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# Exploring the relationship between competition and innovation in Norwegian SMEs

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**Abstract:** This paper explores the relationship between innovation and competition in 380 Norwegian SMEs. In contrast to a large portion of the empiric literature, we utilized the managers' perception of their firm's innovation activities and competitive environment as measures. In particular, this paper aimed to shed some light on this widely debated topic by examining several aspects of innovation and competition, along with including the effects of demand conditions. The results indicate that competition in the form of rapid changes in production technology has the largest overall impact on innovation, and is positively correlated with most innovation indicators. An inverse-U shaped relationship between completion and innovation is only detectable in one out of 60 possible settings. The combination of low levels of competition and high market

## ABOUT THE AUTHORS

Øystein Moen is a professor at the Norwegian University of Science and Technology. His main research area is international marketing, with focus on internationalization and innovation processes of small and medium sized firms. He has been in charge of several research projects related to the maritime and energy industry in Norway and have published in journals as International Business Review, Journal of International Marketing, Journal of Small Business Management, European Journal of Marketing and the International Marketing Review.

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## PUBLIC INTEREST STATEMENT

The relationship between innovation in firms and the level of competitiveness in their environment is crucial for a better understanding, both for policymakers and for managers. Does more competition result in a higher focus on innovation? Prior results have presented mixed results, and in some cases, have led to the identification of a positive relationship (more competition, more innovation), a negative relationship (more competition, less innovation) or an inverse U-shaped relationship (low innovation levels if high/low competition, high innovation levels if medium competition). Based on a sample of Norwegian firms, different measures of competition and innovation, along with the relationship between them are examined. Our results suggest that there are no clear patterns to confirm the existence of higher innovation activity in firms in cases where more competition in a market exists. However, the exception is a rapid change in production technology that seems to stimulate innovation focus. Regarding both managers and public policy, our results indicate that it is important to focus on production technology competition as this has a larger impact on innovation efforts. Furthermore, we did not find an inverse U-relationship as a consistent pattern. However, we did identify a group of firms that functioned within a specific environment that could be described according to the Blue Ocean concept: high demand and limited competition.

demand is identified in one group of firms; these are also characterized by a high focus on the development of new products.

**Subjects: Management of Technology; Innovation Management; Entrepreneurship and Small Business Management; Small BusinessManagement**

**Keywords: competition; innovation; demand conditions; blue ocean**

## 1. Introduction

The relationship between competition and innovation traces back to Joseph Schumpeter's (1883–1950) research, and is a topic that has drawn the attention of the academic community for decades. The importance of innovation to economic efficiency and growth (Aghion & Howitt, 1990; Aghion, Howitt, Brant-Collett, & García-Peñalosa, 1998; Grossman & Helpman, 1993; Hasan & Tucci, 2010; Romer, 1990) is a natural cause for investigation. Empirical research seems to point towards several different directions and discrepancies among endogenous growth models and agency models have caused debates among researchers.

Along with being a key ingredient to economic growth, innovation is said to be the firm's key to success (Tushman, 1997), escaping competition (Kim & Mauborgne, 2004) and creating competitive advantage (Porter, 1990). Kim and Mauborgne (2004) suggests that innovation affects competition by creating blue oceans (new markets) where the innovative firm emerges as a monopolist, escaping the red oceans (existing, competitive markets) where firms compete away their margins. If a relationship between innovation and competition exists, it would serve as valuable knowledge for policy making, as it will allow an assessment as to whether creating incentives facilitate increased or reduced competition can stimulate economic growth. In addition, managers may benefit through understanding the importance of innovations in their specific competitive environment. However, this relationship is not causally asymmetrical, but simultaneous (Halpern & Muraközy, 2015). Even if empiric evidence could lead to the establishment of a relationship, innovation depends on a wide range of other factors (Barton, 1995; Martins & Terblanche, 2003; Mone, McKinley, & Barker, 1998; Tsai, 2001).

While the most influential literature on the relationship between innovation and competition use patent counts and financial data as measures (Aghion, Bloom, Blundell, Griffith, & Howitt, 2005; Aghion & Howitt, 1990; Blundell, Griffith, & Van Reenen, 1999; Dasgupta & Stiglitz, 1980b), this study aims to explore this relationship through a different approach. Our measures are based on the firms' perception of their innovation efforts and their competitive environment, including both demand conditions and competition levels. We believe a firm's behaviour is likely dependent on how they discern their specific competitive environment. This approach allows us to examine the different aspects of environmental conditions and the relationship with innovation.

