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Internal Capabilities and External Knowledge Sourcing for Product Innovation in LMT SMEs

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Abstract: Low- and medium-tech small and medium-sized enterprises (LMT SMEs) constitute a large and important segment in European economies. Because of increasingly international competition, LMT SMEs must rely on innovation to strengthen their competitive position over time. In this study, we empirically analyze possible complementarity or substitutability between internal capabilities and external knowledge sourcing. Using a short panel of 142 Dutch LMT SMEs, we find empirical evidence that suggests a negative interplay between internal capabilities and external knowledge sourcing.

Keywords: Low-tech and Medium-tech Small Sectors, Medium-Sized Enterprises, Open Innovation, Innovation Strategy.

1. Introduction

One may distinguish two dominant approaches to achieving innovation: the first approach views a firm's internal capabilities as the primary drivers of innovation (Dosi, 1982), while the second approach views innovation as driven by a firm's external partnerships (von Hippel, 1998). The theory of open innovation (Chesbrough, 2003) considers that firms cannot longer afford to rely exclusively on internal innovative capabilities to cope with today's global market challenges, but rather need to engage in external knowledge sourcing to ensure survival in nowadays economy where technology shifts occur at an increasingly rapid pace. Open innovation then implicitly posits complementarity between a firm's internal capabilities and external knowledge sourcing (e.g., Cassiman and Valentini, 2011). A key pre-condition to open innovation is that firms dispose of absorptive capacity to internalize external knowledge (e.g., Vanhaverbeke et al., 2008). Absorptive capacity has been defined as a firm's "ability to recognize the value of new information, assimilate it, and apply it to commercial ends" (Cohen and Levinthal, 1990, p.128).

Since its introduction, the concept of open innovation has received considerable coverage in the business management literature (e.g., Cassiman and Valentini, 2011; Chesbrough et al., 2006; Hagedoorn and Ridder, 2012; Laursen and Salter, 2006; Mazzola et al., 2012; Mention, 2011; Mention and Asikainen, 2012). Empirical evidence to support the importance of open innovation has been mainly concentrated on so-called high technology industries, e.g., computers, information technology, and pharmaceuticals (Chesbrough et al., 2006). Additionally, open innovation has been studied mostly in multinational enterprises, of which most have large internal R&D departments (Vanhaverbeke et al., 2012). In this context, empirical evidence has indicated that internal capabilities and external knowledge sourcing are complements

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rather than substitutes (e.g., Chesbrough, 2003; Chesbrough et al., 2006; Denicolai et al., 2014; Laursen and Salter, 2006), suggesting that the greater the internal capabilities of the firm, the greater the effect of external knowledge sourcing on innovative performance.

Despite this considerable attention, research on open innovation in small medium-sized enterprises in low- and medium-technology industries (henceforth, LMT SMEs) has remained scarce and therefore it remains an open question whether the concepts of open innovation can be readily applied (Vanhaverbeke et al., 2012). It may be that open innovation practices do not hold in the context of LMT SMEs because of their specific innovation pattern.

LMT SMEs are not at the forefront of innovation when compared to their counterparts in high-tech sectors. LMT industries are depicted as being characterized by process, organizational and marketing innovations, by weak internal innovation capabilities and by strong dependence on external sources of knowledge (Heidenreich, 2009). Hirsch-Kreinsen (2008) allocates the degree of novelty of innovations in LMT sectors, as somewhere between incremental and architectural in nature. For these firms, innovations are usually the outcome of recognizing new market opportunities, with technology push innovations only playing a minor role (Vanhaverbeke et al., 2012).

The goal of this study is to contribute to the empirical literature by advancing and testing the implicit complementarity connected to open innovation in the context of LMT SMEs. We examine the nature of the relationship between a firm's internal capabilities i.e., technological and marketing-related and external knowledge sourcing. To test our hypotheses, we rely on four innovation surveys conducted by a not-for-profit innovation intermediary in the Netherlands that correspond to the years: 2000 to 2003. From these four waves we constructed an unbalanced panel of 142 Dutch LMT SMEs.

