Article

The effects of R&D intensity and internationalization on the performance of non-high-tech SMEs

Lucas WA Booltink
Bursar Society B.V., The Netherlands

Ayse Saka-Helmhout
Radboud University, The Netherlands

Abstract
Research and Development (R&D) investment is seen as a fundamental driver of high-tech small and medium-sized (SME) firm performance. However, the same driver may be constraining growth among non-high-tech SMEs as it increases the level of risk faced by such firms. We challenge this argument by examining the relationship between R&D intensity and performance among non-high-tech SMEs. While the size of R&D investments is, by definition, limited in the non-high-tech sector, our study shows that such investments are important for non-high-tech firms. There is, however, an inverted U-shaped relationship between R&D intensity and performance among non-high-tech SMEs. Furthermore, increased internationalization leads non-high-tech SMEs to exploit their R&D investment more effectively to enhance firm performance, provided that R&D investment levels exceed a critical threshold.

Introduction

It is acknowledged that small to medium-sized enterprises (SMEs) play a critical role in economic and employment growth in developed countries (European Commission, 2015). However, the focus of both policy makers and SME scholars has been on the innovation and economic performance of high-tech SMEs and the role that technology plays in facilitating this process (Hoffman

Corresponding author:
Ayse Saka-Helmhout, Nijmegen School of Management, Radboud University, P.O. Box 9108, 6500 HK Nijmegen, The Netherlands.
Email: a.saka-helmhout@fm.ru.nl

et al., 1998; Jones, 1999; Nunes et al., 2012; Von Tunzelmann and Acha, 2005). High-tech SMEs are seen as more capable than non-high-tech SMEs of succeeding in highly competitive environments owing to their adaptability, innovativeness and quick response times (Del Monte and Papagni, 2003; Lee, 2009).

Among the fundamental drivers of high-tech SME performance, SME scholars see research and development (R&D) investment as crucial (Ren et al., 2015; Stam and Wennberg, 2009). R&D investments enable SMEs to create new products, develop efficient processes and stimulate strategic cooperation (De Jong and Freel, 2010). There is the contention that small firms that thrive through R&D-driven release of innovative new products will increase their chances of survival and growth (Laforet, 2009). Interestingly, this very same driver of SME performance is seen as restricting growth in non-high-tech SMEs (Müller and Zimmermann, 2009; Nunes et al., 2012), which mainly comprise 'mature' industries such as food processing, furniture and publishing and print (Hirsch-Kreinsen et al., 2006; OECD, 2015). For instance, Nunes et al. (2012) argue that there is a negative linear relationship between R&D intensity and growth in non-high-tech SMEs, because R&D investment can increase the level of risk faced by SMEs as it adds to the challenge of obtaining finances and managing R&D investment efficiently. It is also argued that SMEs tend not to have the means to invest in R&D activities (Avermaete et al., 2003) or cannot always transform R&D into effective innovation (Laforet, 2009). If R&D investments are made in sectors that have limited technological intensity, these investments can easily be copied by competitors (Del Monte and Papagni, 2003; Lee, 2009). There are also suggestions that non-high-tech SMEs opt to substitute R&D by innovation management practices such as human resource management (HRM), teamwork and cooperation with external partners. They may also focus, to a greater extent, on customer- and market-driven innovations (Som, 2012), which demand less investment and bear less uncertainty (e.g. Rammer et al., 2009). As these studies show, R&D intensity in non-high-tech SMEs is seen to impair firm performance (De Jong and Marsili, 2006; Del Monte and Papagni, 2003).