### *1.1. Theory and hypothesis*

The earliest studies and economic theory have suggested that stronger competition results in lower levels of innovation (Hamberg, 1964; Mansfield, 1968), and this is supported by later studies (Dasgupta & Stiglitz, 1980b; Hashmi, 2013; Romer, 1990). However, empirical results from the 1990s have shown evidence that supports the opposite notion (Blundell et al., 1999; Geroski, 1995). In addition, Aghion et al. (2005) indicated an inverted-U relationship, where the level of innovation is low with both the highest and lowest levels of competition, and high in between. This section offers a summary of some the research that has been performed on this topic, looking to discuss the literature in favour of three different theories: the negative linear, the positive linear, and the non-linear inverted-U relationship. It is possible that conflicting empirical results may be caused by other factors that influence the relationship between competition and innovation. Indeed, in complex, real world situations, different combinations of demand conditions and competition may exist. We will thus include the influence of perceived market growth (demand conditions) in the analyses, as this may be a factor that influences the degree of investments in innovation activities.

### *1.2. What is innovation?*

Baregheh, Rowley, and Sambrook (2009) have argued that the lack of a consensual definition of innovation is problematic. Instead, they propose a multidisciplinary definition, noting that "Innovation is the multi-stage process whereby organizations transform ideas into new/improved products, service or processes, in order to advance, compete and differentiate themselves successfully in their marketplace" (Baregheh, Rowley and Sambrook, 2009, p. 1334). This implies that neither patent counts nor R&D expenditures are direct measures of innovation. Rather, they are a measure of the different stages within the innovation process. We argue that R&D is an innovation input, and the patent count is a measure of innovation output. Further, patent numbers vary substantially between industries, partly reflecting industrial structure and type of technology development—as exemplified by differences between developments of new pharmaceutical products versus new software solutions. The Community Innovation Survey, CIS, of the European Union underlines the important difference between R&D and innovation, where they emphasize that R&D is an innovation activity, rather than a measure of innovation. Furthermore, Halpern and Muraközy (2015) have pointed out how innovation is performed by firms without any formal R&D activity, which may lead to significant underestimation of actual innovation activities in terms of R&D statistics. They also argue that variables that show innovation output from surveys are better measures than patent counts, because a majority of innovations do not warrant patent registration, particularly in countries that are not at the technological frontier.

We thus seek to distinguish between innovation inputs and innovation outputs, defining innovation inputs as to the degree of which a firm focuses on innovation activities, and innovation outputs as the performance effects of its innovation activities.

### *1.3. The negative linear relationship*

Most theoretical and empiric studies have resulted in a negative linear relationship that is based on the theory first formulated by Joseph Schumpeter, referred to as the Schumpeterian effect. Schumpeter (1943) introduced the term "creative destruction", after studying Karl Marx' ideas, and used it to describe the disruptive process of transformation that accompanies innovation. The mechanics of the Schumpeterian effect states that it is less profitable to innovate when competition increases, as the incentive for innovating depends on the amount of rent a firm can collect for their innovation. The rent is dependent on the time until the next successful innovation by a competing firm, which decreases with competition because firms are more likely to innovate to keep up with the competition. This leads to the relationship stating that a market with perfect competition decreases the incentive to innovate and vice versa (Aghion et al., 2005). Kraft (1989) then found a strong positive impact of imperfect competition on innovative activity. Other studies that found a negative correlation between competition and innovation includes Hamberg (1964) and Mansfield (1968).

Dasgupta and Stiglitz (1980b) further examined the simultaneous relationship between R&D and competition. Regarding the effects of the present market structure on R&D, they concluded that if a monopolist dominates the market, this will lead to more R&D than a competitive market, due primarily to the decreased competition (and increased profits) in the post-invention market. Furthermore, they conclude that competition in R&D leads to more research being performed than when in a monopoly, but may lead to excessive R&D expenditures relative to the "social optimum". Dasgupta and Stiglitz (1980a) points out that high industry concentration is not evidential of lack of effective competition, and that when the concentration is small, industry levels of R&D increases with concentration.

Aghion and Howitt (1990) constructs a Schumpeterian-based endogenous growth framework through creative destruction, and they identified a negative correlation between competition and

R&D. The model is based on the notion that if innovation is driven by the expectation of higher profits, it would follow that any increase in competition (that lowers profits) will reduce innovation. The concept of creative destruction explains how current R&D is negatively correlated with the expected amount of R&D in the next period, because "the prospect of more future research discourages current research by threatening to destroy the rents created by current research" (Aghion & Howitt, 1990, p. 1).