The study is structured as follows: in the next section, we review the literature on LMT SMEs and open innovation and present the theoretical arguments for our research hypotheses. We then go on to provide information on the database and methodological approach, followed by the empirical results obtained. Finally, we draw some conclusions and discuss the policy implications and limitations of our research.

2. Literature background and hypotheses

The OECD distinguishes four different categories of industries on the basis of the technology intensity (Hatzichronoglou, 1997). Industry sectors with an R&D intensity of more than 5% are classed as high technology and those with an R&D intensity between 3% and 5% as medium-high technology. Industry sectors with an R&D intensity of between 3% and 0.9% are classified as medium-low technology and those with an R&D intensity below 0.9% as low-technology. The latter two are generally referred to as low- and medium-technology (LMT).

LMT industry sectors play an important role in industrialized economies as they provide more than 90% of output[1] (as a result, their contribution to aggregate growth is likely to largely outweigh that of high technology sectors) and account for over 60% of employment in the manufacturing sector (e.g., Hirsch-Kreinsen, 2008; Robertson, Smith and von Tunzelmann, 2009). LMT firms in Europe are mostly

[1] European Union, the USA and Japan

small- and –medium sized enterprises and they constitute a large and significant segment in European economies (e.g., Hirsch-Kreinsen et al., 2003; Hirsch-Kreinsen, 2008; Potters, 2009).

LMT SMEs are a highly heterogeneous population in terms of their technology base, industry classification, internal capabilities and their position in the value added chain (e.g., Hirsch-Kreinsen, 2013). LMT SMEs by their very nature are characterized by a low R&D activity and predominantly include mature industries, such as the manufacture of household appliance, food processing, paper, printing and publishing, wood and furniture, metal and plastic products industries (e.g., Hirsch-Kreinsen et al., 2008).

Given the growing international competition, LMT SMEs must rely on innovation to strengthen their competitive position over time (e.g., Hirsch-Kreinsen, 2008; Morrison, 2011). Literature has distinguished two main types of innovation activity: process and product innovation. A process innovation is defined as the implementation of a new or significantly improved production or delivery method employed to produce a product or service, whereas a product innovation is the commercial introduction of a good or service new or significantly improved with respect to its technology (OECD, 2005). Process and product innovations are two valuable but distinct activities. On one hand, process innovation can lead to improved flexibility and increased capacity of production, reduced costs of labour, materials and energy (Heidenreich, 2009). On the other hand, product innovation enables firms to accomplish product differentiation, whereby an increased range of products and hence new markets can be attained (Wziatek-Kubiak, 2008). By adopting a product differentiation approach, firms seek to distinguish their products from competitors, where quality upgrading and novel characteristics and functionalities can be regarded as differentiating attributes (e.g., Morrison, 2011; von Tunzelmann and Acha, 2006).

A number of studies have stressed the considerable importance of process innovation for firms in LMT sectors (e.g., Heidenreich, 2009; Kierner et al., 2008). The main argument behind is that factors, such as cost competition and economies of scale, are much more prevalent in LMT industries. Then, a logical step for many LMT SMEs would be to focus, by large, on process innovation rather than on product innovation. By this means, firms are able to cut costs quickly and improve their efficiency. However, studies have revealed that LMT firms achieve a significant growth in income from new and technological changed products that have considerable aggregate impact (IMP3rove II study, 2011; Robertson et al., 2009). Increasingly, LMT firms are strategically expanding the share of complex and customized products as a specific strategy of competing with companies from low-cost countries (Hirsch-Kreinsen, 2008). Moreover, by increasing the degree of novelty of innovation in products, LMT firms can improve their competitive advantage and create opportunities to access new market segments ahead of competitors (e.g., Amara et al., 2008; Wziatek-Kubiak, 2008).