However, there is evidence to suggest that non-high-tech SMEs invest in R&D to help them move away from the 'commodity trap', where products can only compete on price (Von Tunzelmann and Acha, 2005). The need for non-high-tech SMEs to upgrade their capabilities tends to be driven by globalization processes through rapid advancements in technology and easy product imitation (Evers, 2011). Perhaps not surprisingly, labour-intensive non-high-tech firms are gradually being replaced by non-high-tech firms emphasizing high-value added niches with investments in highly skilled labour, advanced machinery and R&D (Hansen and Winther, 2014). Hence, it is crucial for non-high-tech SMEs to develop capabilities and competencies for competitive advantage (Love and Roper, 2015). This can include product development via customer involvement, informal business ties, acquisition of knowledge capability and R&D collaborations (Whittaker, 2016). For instance, Grimpe and Sofka (2009) demonstrate that low-tech innovativeness is stimulated by the combination of R&D investments and collaboration with customers in domestic and international markets. Non-high-tech SMEs build, leverage and mobilize their networks to acquire domestic and foreign market knowledge, know-how, technological capabilities, finance and resources that they do not possess. It has also been shown that non-high-tech SMEs have technology strategies that enable them to access external knowledge. For instance, their presence in clusters, including technology centres or participation in international R&D networks, can facilitate the upgrading of firm capabilities (Hervas-Oliver et al., 2012b; McEvily and Zaheer, 1999; Teixeira et al., 2013). Consequently, we see it as significant to address the role of R&D intensity in the performance of non-high-tech SMEs and to assess the extent to which this relationship is influenced by the international activities of non-high-tech SMEs.

Our contributions to the SME performance literature are twofold. First, we clarify the role of R&D intensity in the performance of non-high-tech SMEs. We demonstrate that R&D investment

has both a positive and a negative effect on firm performance in non-high-tech SMEs. The U-shape relationship between R&D investment and SME performance challenges the argument that R&D investments restrict growth in non-high-tech SMEs owing to increased risk and the imitability of the technological investment (Del Monte and Papagni, 2003; Lee, 2009; Nunes et al., 2012). While the size of R&D investments is, by definition, limited in the non-high-tech sector, our results show that such investments are still important for non-high-tech firms. We demonstrate that R&D investment is conducive to the performance of these SMEs until an optimum level is reached, after which there are diminishing returns.

Second, we emphasize the significance of international activities in accentuating the implications of R&D investment for performance in non-high-tech SMEs. The focus of analyses of non-high-tech SMEs has been on innovation via alternative means to R&D investment, such as teamwork and HRM practices (Rammer et al., 2009). As the competitive advantage of non-high-tech SMEs is rarely linked to technological developments, the orientation of these firms to access R&D knowledge internationally to achieve market success remains under-researched (exceptions include Evers, 2011; Hervas-Oliver et al., 2012a; Teixeira et al., 2013). We demonstrate that a non-high-tech SME's degree of internationalization (DOI) can enable it to better exploit R&D investments for higher performance. Non-high-tech SMEs can differentiate products through the creation of unique, intangible knowledge-intensive offerings that are facilitated by technological developments in international markets (Evers, 2011).

Theory and hypotheses

R&D intensity and non-high-tech SME performance

There is a plethora of studies in the SME performance literature that demonstrate the positive influence of R&D investment on the productivity and growth of SMEs. For instance, R&D expenditure can contribute to increased growth of SMEs, given their capacity to diversify their activities (Rogers, 2004). They can increase firm capacity to absorb knowledge created from the relationships forged with external organizations and the capacity to use that knowledge to increase firm performance (Cohen and Levinthal, 1990). However, these investments are shown to be more effective in achieving productivity gains in high-tech sectors than in non-high-tech sectors (Ortega-Argilés et al., 2010). The over-concentration of SME research on technology-intensive and new technology-based sectors is seen as justified given the employment potential (Colombo and Grilli, 2007; Hoffman et al., 1998; Santarelli and Vivarelli, 2007), as well as the greater capacity for internal organization, strategic flexibility and the establishment of strategic cooperation networks with shared resources that high-tech SMEs possess in comparison to non-high-tech SMEs (Eisingerich et al., 2009; Kindström and Kowalkowski, 2009; Nunes et al., 2012). R&D expenditure helps reduce the risk associated with SME growth as these firms engage in strategic networks that complement their knowledge (Rickne, 2006). For instance, Raymond and St-Pierre (2010) argue SMEs innovate in product development and fabrication by adopting advanced manufacturing technologies in order to reduce their operational costs, increase their productivity and the quality of their products and services. Furthermore, investment in R&D can facilitate the absorption and utilization of knowledge obtained from external relationships to increase firm performance (Gilsing et al., 2008).