Hashmi (2013) then revised the inverted U-relationship found by Aghion et al. (2005). In both papers, citation-weighted patents are used as a measure for innovation. To measure competition, the study used the inverse of mark-ups, instead of the Lerner index. The data was derived from publicly traded manufacturing firms in the United States, in contrast to data from UK firms used by Aghion et al. (2005). To control for the possible endogeneity of competition, the trade-weighted average of industry exchange rates is used as an instrument. Hashmi then finds a mildly negative relationship in the US-data. The key theoretical assumption is that the U. K. manufacturing industries are technologically more neck-and-neck than their counterparts in the United States, which the study's findings support for. Hashmi also states that "The different empirical results between the two countries may also arise because of differences in data and samples" (Hashmi, 2013, p. 1)

We see that most of the research in favour of a negative relationship is based on the earliest work by Schumpeter, and they are mainly theoretical, along with predominantly occurring prior to 1990.

### *1.4. The positive linear relationship*

As opposed to Schumpeter's view and the negative relationship, Fellner (1951) and Arrow (1962) showed that firms did benefit more from innovation when the competition is strong. Porter (1990) famously argued that firms are required to innovate during high competition in order to survive. Aghion et al. (2005) further explains the possibility for this relationship by using the term "escape competition effect", which is built on the step-by-step innovation models of Aghion, Harris, Howitt & Vickers (2001), and Aghion, Harris, and Vickers (1997). The model describes how competition may increase the incremental profit from innovating. With stronger the competition, the risk of being matched by and overtaken competitors will be costlier for technically developed firms. Consequently, these firms will increase their R&D expenditure to outpace the competition.

Geroski (1990) uses data on major innovations introduced in the UK during the 1970s to explore the hypothesis which states that increases in competitive rivalry decrease innovativeness. The empiric study is an inter-industry comparison that uses cross-section data. Geroski proposes an exploration of the correlation between innovativeness and monopoly power by examining the effect of rivalry. To do this, he propagates the use of more information on market structure than just concentration ratios, by correcting for inter-industry variations in technological opportunity, and by distinguishing the effect that rivalry has on innovativeness through its effects on post-innovation return. He finds that there is almost no support for the hypothesis that increases in competitive rivalry decrease innovativeness.

Crepon, Duguet, and Kabla (1996) analysed the 1991 data of approximately 10,000 firms. Results on the relationship between market concentration and innovation were found to differ, depending on which innovation indicator was used. When the number of patents and other performance indicators of innovation were used, a negative relationship was established with market concentration, while in the case of the sale of new products, a positive relationship was found. As for R&D investment, no relationship was established.

Blundell et al. (1999) implemented a dynamic feedback model for company innovations, including controls for firm-specific effects. Their model combines two strands in the literature on innovation by estimating both an innovation equation and a value equation on a novel firm panel level data source. The empirical results showed that less competitive industries had fewer aggregate innovations, and simultaneously saw that it was the high market share companies who tended to commercialize more innovations, although increased product market competition in the industry tended to stimulate innovative activity.

Tang (2006) differs from most other studies in that it uses data on firm's perception of their competitive environment, and argues that it is a better measure for firm-specific competition and more crucial for innovation as compared to other measures. Tang (2006) points out that differences in perception could explain why firms undertake different levels of innovation activities, and could also factor into how firms in the same industry may compete in completely different product markets due to the nature of their products. The study measures four different types of competition: easy substitution of products, constant arrival of competing products, quick obsolescence of products, and rapid change of production technologies; with the first three being measures of product market competition. The results show that the relationship between competition and innovation can both be positive and negative, depending on the specific competition perception and innovation activity. Easy substitution of products is negatively correlated with innovation activities, while a constant arrival of competing products is positively correlated with product innovation. Quick obsolescence of products is positively correlated to R&D and negatively correlated to process innovation. Rapid changes in production technologies also have a strong positive correlation with innovation activities.

Correa (2012) finds a structural break in the data sample used by Aghion et al. (2005). Taking this structural break into consideration, the inverted-U empirical relationship between innovation and competition found by Aghion et al. (2005) cannot be reproduced. Depending on what time period the data is taken from, different relationships are found to exist. Correa (2012) finds a positive innovation–competition relationship during the period of 1973–1982, and no relationship in the period of 1983–1994.

Most of the researches that are in favour of a positive relationship is substantiated by empirically-based research and published after 1990.

### *1.5. The inverted-U relationship*

When firms compare the expected pre- and post-innovation rents, and simultaneously try to escape competition, you get behaviours that produce a non-linear relationship (Aghion et al., 2005). However, if competition is fierce, the negative Schumpeterian effect of competition on R&D dominates the positive escape competition effect. When competition is low, a larger equilibrium fraction of sectors involves neck-and-neck competing incumbents, so that overall escape competition effect is more likely to dominate the Schumpeterian effect. The balance between the two effects changes with the level of competition, generating the inverted-U relationship between competition and R&D.