LMT firms are not at the forefront of innovation when compared to their counterparts in high-tech sectors. Hirsch-Kreinsen (2008) places the degree of novelty of innovations, in LMT environments, as somewhere between incremental and architectural in nature. For Hirsch-Kreinsen, incremental innovations are reflected in the step-by-step product development path, which is characterized by the constant further improvement of individual components concerning their material, their function and their quality, however the structure and the technological principles of the products remain unaffected. On the contrary, for Hirsch-Kreinsen, architectural innovations are direct and specific customer-oriented and their main feature is the continual reconfiguration of individual components for the development of new products that can meet special customer requirements and open up new market segments. In LMT industries, innovations that are new to a market segment (or

market niche) are often the result of changes in the overall design of a product or the way its components interact with each other (e.g., Hirsch-Kreinsen, 2008).

Given the shortening of product life cycles, the multidisciplinary nature of many technologies and the growing complexity of knowledge processes, firms are increasingly engaging in external knowledge sourcing to supplement their internal capabilities (e.g., Brunswicker and Vanhaverbeke, 2014; Chesbrough, 2003; Chesbrough et al., 2006). The role of external knowledge sourcing as a determinant of innovation has been underlined by the theory of open innovation (Chesbrough, 2003). At the core of the theory of open innovation is that, firms can gain valuable knowledge for innovation from a wide range of distributed external sources of knowledge. Firms may engage in open innovation in two ways: (1) Inbound open innovation, and (2) Outbound open innovation (Chesbrough and Crowther, 2006). Inbound open innovation refers to inward technology transfer, where firms monitor their environment to source technology and knowledge into their internal knowledge base. Outbound open innovation, in contrast, refers to outward technology transfer, where firms look for external organizations that are better suited to commercialize a given technology (Lichtenthaler, 2009).

In the context of low-tech or mature industries, inbound open innovation has been shown to be prevalent over outbound open innovation (e.g., Chesbrough and Crowther, 2006; Chiaroni et al., 2010; Tsai and Wang, 2009). For LMT firms, it has been customary to consider specialized suppliers as the most important cooperation partners and the main external sources of knowledge for innovation activities (Hirsch-Kreinsen, 2008). As a consequence, we would expect external actors, such as, customers, competitors, universities and knowledge institutions to have a limited role in LMT SMEs' inbound open innovation activities. This challenges the assumption from an open innovation perspective that LMT SMEs' innovate performance relies on different external knowledge sourcing modes (Vanhaverbeke, 2006). Moreover, depending heavily on suppliers for critical knowledge may pose substantial risks (Fine and Whitney, 1996).

Although their relative importance may vary from enterprise to enterprise and from sector to sector, innovation depends, to one degree or another, on externally generated technological and market knowledge (e.g., Amara and Landry, 2005; Bender, 2008; Grimpe and Sofka, 2009; Hervas-Oliver et al., 2012; Laursen and Salter, 2006; Robertson and Smith, 2008). Technological and market knowledge can increase a firm's ability to discover and exploit opportunities e.g., to recognize wants and needs in the marketplace and to determine a product's optimal design and market value of new scientific discoveries (Wiklund and Shepherd, 2003). Technological knowledge is largely associated with university research and specialized suppliers (Laursen and Salter, 2006), while market knowledge is linked to customers and competitors (Grimpe & Sofka, 2009; Li and Calantone, 1998). Applying the concepts of open innovation, we anticipate that LMT SMEs that tap on external knowledge-be it technological or market-will be more likely to develop product innovations with a higher degree of novelty. Taken together, these arguments suggest the following hypotheses:

> *Hypothesis 1: External sources of market knowledge (customers and competitors) will have a positive impact on a LMT SME's innovative performance.*
>
> *Hypothesis 2: External sources of technology knowledge (universities and suppliers) will have a positive impact on a LMT SME's innovative performance.*

Having access to external knowledge stocks is recognized as a necessary but not sufficient condition for value delivery (Dierickx and Cool, 1989). It is only when

knowledge is properly deployed via the firm's capabilities that superior organizational performance can be developed (Day, 1994). Previous research suggests that there are firm-specific capabilities that affect the value that a firm derives from external knowledge sourcing (Su et al., 2009; Vega-Jurado et al., 2009). More specifically, a firm's technological and marketing capabilities affect its ability to identify and explore external knowledge sourcing opportunities (e.g., Su et al., 2009).