To our surprise, the positive effect of R&D investment on performance is not confirmed in non-high-tech SMEs (Del Monte and Papagni, 2003; Lee, 2009). In fact, the SME performance literature shows R&D investment to restrict growth in non-high-tech SMEs. It is argued that innovations resulting from R&D investments of non-high-tech SMEs are relatively easily imitable by rivals

and serve as ineffective barriers to market entry (Nunes et al., 2012). Non-high-tech SMEs find investments in R&D costly and risky (Rammer et al., 2009). R&D projects demand financial commitment, exert pressure on profits and imply risk on firm survival. Information asymmetries, high management costs and challenges in financing continuous R&D activities can lead to non-high-tech SMEs refraining from or investing occasionally in such activities (Hall, 2002). Alternatively, they can drive such SMEs to emphasize the management of innovation processes and network competences (Ritter and Gemünden, 2004).

The extant literature lacks explorations of the extent to which R&D investment matters for the growth of non-high-tech SMEs. It assumes that there exists a linear and boundless relationship between R&D investment and SME performance. In other words, as SMEs make R&D investments, they increase their costs and exposure to risk, and diminish the possibility of diversifying activities. This can mean limited impact of R&D on growth of non-high-tech SMEs (Nunes et al., 2012). Non-high-tech SME growth tends to be associated more with organizational and market innovations than with the product and production process (Eisingerich et al., 2009; Lee and Lim, 2009). We challenge this view to suggest that R&D intensity can have positive implications up to a point for non-high-tech SMEs. We elaborate upon our reasoning below.

Hypotheses

The SME performance literature offers theoretical and empirical support for a negative relationship between R&D investment and non-high-tech SME performance. However, the arguments rest on the assumption that there exists a linear relationship. For instance, Nunes et al. (2012) find a negative linear relationship between R&D intensity and growth in non-high-tech SMEs. We challenge this assumption to propose that there may be a saturation point above which an increase in R&D investment does not add to SME capability to perform well. We focus on two rationales supporting the possibility that too much R&D investment may be an impediment to SME performance. Drawing on the resource-based view (RBV), we argue that non-high-tech SMEs investing in R&D may be subject to time compression diseconomies or exhibit diminishing returns (Dierickx and Cool, 1989). This implies that the more non-high-tech SMEs extend their stock of R&D know-how, the more likely they are to accumulate R&D marginal know-how. The contention in RBV is that competitive advantage arises from technological and organizational capabilities (Harrison, 2003; Teece et al., 1997). In other words, competitive advantage and performance results are a consequence of firm-specific resources and capabilities (Barney, 1986). Hence, non-high-tech SMEs seek complementary assets to enhance learning capabilities and to boost innovation performance and growth (e.g. Wu, 2012). However, time and resource constraints in developing these capabilities internally would increase a firm's needs to collaborate to access complementary technologies and a wider scale and scope of assets (Teece, 1992). Cooperation with other firms and knowledge centres would allow small firms to complement their resource endowments, and thus overcome, at least partially, small-size related burdens (Nieto and Santamaría, 2010). However, not all collaborations will make an equal contribution to developing capabilities, and firms may not be able to effectively select and manage collaborations. Collaborations require time, energy and attention to establish and maintain, and because these are limited, they involve costs. There are inherent limitations in human capital and the associated acquisition of tangible and intangible resources as the number of collaborations increase. The resource investments and collaborations are likely to become progressively less efficient as the commitments necessary to acquire new knowledge increase with the scope of search efforts (Wales et al., 2013). In other words, the effort associated with establishing

and maintaining collaborations can result in diminishing or negative returns to capability development (McFadyen and Cannella, 2004). Furthermore, as the scope of the search efforts increases, SMEs are more likely to encounter knowledge sources with which they do not share commonality, leading to an increase in assimilation costs (Wales et al., 2013). Consequently, we expect R&D investments to initially enhance non-high-tech SME performance with diminishing returns up to a point (Erden et al., 2014). Beyond this threshold, a greater share of R&D investment is expected to reduce a non-high-tech SME's performance. Hence, we propose the following:

> *Hypothesis 1*. The relationship between R&D intensity and non-high-tech SME performance is curvilinear (inverted U-shaped).