Aghion et al. (2005) developed the first model which predicted an inverted-U relationship between competition and innovation by expanding on his previous work (1997). The study measures innovation by a citation-weighted patent count, and the average number of patents taken out by firms in an industry is used. Each patent is weighted by the number of times it has been cited by another patent in order to account for each patents importance. Competition is measured by the Lerner Index (or price-cost margin, PCM). It is argued that this is the best indicator, as other indicators such as market share or the Herfindahl concentration index rely on precise definitions of geographic and product markets to a larger degree (which is difficult when many firms in the study operate internationally). The competition measure is the average of the Lerner index across firms within the industry. The study uses flexible nonlinear estimators to investigate the basic shape of the relationship between innovation and competition. The specification is based on the Poisson model, with relaxed strong assumptions for higher moments (Hausman, Hall, & Griliches, 1984). In addition, time effects are included to remove common macroeconomic shocks. The study finds evidence of an inverted-U relationship between innovation and competition, with industries distributed across both the increasing and decreasing sections of the U-shape. The inverted-U is robust to a number of alternative specifications.

Tingvall and Poldahl (2006) sought to test whether the predictions of Aghion et al. (2005) held for firm-level data of manufacturing firms with a minimum of 50 employees. R&D expenditure is used as the measure for innovation, while both the Herfindahl-index and price-cost margin (PCM) is used as measures for competition. They detect a significant inverted-U relationship when measuring competition with the Herfindahl index, suggesting that R&D increases when monopolies are broken up, but a further increase in competition results in decreased R&D. This result is robust when controlling for other variables. However, when using fixed-effect estimators, the effects become insignificant. When using the price-cost margin as a competition measure, they were unable to detect any positive effects of competition on R&D, finding only a negative relation (the Schumpeterian effect). They point to a possible explanation for the different results being that the PCM is an ex post realized reaction to changes in the environment, whereas changes in the Herfindahl index may not be realized with changes in competition. In addition to this, given the non-segmented markets, the PCM may be affected by both domestic and international competition, while the Herfindahl index is only affected by the number of domestic competitors and their market share.

Halpern and Muraközy (2015) builds upon Aghion et al. (2005) for their empirical study, and aimed to examine the relationship between competition and R&D expenditures, based on Hungarian firm-level and industry-level data. The data source for this study are balance sheets and profit and loss accounts from manufacturing firms, the reason being that the relationship would be easier to measure and interpret for this industry as compared to those in services. The study estimates three models. In the first one, industry-level R&D intensity is modelled with industry competition variables and other explanatory variables, which is similar to Aghion et al. (2005). Two other models are at the firm level. The first uses a probit model, where the dependent variable indicates whether the firm performed R&D activity in 2005. In the next model, the dependent variable is the firm-level R&D intensity. Competition is measured by three different variables: Two estimate market structure (C3 and Herfindahl), while ROA approximates profit margin. Innovation is measured by the R&D value from the year 2005, and the model is estimated with a quadratic specification. The empirical results show a detectable inverted-U relationship between competition and innovation at both an industry and firm level. However, it is only established for the concentration indicator (C3) and the Herfindahl index, as the ROA did not reveal any significant effects.

The publications that are thus in favour of an inverse-U relationship is among the most recent research, a position that is achieved by combining both earlier theory and empiric research to explain the relationship.

### *1.6. Hypothesis*

Aghion et al. (2005) argue that some earlier studies contradicted each other because they did not account for possible nonlinear relationships. In addition to this, indicators of competition related to market structure are prone to inaccuracies due to external competition. Hence, Halpern and Muraközy (2015) argues that it is more practical to use indicators to measure market power, such as the Lerner index.

Furthermore, it is problematic to select a measure of innovation. Most studies use R&D expenditures, R&D employment or patents. As previously stated, we have argued that R&D expenditures cannot be directly translated to innovation, and the opposite may as well be true (Gilbert, 2006). R&D expenditures may correlate with innovation and R&D output for larger firms, while smaller firms may generate high impact innovation without much spending. In addition, effective R&D expenditure may vary widely across industries (Freeman, 1982).

Patent count is thus a flawed measure for innovation due to the fact that they are all not of equal importance or measure the same level of innovation. To counter this, a citation weighted patent count often is used as a measure (Jaffe, 1986). Halpern and Muraközy (2015) points out that this measure still is flawed, especially for countries not at the technological frontier. Indeed, Gilbert (2006) notes that a failure to distinguish product and process innovation could be a possible cause of inaccuracies, while Halpern and Muraközy (2015) call attention to the fact that innovation does not solely depend on competition. It should also be noted that the relationship between competition and innovation is not causally asymmetrical, but rather a simultaneous one (Dasgupta & Stiglitz, 1980a, b; Pohlmeier, 1992).