Technological capability refers to as a stock of technological knowledge that a firm accumulates over time (e.g., Srivastava and Gnyawali, 2011; Wu, 2014). One of the key components of a firm's technological capability is absorptive capacity, which refers to its ability to identify, assimilate and utilize external technological knowledge (e.g., Cohen and Levinthal, 1990; Jo and Lee, 2014). Building technological capability requires firms to invest substantial resources in R&D (Zhou and Wu, 2010). As a result, the accumulation of technological knowledge increases the firm's ability to engage in product innovations beyond the current technological boundaries. In the context of LMT SMEs, internal R&D activities and consequent technological capabilities are expected to be conducive to the introduction of architectural innovations, which Hirsch-Kreinsen (2008) characterizes as the recombination of existing components in order to obtain a new product design.

In the debate on LMT industry innovations, it is often assumed that external sources of knowledge are considerable important and that these compensate for lower levels of internal R&D activities. At lower levels of technological capability, specialized suppliers and universities may constitute the main sources of technological knowledge generation. Universities or research institutes may represent a viable alternative to gain technological knowledge, as LMT SMEs may have access to the expertise of the academic staff and technical facilities they need for new product development (George et al., 2002). A similar alternative to gain technological knowledge may be through highly specialized suppliers, as LMT SMEs may have access to their in-depth technical knowledge of individual components (e.g., Cui and Loch, 2011; Lee and Veloso, 2008). Therefore, we anticipate that LMT SMEs may opt to substitute their relatively little R&D and technological capabilities for external sources of technological knowledge. We therefore hypothesize:

> *Hypothesis 3: At lower levels of technological capability, universities and suppliers (external sources of technological knowledge) become a substitute for the in-house R&D performed.*

Marketing capability is related to a firm's ability to integrate knowledge pertaining to customers' current and potential needs for new products and knowledge about competitors' products and strategies to take advantage of market opportunities (e.g., Su et al., 2009). A review of the literature shows the debate whether market knowledge fosters or hinders innovation. Empirical evidence on this topic has varied; some indicating that having a strong customer and competitor orientation may lead to imitations and incremental innovation in products (e.g., Atuahene-Gima, 1995; Christensen & Bower 1996; Lukas & Ferrell, 2000). This might hold true particularly for technology-driven industries, where it is assumed that a strong focus on R&D is required for truly innovative products. But, in certain sectors, where innovation is not solely about technology but is rather a market-driven process, market knowledge might directly contribute to the increase of the share of sales of new products, regardless the level of R&D expenditure (e.g., Kirner et al., 2009). More specifically, in the context of LMT industries, the exploration and understanding of markets and the use of market information to shape the creation of new products, taking advantage of market niches, are central to innovation (e.g., Grimpe and Sofka, 2009; Hirsch-Kreinsen, 2008; Robertson and Smith, 2008).

Marketing capability may enable LMT SMEs to leverage customer-related market

knowledge as their needs can be identified, elaborated and translated into new product specifications (e.g., Hauser and Clausing, 1988; Li and Calantone, 1998; Song et al., 2005; von Hippel et al., 1999; Yassine and Wissmann, 2007). Additionally, marketing capability may enable LMT SMEs to leverage competitor-related market knowledge to enhance its understanding about market conditions that can be used to create products or marketing programs that are differentiated from those of competitors (e.g., Im and Workman, 2004; Wu, 2014). We anticipate a synergy effect between marketing capability and external market knowledge. Thus, the following hypothesis is proposed:

> *Hypothesis 4: Marketing capability and customers and competitors (external sources of market knowledge) are complements, thus having a positive impact on a LMT SME's innovative performance.*

3. Data, Methods and Sample Description

For our empirical analysis, we rely on four innovation surveys conducted by Syntens a not-for-profit innovation intermediary in the Netherlands that correspond to the years: 2000-2001-2002-2003. From these four waves we construct an unbalanced panel of Dutch SMEs since not all firms responded throughout the four years. A firm is included within the 4-year panel if, and only if, it consecutively answered the survey for at least two years.