The moderating role of the DOI

Many SMEs rely on network linkages such as R&D cooperation and research joint ventures to access information and resources not available internally to gain a competitive advantage having a greater ability to rely on external networks (Nooteboom, 1994) and to create innovative alliances (Van Dijk et al., 1997). These networks may either be built, initially, domestically and, subsequently, extended to foreign markets (Johanson and Vahlne, 1990) or established in foreign markets in the early years of firm inception (Oviatt and McDougall, 1994). There is abundant evidence of the role of networks and the benefits accrued from internationalization among high-tech SMEs (Crick and Spence, 2005; Filatotchev et al., 2009; Ojala, 2009). What is less clear in the literature is the effect international R&D networks, in particular, have on non-high-tech SMEs. This is problematic as engagement in international R&D networks can have positive implications for SME performance (Fryges, 2009; Pangarkar, 2008). Non-high-tech SMEs can fill their technological gap through collaborations with external partners, such as technology intermediaries, to attain a competitive advantage Hervas-Oliver et al. (2012a); Spithoven and Knockaert (2012).

International business studies demonstrate that geographic expansion is one of the most important paths for firm growth (Lu and Beamish, 2006). It is an important growth strategy, in particular, for SMEs that seek to leverage core competencies in different markets (Zahra et al., 2000). In the light of growing connectedness and exchange between different actors in an innovation system, non-high-tech SMEs face the increasing necessity of assessing and adopting external knowledge (Som et al., 2015). These SMEs also rely on network linkages to mobilize, accumulate and develop resource stocks for a competitive advantage participating in a learning process with co-located firms and supporting organizations in the same regional area or via international networks to improve their knowledge base (Teixeira et al., 2013; Tsang, 2002). As organizational learning theory suggests, this learning can stimulate and even intensify product innovation (George et al., 2005; Zahra and George, 2002). It can also help SMEs overcome resource limitations that frequently constrain their growth (Zhou et al., 2007). As the international scope broadens, firms are provided with more opportunities to leverage their strategic resources while diversifying market risks (Barkema and Vermeulen, 1998). Given the distributed nature of knowledge base in non-high-tech SMEs,[1] the ability to manage and effectively coordinate network relations across company borders is a central precondition for successful non-high-tech innovation strategies (Hirsch-Kreinsen, 2008). Hence, we argue that there may be greater performance implications of R&D investments for non-high-tech SMEs that are looking to augment these investments through international collaborations.

Non-high-tech SMEs may seek support from technology intermediaries that can help 'build the ability to scan the market for technology and to absorb the knowledge and technology acquired' (Spithoven and Knockaert, 2012: 379). They can also participate in formal international R&D networks to accelerate their pace of innovation, stay abreast of technological and market trends and develop new products (Teixeira et al., 2013). For instance, non-high-tech SMEs have been shown to benefit from access to technology centres[2] to complement their limited R&D capabilities in non-high-tech clusters (Hervas-Oliver et al., 2012b). Similarly, Evers (2011) demonstrates that proactive engagement in R&D activities adds value to the products of newly internationalizing non-high-tech SMEs. This is owing to the need to compete on the basis of differentiated products that offer value through innovative technology and product design despite the non-high-tech nature of the business. Being hands-on in R&D on food quality and new product development enables internationalizing SMEs to address the changing and evolving nature of the seafood processing market. As these studies illustrate, internationalization allows SMEs to better exploit and appropriate benefits that accrue from technological investment (Lu and Beamish, 2006; Musteen et al., 2010; Pangarkar, 2008). Rather than serving as a substitute for R&D intensity, DOI can complement the influence of R&D intensity on the performance of non-high-tech SMEs. Consequently, we propose the following moderating role for DOI.

