of items was that they were sampling firms in a high tech sector. There is also a delicate balance between the numbers of items used in a sample as small as ours and the production of reliable data. When re-examining Yams' nine original items used for measuring learning capabilities, we find the following items related to tacit knowledge:

- Paying attention to tacit knowledge
- Learning the lessons of experience
- Passing lessons learned across boundaries and time
- Work teams encouraged to identify opportunities for improvement

The inclusion of these items would probably have given us a significant contribution from learning capabilities and brought the results in line with the majority of cluster literature which underlines the importance of localized knowledge sharing and learning (Porter, 1998; Reve & Jacobsen, 2001).

The dominance of the doing-using-interacting (DUI) mode of learning amongst the cluster firms has been underlined by several authors (Froystad & Nesset, 2015; Reve & Jacobsen, 2001). The same dominance is characteristic for Norwegian industry in general (Cooke, 2016). Yam's original items would have been a better choice for measuring learning capabilities in Norwegian industries, but this will require a larger sample.

The role of manufacturing capabilities has been discussed by Guan and Ma (2003), who commented on the lack of significance for manufacturing capabilities in their data. Their study focused on the relationship between TICs and export performance for 213 Chinese manufacturing firms. They show that the export-intensive firms are significantly larger (an average of 1,364 employees) than export lagging firms. The number of employees in this study is very high compared to our sample, with an average of 68 employees. We expect that larger firms have a more structured organisation with more formal procedures and higher levels of specialisation. Guan and Ma (2003) also found that supplementary innovation assets (learning, organization, resource and strategy) were more important than core innovation assets (R&D, manufacturing and marketing). The importance of manufacturing and marketing capabilities in our data are both part of the core innovation assets. Given this framework, our data indicate that core innovation assets are more important for firm performance than supplementary innovation assets. They are also in line with (Teece, 1986) results that manufacturing capabilities are a key asset for firm performance.

Yam et al., 2004 found that only R&D capability and recourse allocation capability were significant for product competitiveness, their data source is similar to that of Guan and Ma (2003), so the same arguments apply for the size of firms in the sample.

The findings that cooperation with global actors positively affects the innovation performance resonates well with the findings from Dahl Fitjar and Rodríguez-Pose (2013) and Froystad and Nesset (2015). The fact that a high level of innovation performance does not necessarily lead to a high firm performance on firm performance is in agreement with the findings from Teece (1986) and Koellinger (2008).

## 6 Conclusions and implication

Contradictory to expectations, learning capabilities, R&D capabilities, resource capabilities and strategic capabilities were identified as insignificant predictors of firm performance. These results conflict with the findings of several studies on TICs, such as Guan and Ma (2003) who identified manufacturing capabilities as the only insignificant construct among industrial companies in China. Their study also found that resource capability had the highest correlation with firm performance, a result in strong contrast to the present study where the lowest correlation was found for this construct. Similarly, Lang et al. (2012) analysed the effect of TICs on competitive performance, whereas they stress the importance of learning capabilities as the main driver for firm performance. However, our findings are partially in line with a few other studies questioning learning, organizing and resource capabilities as drivers for competitive advantages (Azubuike, 2013; Yam et al., 2004).

No evidence was found to support the Schumpeterian hypothesis stating that large companies enjoy econometric benefits from innovation. These results resonate well with a stream of research arguing for an inverted U-shape between company size and innovation performance (Lang et al., 2012). However, neither of these hypotheses find support in the actual survey data.

The findings regarding the moderating effects of cluster interaction on firm performance is coherent with prior research (Porter, 1998; Rogers, 2004) and brings new knowledge to the TIC literature.

The positive effect of cooperation with global actors on innovation performance and the negative effect on firm performance is interesting and partly confirms work by Teece (1986), Koellinger (2008), Froystad and Nesset (2015), Dahl Fitjar and Rodríguez-Pose (2013).

Some of the results may also be interpreted as an indication of small cluster companies being more flexible and adaptable than larger organizations in times of crisis. Through a higher level of cluster interaction, they are better able to utilize the innovation ecosystem of which they are a part. However, the calculations show that the nature of this interaction effect is not fully understood. The limited sample size allows us to identify the effect, but further research is needed in order to reveal the details of the mechanism.