Our final dataset consists of an unbalanced panel of 250 observations on 142 LMT SMEs. The percentage distribution of LMT SMEs across the different industries is as follows: Manufacture of Food and Beverages (9%); Manufacture of Wood and Products of Woods (4%); Publishing and Printing (5%); Manufacture of Rubber and Plastic Products (5%); Manufacture of Non-Metallic Mineral Products (5%); Manufacture of Basic Metal (3%); Manufacture of Fabricated Metal Products, except machinery and equipment (29%); Manufacture of Machinery and Equipment (12%); Manufacture of Furniture (6%); and Construction (21%).

3.1. Measures

Our dependent variable is *innovative performance*, reflected in product innovations that were successfully introduced by a firm into the market. New product development is a quite common measure of firm's innovation performance in open innovation literature (Mazzola et al., 2015). It provides an indication of a firm's innovative performance, as it shows how well a firm succeeded in introducing a new technological product into the market (e.g., Brouwer and Kleinknecht, 1999). Variable *innovative performance* is estimated as the percentage of turnover resulted from new to market product innovations.

3.2. Hypothesis testing variables

A first group of focal variables captures a LMT SME's internal capabilities. Prior studies (Wu and Wu, 2013; Wu, 2014) have used R&D intensity as a measure of a firm's technological capability, suggesting that firms that invest more in R&D, are considered to have greater technological capabilities. We follow that lead by using the ratio of internal R&D spending to total sales as a measure of the variable *technological capability*. Following previous studies (Wang et al., 2011), the variable *marketing capability* is measured as a LMT SME's marketing intensity (the share of annual expenditure incurred in marketing in sales). A second group of focal variables captures a LMT SME's inbound open innovation activities. The variable *external business knowledge* measures the variety of external sources of business knowledge:

customers and competitors. The variable *external technological knowledge* reflects the variety of external sources of technological knowledge: universities and suppliers. These variables can take integral values between 0 and 2 respectively, because a firm can use up to two different external sources, including clients and/or competitors for business knowledge and universities and/or suppliers for technological knowledge.

3.3. Control variables

We include a number of firm-level variables to control for the effect of own R&D efforts as well as the impact of incoming knowledge spillovers that are not due to external knowledge sourcing. The first control variable is *firm size* (the logarithm of the number of employees). In addition, we include the variable *human capital* (share of employees with a university degree) and the variable *purchased R&D-related intensity* (as share of annual expenditure incurred in the acquisition of other external knowledge in sales e.g., machinery, equipment, software). We include the lagged dependent variable *innovative performance* as a control variable, as we expect a firm's innovative performance to be largely determined by its past performance. In addition, the LMT SME's past innovative performance controls for unobserved heterogeneity. An additional control variable includes *training* (share of annual expenditure incurred in employee training in sales). Further control variables include a set of 2-digit industry dummies (we distinguish 10 LMT manufacturing sectors) and 4 time dummies with 2000 as the base year. Table 1 shows descriptive statistics and pairwise correlations for the variables used.

3.4. Statistical method

Our statistical method is determined by the nature of our dependent variable, *innovative performance* and by the fact that we use an unbalanced panel dataset. The underlying dependent variable can take values from 0 to 1, as the share of new to the market products in sales is nonnegative. Given the left and right censoring in the dependent variable, the Tobit model, also called a censored regression model, is applicable. Since the panel data is highly unbalanced (as only 25% of the LMT SMEs are observed for two years or more), a fixed-effects model is not preferable. In these circumstances we apply a Tobit analysis, which is also assumed to allow for unobserved firm heterogeneity.

4. Results

Table 1 indicates that the average annual internal R&D intensity is 0.60%. Additionally, 7.2% of the SMEs' sales refer to products that were introduced to new markets. The average firm in our sample consists of 26 employees and on average 14% of its workforce possesses university degrees. Following the standard definition used by the European Commission, all firms of the sample can be considered SMEs as they have less than 250 employees, their turnovers do not exceed EUR 50 million and their assets are valued at under EUR 43 million. Additionally, in accordance to previous studies (e.g., Nieto and Santamaria, 2007), no distinction was made between innovating and non-innovating firms, since such a distinction could give rise to a biased result.