Theory and empirical evidence have pointed in several different directions. Although disputed by Hashmi (2013), the work of Aghion et al. (2005) is supported by Tingvall and Poldahl (2006) and Halpern and Muraközy (2015). We thus wish to expand on the latest research by investigating whether one specific model is sufficient for describing the relationship across several aspects of innovation and competition. The inverse-U relationship has received an increasing amount of attention in recent years due to the innovative way of explaining the inconclusiveness in empiric data. This might not be a complete model for the description of such a relationship, but we consider it to be a step towards the right direction. The alternative would be to take a step back and use older models, which we have concluded to be inaccurate. We thus propose the following hypothesis:

**H1**: *The relationship between competition and innovation can be described with an inverse u-shape.*

One possible reason for the different results of former empirical investigations of the relationship between competition and innovation inputs may be caused by a lack of focus on the demand conditions. For example, it is possible to have scenarios with higher levels of competition within markets with high growth levels, or low levels of competition in stagnating markets. From a company perspective, the superior strategic position could be characterized as operating within high growth markets with limited competition, as described in the concept of Blue Oceans (Kim & Mauborgne, 2004). We propose the following hypotheses:

**H2**: *High perceived market demand will have a positive impact on innovation inputs in a firm.*

**H3**: *Different combinations of competition and demand conditions will have impact on the innovation inputs of a firm.*

H2 is based on an expectation that high levels of market demand represent a profit potential that will be positive for investments in innovation-related activities. Regarding H3, different combination effects are possible and we will explore these in order to investigate if the interaction effects between external competition and demand conditions may contribute to or lead to an understanding of the variation in innovation efforts by firms.

## 2. Methodology

### *2.1. Dataset*

Based on the KOMPASS Norway database, we targeted small and medium-sized exporting firms, which are firms defined as having less than 250 employees. It should be noted that some firms were listed as having less than 250 employees in the database, but the results showed that at the time of the survey, they had more than 250 employees. In order to comply with EU's definition of SME's, these firms were taken out of the data set. This reduced the total number to 363 firms.

In the development of the questionnaire, we followed the stages suggested by Fowler (1984), which we refined and improved, according to the advice of Nunnally (1978), as well as Gerbing and Anderson (1988). We did a test of the questionnaire and involved ten company managers. Most measures were formatted in seven-point Likert type scales, and this was chosen to reduce the effort and time used by respondents (Fowler, 1984). The survey was sent in paper, which also included a cover letter. The respondents could decide to reply in paper or through an online version via an Internet link provided. Furthermore, we sent a follow-up email. We asked that the survey should be answered by the CEO or the individual with the most knowledge of the firm's international operations. In total, 380 usable questionnaires were returned; this equals a response rate of about 17%.

### 2.2. Measures

Our measures build on a large innovation survey by Statistics Canada (Nemes & Schaan, 2002), Table 1 presents the measures used.

#### 2.2.1. Competition

We drew inspiration from the indicators used by Tang (2006) by using the firms' perceived competitive environment as the competition measure, rather than traditional measures, such as industrial statistics. Tang (2006) argues that this may be more desirable, as a manager's perception of the degree of competition would more likely capture the firm-specific competition, as firms in the same industry may face different degrees of competition depending on their products. In addition, a perception-based measure captures both domestic and international competition. The three indicators capture the product/service competition dimensions (constant threats, easy to substitute, new competitors),and the managers evaluate each statement on a Likert scale from 1 to 7, where 1 is "disagree" and 7 is "strongly agree", 4 is "somewhat agree". These measures build on previous studies that assessed

**Table 1. Measures**

| Measures | Average. | Std. dev. |
|---|---|---|
| ***Degree of competitiveness (alpha = 0.683)*** | | |
| *Comp1)* Competing products/services are a constant threat for the company | 4.48 | 1.65 |
| *Comp2)* The customer can easily change our product/service with competitor's products/services | 4.26 | 1.75 |
| *Comp4)* The arrival of new competitors is a constant threat for our company | 3.99 | 1.73 |
| *Not included: Comp3)* The products/services quickly becomes out-dated | 2.58 | 1.57 |
| *Not included: Comp5)* Production technology change rapidly | 2.98 | 1.60 |
| ***Market demand (alpha 0.771)*** | | |
| *Dem1)* Market growth in home market | 3.88 | 1.20 |
| *Dem2)* Market growth in most important international market | 3.98 | 1.34 |
| *Dem3)* Total market growth in the past three years | 4.07 | 1.38 |
| ***Innovation inputs (alpha = 0.727)***<br>*Inn1) Product exploitation*: to what extent have the firm focused on improving current products | 5.47 | 1.47 |
| *Inn2) Product exploration*: to what extent have the firm focused on developing new products | 4.90 | 1.64 |
| *Inn3) Service exploitation*: to what extent have the firm focused on improving current services | 4.77 | 1.66 |
| *Inn4) Service exploration*: to what extent have the firm focused on developing new services | 4.18 | 1.71 |
| *Inn5) Process exploitation*: to what extent have the firm focused on improving current production processes | 4.80 | 1.61 |
| *Inn6) Process exploration*: to what extent have the firm focused on developing new production processes | 4.22 | 1.76 |

competitiveness (Jansen, van der Bosch & Volberda, 2006; Yang & Li, 2011). Cronbach alpha equals 0.68 for the competition scale. We initially also tried to include two other competition measures (C3: products quickly gets out-dated and C5: production technology changes rapidly) but an inclusion of these would have resulted in a low Cronbach alpha score.