The counter intuitive findings regarding the lack of significance of learning capability, combined with a strong effect of cluster interaction is probably due to the use of Lang et al.'s three item version of the learning capabilities construct. They justified reducing the nine original items down to three by targeting high tech firms in their survey. We expect that use of the nine original items would result in a significant contribution from learning capabilities to firm performance.

The study contributes to our understanding of the technological innovation capabilities of companies in a specific industry sector in a cluster located in a Scandinavian region. Due care should be taken when generalizing the results from this study to other geographical and industrial contexts; however, this study broadens the TIC literature with several new findings regarding the role of company level interaction in an innovation ecosystem.

### *Managerial implication*

The results from this study show that manufacturing capabilities, and marketing capabilities are important for firm performance and there are several managerial implications. First, products and services should be developed with a deep understanding of the customers' needs, combined with the capability of organizing the projects and manufacturing the product to the highest standard. A second implication is the need to focus on increasing manufacturing capabilities by matching R&D-output with market needs. Third, this study shows that companies can enhance their performance by exploiting their organisational capabilities. It is vital for companies to exploit the full potential of their staff and organizational structure. Emphasis should be given to coordinating activities across divisions towards shared objectives. This can be done through in-house training, performance monitoring systems and knowledge-enhancing activities. Finally, the actors in the cluster should actively contribute to knowledge sharing through industry collaboration and enhance the interaction between the cluster participants.

### *Policy implications*

Several policy implications can be drawn from our results. The government should encourage interaction and knowledge-sharing mechanisms within the innovation ecosystem. This can be done by funding projects where several industry partners work together with R&D organizations and customers in order to develop new and innovative products.

The government should also consider setting up regional manufacturing centres where the latest technology and manufacturing processes are available, even for small and medium sized companies.

The fact that marketing and organisational capabilities are so important for the technological innovation capabilities should spur the government to set up flexible arrangements where unemployment benefits can be combined with targeted education and training during times of slack. This is currently not the situation in Norway, where unemployment benefit cannot be used for funding further education.

### *Limitations and further research*

This study has a number of limitations. The number of respondents is limited. A comparison with all Norwegian equipment suppliers would have been preferable. Data from the other subgroups in the cluster may have given a better understanding of the dynamics within the cluster. Comparison with other maritime related clusters would also have strengthened the conclusions. It is also an obvious weakness that the direct effect of cluster relations and firm size on firm performance was not calculated in the regression analysis. We also suggest using the full nine item construct from Yam et al., for measuring learning capability. A complementary study using financial data could also shed new light on the effects of firm size and TICs on performance.

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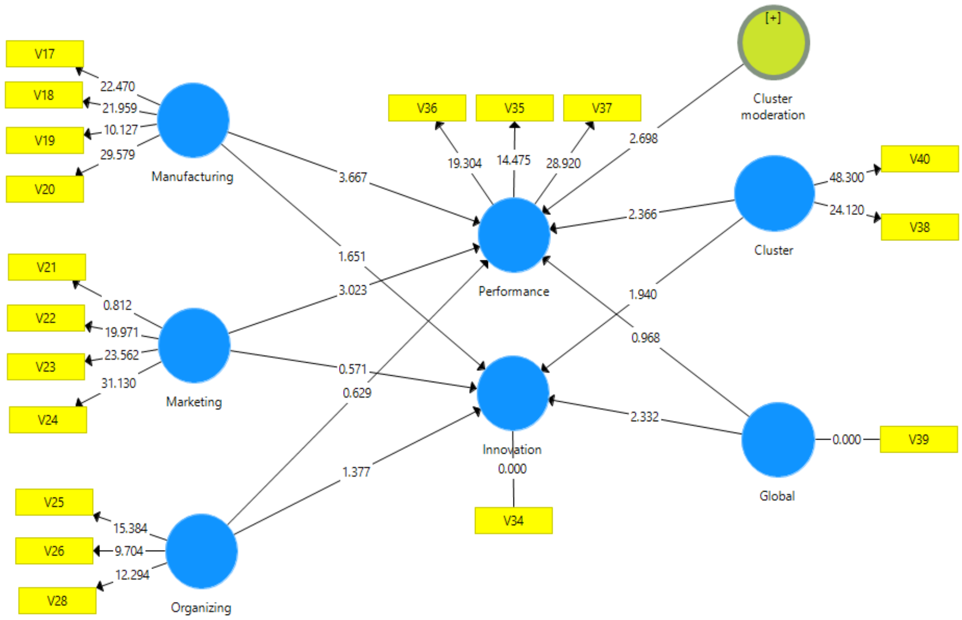
**Appendix A** TICs**,** constructs and sources used in the questionnaire.