Table 1. Descriptive statistics and pairwise correlations

	Mean	S.D.	1	2	3	4	5	6	7	8	9
1 Innovative performance *	0.072	0.160	1								
2 Innovative performance	0.085	0.216	0.575								
3 Technological capability	0.006	0.013	0.273	0.183							
4 Marketing capability	0.009	0.019	0.248	0.147	0.083						
5 External market knowledge	0.858	0.349	0.127	0.079	0.077	0.052					
6 External technological knowledge	1.439	0.845	0.169	0.085	0.157	0.207	0.400				
7 Human capital	0.143	0.227	0.197	0.274	0.243	0.375	0.050	0.232			
8 Training	0.002	0.005	0.126	0.051	0.069	0.170	0.125	0.145	0.189		
9 Firm size	2.693	1.112	0.004	-0.100	-0.044	-0.210	0.147	0.138	-0.357	-0.053	
10 Purchased R&D-related intensity	0.023	0.071	-0.004	-0.022	0.011	-0.063	0.050	0.046	-0.048	0.018	0.008

Notes: The descriptive statistics are sample means for the years 2000-2003. The number of observations is 250. All time-variant explanatory variables are in t-1. Absolute values of the correlation coefficient of 0.138 or higher are significant at the 5% significance level.

Table 2. Tobit regression results for external market, and external technological knowledge and LMT SME's innovation performance

	Model I	**Model II**	**Model III**
Intercept	-0.217***	-0.312***	-0.450***
	(0.067)	(0.073)	(0.094)
Innovative performance lagged	0.497***	0.5000***	0.437***
	(0.077)	(0.650)	(0.063)
Human capital	0.089	-0.035	-0.087
	(0.097)	(0.0853)	(0.086)
Training	3.581	3.145	2.889
	(2.926)	(2.753)	(2.683)
Firm size	0.310*	0.028*	0.025*
	(0.018)	(0.015)	(0.014)
Purchased R&D-related intensity	0.208	0.098	0.026
	(0.210)	(0.196)	(0.190)
Technological capability		3.528***	8.725***
		(1.070)	(2.807)
Marketing capability		2.103**	13.533***
		(0.836)	(3.998)
External market knowledge		0.101*	0.236**
		(0.056)	(0.086)
External technological knowledge		0.007	0.028
		(0.019)	(0.213)
Interactions terms			
Market knowledge x marketing capability			-2.846**
			(1.489)
Technological knowledge x technological capability			-11.758***
			(3.996)
Log Likelihood	-29.696	-18.758	-7.837
LR test (II vs. I; III vs. II)		21.88***	21.84***
Sigma	0.190(0.02)	0.176(0.02)	0.147(0.02)
Left-censored obs.	158	158	158
Right-censored obs.	3	3	3

Notes: Standard errors in parenthesis, *p < 0.1, **p < 0.05, ***p < 0.01. All samples are estimated on a sample of 250 observations for 142 LMT SMEs. All models include 3 time dummies and 9 industry dummies.

Model (I) contains regression results incorporating the control variables,

manufacturing sector and year dummies only. Results show that *innovative performance* ($p < 0.01$) and firm *size* ($p < 0.10$) have a significant and positive effect on innovative performance. Regarding the industries dummies, the industry effects together are jointly significant ($p < 0.10$). Additionally results show a negative significance for Publishing and Printing ($p < 0.05$), Wood and Products of Woods ($p < 0.10$) compared to the reference sector Food and Beverages. Firms from these sectors seem to innovate less. Whereas, for Rubber and Plastic Products, Machinery and Equipment and Fabricated Metal Products ($p < 0.05$), show a positive significance compared to the reference sector.