> *Hypothesis 2.* A non-high-tech SME's DOI moderates the relationship between R&D intensity and firm performance in such a way that high levels of DOI increase the performance gains attributable to R&D intensity.

Research method

Sample

We used data from the 2013 Flash Eurobarometer Survey on Investing in Intangibles: Economic Assets and Innovation Drivers for Growth (European Commission, 2013a) to test our hypotheses. This survey is designed to probe investment in a range of intangible assets, including R&D investment, of European firms. The Eurobarometer data were collected by Taylor Nelson Sofres (TNS) Opinion & Social Network in all 28 member states of the European Union at the request of the European Commission. A computer-assisted telephone interviewing (CATI) technique was used to gather survey data. Respondents were called on both fixed lines and mobile phones via random digit dialling (RDD) of existing seed numbers. These seed numbers provided a working block of telephone numbers, which were subsequently stratified by the Nomenclature of Territorial Units for Statistics (NUTS2) regions and urbanization levels. For example, in Germany the seed numbers are stratified by 39 Regierungsbezirke and the urbanization levels across these government regions. Thus, we could employ a multi-stage random probability sampling design. All variables pertain to 2011 with the exception of the dependent variable of firm performance, which relates to 2013.

Our sample consists of SMEs operating in areas as wide as manufacturing (42.4%) and services (57.6%). Manufacturing firms operate in industries such as machining, outerwear, metal structures and furniture. Service firms operate in industries such as wholesale and retail, transportation and storage, and food services and accommodation. Although SMEs from all 28 European Union (EU) member countries are represented in the sample, the national sample sizes vary from 11 (Cyprus) to 61 (Spain). The final sample for the analysis totals 947 firms. The sample is characterized by SMEs that generate, on average, 48.7% of their total turnover from outside their home country. From the turnover generated in 2011, SMEs invested, on average, 2.8% in R&D and 3.4% in marketing.

Variables

Dependent variable. To assess firm performance, we use a devised measure which captures the benefits that accrue to the firm as a result of investment in intangible assets using a 2-year time lag. Several scholars contend that the effect of investment in intangibles on firm performance can only be observed after a certain time lag (Falk, 2012; Fryxel, 1990). Exceptions to this commonly accepted view include Huang and Liu (2005) who find a significant linear and quadratic relationship between R&D investment and firm profit as an indicator of firm performance in the focal investment year. We align ourselves with Falk (2012) to examine the impact of R&D investment on firm performance using a two-year time-lagged performance measure relative to the R&D investment's year.

In accordance with Das et al. (2009) and Shankar (2012), firm performance is captured by four survey-based ordinal indicators – turnover, profit margin, market share and overall value of the company. In accordance with aspiration-driven decision-making by organizations (e.g. Greve, 1998), all four indicators are considered to reflect short-term changes in firm performance (Ho et al., 2005). We execute a categorical principal component analysis (CATPCA) – a nonlinear equivalent of principal component analysis (PCA) – to create a Likert scale from a series of Likert-type items in the survey. This enables us to examine the validity of constructing 'firm performance' from four Likert-type items. The CATPCA resulted in values that were well above the critical thresholds: (1) percentage of variance of 69, (2) eigenvalue of 2.78 and (3) four component loadings of >0.80 (Hair et al., 2010). The scale proved reliable with a Cronbach's α of 0.85 with item-to-total correlations being all greater than 0.65 and inter-item correlations all exceeding 0.50 (Robinson et al., 1991).

Independent variable. To assess R&D intensity, we use a devised measure that captures the firm's ratio of R&D investment to its total turnover (see Titus et al., 2017; Tyler and Caner, 2016). This measure is reflected in two ordinal variables – in particular, internally sourced R&D investment and externally sourced R&D investment. We compute class means[3] for all seven categories to operationalize R&D intensity. We average internally resourced R&D investment and externally resourced R&D investment only for cases that exhibit valid values for both constituting variables. In line with the widely accepted method in strategic management (Haans et al., 2016), we also include a linear and a squared term to allow for an inverted U-shaped impact of R&D intensity on firm performance.