#### *2.2.2. Market demand conditions*

On a scale ranging from strong decline (1) to Strong growth (7), we asked about the current market development in the home market and in the most important international market. We also asked the respondents to rate the overall market development within the past three years, using the same scale. This market demand scale has a Cronbach alpha score of 0.771.

#### *2.2.3. Innovation inputs*

The most common measure of innovation inputs would be R&D expenditures. Instead, we utilized six measures of perceived innovation inputs (improvements and new solutions related to products, services and production processes). Following the reasoning by Tang (2006) we argue that these measures may capture the firms' intended innovation efforts better than R&D, because they are firm-specific and capture different aspects of innovation within products, services, and production processes. We also build also on the measures presented by Thuriaux-Alemán, Eagar, and Johansson (2013) and Weerawardena (2003), and the Cronbach alpha equals 0.727 for the innovation input scale.

### ***2.3. Method of analysis***

We performed the analysis based on the scales presented and the individual items; the last item was inspired by Tang (2006), who showed variation in results based on the specific measures used. Table 2 present the correlations between our three scales

As indicated in the table, higher levels of innovation inputs are reflected in cases of better innovation performance. However, there is no significant correlation between the degree of competition and the degree of innovation input. As expected, lower levels of market demand development were related to higher levels of competition. However, higher market demand was not significant, particularly with regard to innovation input.

In addition to the direct linear relation, we also tested non-linear paths (U-shaped) between innovation input and competition, but no such relationship was identified. Figure 1 shows the distribution based on innovation input and the competition scale.

Some of the dots represent more than one company, but this figure does not reveal any significant non-linear or linear relationship between the competition and innovation inputs. It seems that a variation in the level of competition does not result in a variation in the amount of focus a company direct towards innovation activities.

We have also presented an analysis based on the scales, as shown above. However, following Tang (2006), we also make an analysis based on the specific measures used (Table 3).

**Table 2. Correlations between scales**

| Measures | Competition | Market demand |
|---|---|---|
| Competition scale | | |
| Market demand scale | −0.154** | |
| Innovation input | −0.095 | 0.049 |

Notes: **: $p < 0.01$

**Figure 1. Correlations between competition and innovation inputs.**

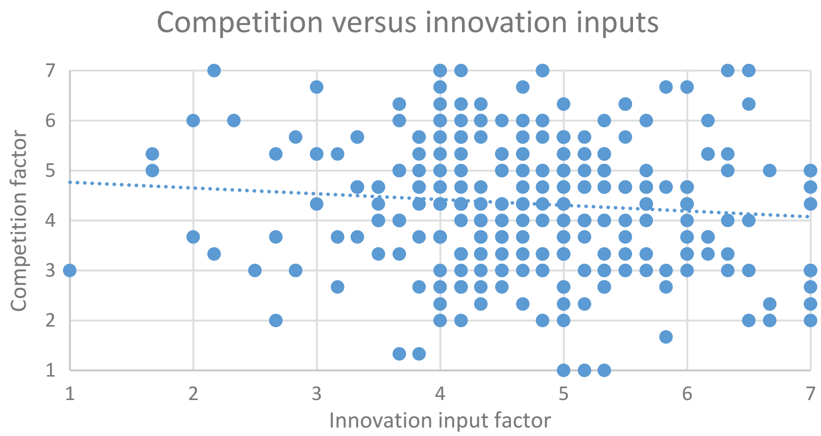


**Table 3. Correlation matrix between scale items**

| | Inn1 | Inn2 | Inn3 | Inn4 | Inn5 | Inn6 |
|---|---|---|---|---|---|---|
| Comp1 | 0.027 | −0.033 | −0.029 | −0.073 | 0.031 | −0.002 |
| Comp2 | 0.009 | −0.073 | −0.139* | −0.129* | 0.066 | −0.034 |
| Comp3 | 0.004 | 0.158** | 0.047 | 0.094 | 0.016 | 0.065 |
| Comp4 | −0.041 | −0.119* | −0.086 | −0.063 | −0.037 | −0.096 |
| Comp5 | 0.025 | 0.167** | 0.178** | 0.206*** | 0.156** | 0.254*** |
| Dem1 | 0.029 | 0.074 | −0.018 | −0.012 | −0.096 | −0.116* |
| Dem2 | 0.119* | 0.107 | −0.013 | 0.079 | 0.033 | −0.016 |
| Dem3 | 0.056 | 0.116* | 0.017 | 0.043 | −0.052 | −0.036 |

Notes: *: $p < 0.05$; **: $p < 0.01$; ***: $p < 0.001$

The correlation table suggests that Comp5 (new production technology) is significantly related to four out of the five innovation input items. This is as this item appears to be more important than the others in influencing innovation activities.