Model (II) shows regressions results including technological and marketing capabilities, as well as external sources of business and technological knowledge. Control variables at firm level, manufacturing sector and year dummies were included. Results show significant and positive effects on the innovative performance for *technological capability* ($p < 0.01$), *marketing capability* ($p < 0.05$) and *external business knowledge* ($p < 0.10$). The coefficient for *external technological knowledge* and *purchased R&D-related intensity* are statistically not significant. These results support the proposed hypothesis 1) confirming the overall positive contribution of external market knowledge sourcing to firm's innovative performance. These results, contrary to expectations, do not support the proposed hypothesis 2) with regard to the impact of external technology sourcing on LMT SME's innovative performance.

In *Model (III)*, the coefficient for the interaction term *external technical knowledge x technological capability* is negative and statistically significant ($p < 0.01$) whereas for *external business knowledge x marketing capability* is negative and statistically significant ($p < 0.05$). The coefficients for the variables *technological capability*, *marketing capability*, *purchased R&D-related intensity* and *external market knowledge* retain their signs and significance, when the interaction terms are added. These results support the proposed hypothesis 3) confirming that for LMT SMEs external (technological) knowledge sourcing substitutes or compensates for the low in-house R&D and technological capability. These results, however, do not support the proposed hypothesis 4) with regard to the complementarity between marketing capability and external sources of market knowledge.

Table 3 is used for robustness check whether the two types customers and competitors, and the two types universities and suppliers can be aggregated into market and technological knowledge source groups. Table 3 shows significant and positive effects on innovative performance for technological and marketing internal capabilities. We observe that customers and competitors (both sources of market knowledge) have different effects on LMT SME's innovative performance. While the statistical significance of market knowledge inputs from customers is apparent, market knowledge inputs from competitors is statistically not significant. These results suggest that market knowledge for innovation is primarily customer-driven. The knowledge inputs from universities and suppliers (both sources of technological knowledge) appear not to have a statistical significant effect. The coefficient for the interaction term *customers x marketing capability* is statistically not significant, whereas for *competitors x marketing capability* is negative and statistically significant. The coefficients for both interaction terms *universities x technological capability* and *suppliers x technological capability* are statistically not significant. Likelihood ratio tests for Model II is 2.86, and for Model III is 1.28, respectively. This suggests that the aggregation as done in Table 3 is warranted.

Table 3. Tobit regression results for customers, competitors, universities, and suppliers and LMT SME's innovation performance

	Model I	**Model II**	**Model III**
Intercept	-0.217***	-0.278***	-0.379***
	(0.067)	(0.075)	(0.091)
Innovative performance lagged	0.497***	0.489***	0.428***
	(0.077)	(0.640)	(0.061)
Human capital	0.089	-0.039	-0.082
	(0.097)	(0.089)	(0.083)
Training	3.581	3.251	2.721
	(2.926)	(2.618)	(2.539)
Firm size	0.310*	0.029*	0.023*
	(0.018)	(0.016)	(0.015)
Purchased R&D-related intensity	0.208	0.089	0.024
	(0.210)	(0.189)	(0.193)
Technological capability		4.748***	7.525***
		(1.241)	(2.683)
Marketing capability		1.773*	11.523***
		(0.933)	(2.998)
Customers		0.132**	0.089*
		(0.064)	(0.065)
Competitors		-0.066	-0.079
		(0.088)	(0.221)
Universities		-0.046	-0.031
		(0.113)	(0.221)
Suppliers		0.198*	0.252
		(0.184)	(0.388)
Interactions terms			
Customers x marketing capability			-3.460
			(5.094)
Competitors x marketing capability			-13.436***
			(3.962)
Universities x technological capability			-1.058
			(2.086)
Suppliers x technological capability			17.045
			(11.90)
Log Likelihood	-29.696	-17.327	-7.196
LR test (II vs. I; III vs. II)		25.57***	20.26***
Sigma	0.190(0.02)	0.168(0.08)	0.143(0.01)
Left-censored obs.	158	158	158
Right-censored obs.	3	3	3

Notes: Standard errors in parenthesis, *p < 0.1, **p < 0.05, ***p < 0.01. All samples are estimated on a sample of 250 observations for 142 LMT SMEs. All models include 3 time dummies and 9 industry dummies.