Moderating variable. To assess DOI, we use a devised measure that captures the firm's ratio of foreign sales to total sales (see Cerrato et al., 2016; Chen and Tan, 2012). This measure is calculated as the percentage of the company's turnover in 2011 generated from sales in countries outside their home country. It is reflected in a ratio variable that ranges from 10% to 100%.

Control variables. Previous research has identified several variables that might potentially affect firm performance and, hence, need to be systematically controlled for. First, several works report industry-related variables to affect performance (Hawawini et al., 2003; Li, 2005; Roquebert et al., 1996). Therefore, we control for the finding that R&D investment in a post-economic crisis period can create more value for firms in the services sector. We incorporate an industry-related dummy variable that distinguishes firms operating in the services category from those operating in the manufacturing category. Second, business group membership can affect performance (e.g. Lu and Yao, 2006). About 28.1% of our SMEs belong to a business group, and 71.9% are described as standalone companies. We control for business group membership by using a dummy variable that

discriminates between business group companies and standalone companies. Third, firm age is often linked to firm performance (Qian et al., 2008). About 12.1% of our sampled SMEs are established between 2007 and 2012, whereas the remaining 87.9% are established prior to 2007. We, therefore, control for firm age by incorporating a dummy variable that distinguishes SMEs established prior to 1 January 2007 from those that are founded between 1 January 2007 and 1 January 2012. This particular time period corresponds to the distinction made by the European Commission (2011) between young and old firms.[4] Fourth, firm size, as represented by the number of employees, is found to positively affect performance (e.g. Goerzen and Beamish, 2003; Ho et al., 2005; Naik, 2014). We control for firm size by incorporating the number of full-time equivalents that a firm provides for. Fifth, marketing investments in brand image and reputation can affect performance as it shapes a firm's positioning in various stakeholder groups (Brown et al., 2006). We control for marketing intensity by incorporating a firm's ratio of marketing investment in brand image and reputation to its total turnover. In addition, we include both a linear and a squared term to allow for an inverted U-shaped impact of marketing intensity on firm performance (Peng et al., 2014). Finally, we control for different propensities to innovate in the EU-28 by adding country dummies.

Analysis

We use a hierarchical multiple regression to test our hypotheses, which is a fitting model owing to (1) our measure of metric predictor variables using different participants, (2) the interval scale used to measure our dependent variable and (3) the need to incorporate moderator effects, polynomials and relevant control variables (Hair et al., 2010). In particular, we apply the following specification of a regression model:

$$Y = \begin{pmatrix} b0 + b1 SER_i + b2 BGM_i + b3 YNG_i + b4 SIZE_i + b5 MRK_i + b6 MRK^2_i \\ + b7 DOI_i + b8 R\&D_i + b9 R\&D^2_i + b10 R\&D_i DOI_i + \\ b11 R\&D^2_i DOI_i + b12 CDAUS_i + \ldots + b37 CDSLO_i \end{pmatrix} + e_i,$$

where *Y* represents firm performance, and *R&D* and *DOI* are R&D intensity and DOI, respectively. The remaining variables – services (*SER*), business group membership (*BGM*), young age (*YNG*), firm size (*SIZE*), marketing intensity (*MRK*) and country dummies (CD) – represent the control variables.

To correct for the skewness of the data, we apply log-transformations to *firm size, marketing intensity* and *R&D intensity*. Specifically, we add a constant (+1) to the log-transformations to incorporate their zero values in the analysis. To eliminate multicollinearity between linear and quadratic terms, as well as between the interaction terms and their components, we mean-centre the higher order and interaction terms prior to computation (Afshartous and Preston, 2011). We find that all regression models including the model that incorporated polynomial and moderator terms exhibit variance inflation factors (VIFs) < 5. Thus, multicollinearity is perceived not to be an issue in our model.

Results

Means, standard deviations and correlations are presented in Table 1.