| *Construct* | *Source* |
|---|---|
| How would you evaluate the firm `s capability to:<br>(Scale: 1= Very poor, 2= Poor, 3= Somewhat poor, 4= Neither Poor Nor Good, 5= Good, 6= Very Good, 7= Excellent) | |
| **Learning capability** | |
| V7…Assess trends relevant for the company? | Yam et al. (2004), Lang et al. (2012), Guan and Ma (2003) |
| V8…Adapt technology to match market needs? | |
| V9…Collaborate with other actors to identify opportunities in different market segments? | |
| **R&D Capability** | |
| V10…Invest sufficiently in the development of new products and/or services? | Yam et al. (2004), Lang et al (2012), Guan and Ma (2003) |
| V11…Efficiently communicate R&D activities across the various departments? | |
| V12…Apply customer feedback in technology development? | |
| V13…Specify clear goals and plans for research projects? | |
| **Resource capability** | |
| V14…Employ qualified staff to the various departments? | Burgelman et al. (2004) |
| V15…Allocate adequate resources for courses and further education of employees? | Yam et al. (2004), Lang et al. (2012), Guan and Ma (2003) |
| V16…Allocate adequate resources for the development of products and systems? | |
| **Manufacturing capability** | |
| V17…Implement efficient methods of production? | |
| V18…Develop a project from R&D to commercial production? | Yam et al. (2004), Lang et al. (2012), Guan and Ma (2003) |
| V19…Implement quality control throughout the supply chain? | |
| V20…Generate feasible product development ideas? | |
| **Marketing capability** | |
| V21…Establish good relationships with customers? | Yam et al. (2004), Lang et al. (2012), Guan and Ma (2003), Burgelman et al. (2004) |
| V22…Maintain a positive reputation? | |
| V23…Attain information of different market segments? | |
| V24…Meet customers' needs after sales? | |
| **Organizing capability** | |
| V25…Coordinate R&D, marketing and production activities | Yam et al. (2004), Lang et al. (2012), Guan and Ma (2003), Burgelman et al. (2004) |
| V26…Handle multiple time and resource demanding projects in parallel | |
| V27…Communicate with suppliers and customers | |
| V28…Measure the performance of its employees | |
| **Strategic capability** | |
| V29...Identify external opportunities and threats | Yam et al. (2004), Lang et al. (2012), Guan and Ma (2003), Burgelman et al.(2004) |
| V30…Identify internal strengths and weaknesses | |
| V31…Implement strategic plans using quantitative objectives (e.g. balanced scorecard) | |
| V32…Convey the its overall goals and core values to the employees | |
| **Cluster relation** | |
| How would you rate:<br>(Scale: 1= Not important, 2= Somewhat important, 3= Moderately important, 4= Very important, 5= Extremely important)<br>V38: Importance of local actors for the performance of the firm<br>V40: The importance of collaboration between local actors for the innovative capability of the maritime cluster in MR | Yam et al. (2004), Lang et al. (2012), Guan and Ma (2003), Burgelman et al. (2004) |
| **Firm performance** | |
| How would you rate the company's position compared to your nearest competitor, in regards to the following factors: (Scale as for TICs)<br>V35 …Product/ service quality? V36 Cost level? V37 Development time from R&D to commercial production*?* | Yam et al. (2004), Lang et al. (2012), Guan and Ma (2003), Burgelman et al.(2004) |

**Appendix B** PLS structural equation model of TICs, firm performance and innovation performance: Bootstrapping t-values (based on 1,000 samples)



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