5. Conclusions and further research

This study sheds light on the possible complementarity between internal capabilities and external knowledge sourcing defined by the theory of open innovation. To test our hypotheses, we mainly focused on a short panel of 142 Dutch LMT SMEs in the period 2000-2003. In the Netherlands, LMT industries continue to play a key role in the economic development in terms of both employment and value added (OECD, 2013). This underscores the major importance of this sector and makes the Netherlands a very suitable research setting to be able to pick up on the kind of trends we wish to capture.

Our results reveal the importance of technological and marketing capabilities for product innovation and may confirm the view that product innovation in LMT industries is not solely about technology, but is rather a market-driven process. As noted by prior studies (e.g., Hirsch-Kreinsen, 2008) LMT firms may engage in product innovations that are architectural in nature. Architectural innovation is based on the rearrangement of the product's components, aimed not only to meet special customer requirements but also to open up new market segments. Then, this specific type of innovation would involve marketing capabilities for the identification of customer needs and technological capabilities for the functional and technical upgrading of the product's architecture In the case of LMT SMEs, their small-scale R&D may indicate that the nature of internal R&D is largely adaptive and often carried out on an occasional basis. LMT SMEs may initiate occasional R&D when there is a direct demand, primarily aimed at adjusting product specifications to suit niche markets. Product components, for instance, are often improved incrementally with regard to materials, function and quality to accommodate changing customer demands. In the context of LMT SMEs, we suggest that product innovations largely depend upon adaptive technological capability.

With regard to external knowledge sourcing, our findings suggest that externally generated (market) knowledge plays an important role for the development of highly custom-designed products. LMT SMEs provide up-to-date customized product innovations, which are usually developed in close partnership with customers. As the research findings show, externally generated technological knowledge plays a marginal role, which underscores the strong market orientation of product innovation. We find that technological capability and external technology knowledge sourcing are substitutes, leading to a negative relationship between the two. One potential interpretation is that, R&D-related technological capability and external technology knowledge sourcing provides a LMT SME with similar type of knowledge. More specifically, our interpretation is that a LMT SME's efforts on R&D and external technology knowledge sourcing both put emphasis on component-type knowledge. LMT product innovations can be triggered by a change in an individual component (such as size or function) that creates new interactions or new linkages with other components within the product (e.g., Henderson and Clark, 1990; Hirsch-Kreinsen, 2008). Thus, for LMT SMEs component-type knowledge may be generated either by internal R&D or by external technology sourcing.

We find a negative interplay between marketing capability and external market knowledge sourcing. We interpret these results as evidence of liability of smallness and attention-allocation problems. While the possession of market knowledge makes the conditions for superior performance possible, marketing capabilities enable firms to deploy that knowledge (Vorhies et al., 2011). Compared to larger firms, LMT SMEs generally face constraints associated with the shortage of financial, management, and marketing resources. As a consequence, LMT SMEs may fail to integrate new externally generated market knowledge into their existing (market) knowledge base to develop new products. With regard to control variables, most

results are intuitive and in alignment with previous studies, for example, firm size has a positive association with innovative intensity (e.g., Archibugi et al., 1995).

Our results have some relevance for innovation policy. Our findings suggest that, in the case of LMT SMEs, technological and marketing capabilities are particularly effective to increased innovative performance. Policy initiatives should thus attempt to support R&D activities within LMT SMEs. Alternatively, initiatives can include the establishment of specific types of technology intermediaries that help SMEs in traditional sectors to scan the market for emergent technologies, as well as to perform complementary R&D activities if needed. Policies initiatives should also attempt to extend collaboration (open innovation) between LMT SMEs and customers, as well as, advisory and assistance services that help SMEs to capture, analyze, interpret and integrate external market knowledge effectively.

Given the exploratory nature of this study and the relative small sample size, results should be regarded with some caution. The preliminary nature of this empirical study points the way towards further research. Future studies may focus on the integration of external market knowledge in product innovation, in the case of LMT SMEs. Additionally, when LMT SMEs carry out their innovative activities, they often do so without formalized procedures. Future research thus may include these often informal and small-scale innovative activities.

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