Our first hypothesis suggested a U-formed relation between competition and innovation input. We examined this in SPSS and in Excel, both by regression analysis and visually. In addition to U-formed relations, other aspects (linear positive, linear negative, logarithmic, exponential and polynomial) were also examined. We were unable to find any significant relationship between competition and innovation levels based on our data, and H1 is rejected.

Our second hypothesis suggests that higher market demand would be reflected in more investments in innovation activities. From Table 3, we notice that the correlation coefficient is non-significant and testing based on different non-linear paths do not result in any significant pattern. Therefore, H2 is also rejected.

The third hypothesis suggests that the combination of market demand and competition would result in different levels of investments in innovation activities. In order to test this hypothesis, we performed a K-means clustering with a four cluster solution, as described in Table 4.

We observed one cluster with high scores on both innovation and market demand (cluster 1), and one with low scores on both measures (cluster 2). Firms in cluster 3 operate in a highly competitive environment with a limited market demand, which should be regarded as an unfavourable environment. The opposite situation was identified for cluster 4, with low levels of competition and high market demand.

Table 4. Cluster analysis, competition and demand conditions

| Measures | Cluster 1 (n = 74) | Cluster 2 (n = 88) | Cluster 3 (n = 60) | Cluster 4 (n = 58) |
|---|---|---|---|---|
| Competition scale | 4.96 | 3.80 | 5.77 | 2.68 |
| Market demand scale | 4.86 | 3.28 | 3.10 | 4.84 |

Table 5. Testing of mean differences between clusters

| Bonferroni test, group differences | Mean | Std. dev. | F-value |
|---|---|---|---|
| ***Innovation input*** | | | 1.96 |
| a) Cluster 1 | 4.79 | 0.95 | |
| b) Cluster 2 | 4.71 | 0.96 | |
| c) Cluster 3 | 4.65 | 1.05 | |
| d) Cluster 4 | 5.09 | 1.14 | |
| ***Focus on new product innovations*** | | | 4.37** |
| a) Cluster 1 | 5.05 | 1.61 | |
| b) Cluster 2 | $4.79^{d}$ | 1.53 | |
| c) Cluster 3 | $4.76^{d}$ | 1.81 | |
| d) Cluster 4 | $5.67^{b,c}$ | 1.23 | |

**: $p < 0.01$; b/c/d: $p < 0.01$

In Table 5, we compared the mean score differences between these cluster in relation to their innovation inputs, i.e. how much effort they put into innovation activities. We include both the total scale and the item that focused on new product innovations.

The table shows that the firms with the most favourable environments (high growth and low competition) scored highest on the innovation input scale, followed by the firm experiencing high market growth and high competition. The two clusters with the weakest demand situation had the lowest score in innovation input. However, none of these differences was statistically significant. However, we also checked each of the items in the scale, and five out of six of these did not include any significant differences. The exception was the item that was related to the focus on new product innovations. We did find that the group of firms in the most attractive environment (cluster 4) had a significantly higher score than those found in cluster 2 and cluster 3 with regards to innovation input in relation to the development of new products. This suggests that the most attractive combination of demand and competitive environment result in more resources being directed towards the development of new products. In the discussion section, we will comment on these results and the possible interpretations.

## 3. Discussion

In the introduction, we presented the wide ambiguity on research on this field historically, as well as the complexity in the way that innovation and competition was measured and defined. Our research explored this complexity by using several measures for both innovation and competition, as well as demonstrated several ways of analysing relationships, including linear regression, curved regression and a cluster analysis. We will structure our discussion according to three major issues: changes in production technology, the inverted u-pattern, and how competition and innovation interact.

### *3.1. The importance of changes in production technology*
One of the original competition items was the changes in production technology. However, due to low Cronbach alpha, it was not included in the competition scale. When we examined the correlations between competition and innovation inputs, this item did have a significant, positive correlation with five out of the six innovation inputs elements. The result is consistent with those made by Tang (2006). Overall, a change in production technology appears to be a bigger driver for innovation than any other measures of competition.

### *3.2. The lack of an inverse U relationship?*
When examining the possibility of an inverse U relationship between six innovation input measures and five completion measures, 30 different combinations existed. None of these showed an inverse U relation. If we were to go even further and divide the data into product, process and service-oriented firms, 90 different combinations occur. One of these supports an inverse U: Comp5 (rapid changes in production technology) versus Inn5 (improvements of production technology) within the firms, which was characterized as service-oriented. If we were to only examine the linear relationship, we would conclude that this relationship could be described by the significant positive linear relationship with an adjusted R-squared at 0.17. However, when we do the curved linear regression, we obtain a significant inverse U-relationship with an adjusted R-squared of 0.23. Out of the 90 possible regressions, this would indicate that the quadratic regression line is a better fit than the linear. This single result supports Aghion et al. (2005)'s claim that this relationship might exist, but the ambiguity in empirical evidence is due to a discrepancy in the way in which researchers analyse their data. This is the only relationship between the competition and the innovation indicator that fits the curved regression analysis best, as the other 89 combinations do not indicate a similar pattern. However, as an isolated case, this sole occurrence would not be sufficient in confirming hypothesis H1.

### *3.3. The combined effects of competition and market demand*
We included demand conditions and have identified different environments from the perspective of the firm managers. Highly competitive growth markets, highly competitive stagnating markets, stagnating markets with limited competition, as well as growth markets with limited competition. When we compare how much companies invest in innovation in each of these situations, we observed the mean value differences. However, the significance level was just outside the 0.05 threshold. Therefore, we also tested each of the items in the scale and found a significant difference where the companies experiencing both high market demand and limited competition invested significantly more in development of new products than firms in less favourable demand conditions. Our interpretation is that development of new products would need resources, including the risk of failure, and may be characterized as a major decision in many firms. Incremental improvements may be done with less investment and less risk. In this perspective, it is not surprising instances that resemble ideal external opportunities would increase the likelihood of engaging in new product development initiatives.

## 4. Implications, limitations and further research
From the perspective of managers, our results grant an insight as to how different external conditions influence the way in which resources are allocated towards innovation activities in a sample of small- and medium-sized firms. This is important, as it gives guidelines for an understanding of a firm's challenges and what the typical adjustments in similar situations would be. Each firm may then choose to follow what is common or make different choices. Five different aspects of competition were included, three aspects related to demand conditions. Of these nine, only one in itself really mattered in terms of influencing innovation inputs: rapid changes in production technology. Such changes may open the possibility of new products, new or changed services or more cost efficient production processes. We do not know if firms, in order to survive, are forced to be innovative when production technology changes or this course of action is evaluated in reacting to opportunities created by new production technology solutions.

From the perspective of the managers, our study also supports the existence of "Blue Oceans", which is described by Kim & Marbougne (2004) as markets with high demand and limited competition. We have limited knowledge about the processes in which firms get into "Blue Ocean" positions—is this driven by an innovation focus or do firms identify opportunities and then direct resources towards not least new product development to exploit them? Regardless of how these processes unfold, managers should pay considerable attention towards market niches that are characterized by limited competition and limited demand. It should also be noted by managers that when focusing on new product innovations, previous research by Lasagni (2012), Lefebvre, De Steur, and Gellynck (2015) suggest that cooperation with customers are particularly important.

Considering the implications for research, we noticed that the concept of both competition and innovation are highly complex and both divide into several sub-categories which will also need to be examined separately. For future studies, attempts to develop robust scales and single item analysis should be included. We have focused on how external factors that are perceived by managers influence the firm's innovation activities. We identified a combined effect of demand and competition in particular, influencing the development of new products. Further studies should thus follow this approach and highlight these interaction effects, along with including internal factors as growth ambitions. Such studies should be focusing on innovation drivers in high-technology industries (Audio & Gonzalo, 2007), as well as in more mature industries (Caiazza, 2015).

From a public policy perspective, our results do not suggest that more or less competition should be targeted if the goal is to increase innovation activities in firms. However, if firms in an industry that experiences rapid changes in production technology, the innovation pressure will most likely be high and represent significant challenges to resources. As such, access to production-related technology knowledge and innovation funding mechanisms in such conditions may be particularly important when developing public policy.

## 5. Concluding remarks

We started out by presenting the ambiguous conclusions that were reached from earlier literature and ended up with some of the same ambiguity in our own data. However, our research offers value by identifying how different measures of innovation and competition may yield significantly different results. We also found a clear indication that the way in which we conduct our analysis has an impact on the type of relationship we detect.

Our main contribution is the identification of how one other factor in particular (demand development) could influence the innovation versus competition relationship. Several authors suggest that innovation depends on a number of factors (Barton, 1995; Martins & Terblanche, 2003; Tsai, 2001). In further studies, this approach should be further developed by, for example, focusing on the firm's age and size (Petruzzelli, Ardito, & Savino, 2018) and other factors both related to internal and external conditions that may influence the innovation versus competition relationship.

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