As can be observed, correlations among the predictor variables take on low-to-moderate values. Since no correlations exceeding 0.70 are observed, the VIF findings of the absence of multicollinearity are confirmed.

Table 1. Summary statistics and correlations.

	1	2	3	4	5	6	7	8
1. Firm performance	1							
2. Services	0.040	1						
3. BGM	0.053	−0.057	1					
4. Young age	0.026	0.090	−0.002	1				
5. Firm size[a]	0.045	−0.329	0.250	−0.179	1			
6. Marketing intensity[a,b]	0.230	0.140	−0.025	0.064	−0.067	1		
7. DOI[b]	−0.048	−0.092	0.115	0.056	0.037	−0.081	1	
8. R&D intensity[a,b]	0.239	−0.058	−0.001	0.017	0.013	0.437	0.025	1
Mean	1.44	0.58	0.28	0.12	1.27	0.00	0.00	0.00
SD	0.810	0.495	0.450	0.327	0.591	0.407	31.949	0.399
Min	0.00	0	0	0	0.00	−0.38	−38.72	−0.32
Max	3.00	1	1	1	2.39	1.50	51.28	1.56
N	947	947	947	947	947	947	947	947

BGM: business group membership; DOI: degree of internationalization; R&D: Research and Development; SD: standard deviation.
[a]This variable is log-transformed.
[b]This variable is centred.
Country dummies are not included.
Correlations > |0.064| are significant at 5%.

The results of the multiple regression analyses are provided in Table 2, and the corresponding graphs depicting the effects of R&D intensity and DOI on the performance of non-high-tech SMEs are shown in Figures 1 and 2. Model 1 incorporates the control variables and represents our baseline model. Model 2 adds the linear predictor variables to assess the main effects. Model 3 includes the quadratic R&D intensity term. Furthermore, in Models 4 and 5, we add linear and quadratic interaction terms of DOI. Model 5 represents the fully specified model, incorporating all controls, (non-)linear predictor variables and the interaction terms.

All models are statistically significant ($p < 0.001$) and, therefore, fit the data well. Overall, Model 3 represents a significant ($p < 0.01$) improvement over Models 1 and 2. In addition, Model 4 represents a significant ($p < 0.05$) improvement over Model 3, whereas Model 5 represents a nonsignificant improvement over Model 4 ($p > 0.05$). Consequently, we rely on Model 4 to test our hypotheses.

Hypothesis 1 predicts that R&D intensity has a negative and quadratic (inverted U-shaped) impact on firm performance. As shown in Model 2, the main effect of R&D intensity in Model 2 is significant ($p < 0.001$) as are the linear and quadratic terms of R&D intensity in Models 3 and 4 ($p < 0.01$). Moreover, the linear term is uniformly positive and the quadratic term is uniformly negative. Taken together, these results provide strong empirical evidence for the hypothesized inverted U-shaped relationship between R&D intensity and firm performance (see Figure 1). Therefore, Hypothesis 1 is supported. This implies that an optimum level of R&D intensity exists for non-high-tech SMEs at 9.8%. Thus, for firms with below-optimum R&D intensity levels, there may be substantial advantages in increasing their R&D investment. Conversely, for firms with above-optimum R&D intensity levels, there may be substantial disadvantages in increasing R&D investment.

Specifically, our firm size and linear marketing intensity variables show a significant positive impact on firm performance. In contrast, quadratic marketing intensity has a significant negative impact on firm performance. The country effects indicate that SMEs from the Czech Republic,

Table 2. Multiple regression of R&D intensity and DOI on the performance of non-high-tech SMEs.

	Model 1	Model 2	Model 3	Model 4	Model 5
Intercept	1.500*** (0.155)	1.469*** (0.152)	1.516*** (0.152)	1.521*** (0.152)	1.521*** (0.152)
Services	0.010 (0.055)	0.044 (0.055)	0.065 (0.055)	0.065 (0.055)	0.065 (0.055)
BGM	0.052 (0.060)	0.060 (0.059)	0.065 (0.059)	0.066 (0.059)	0.066 (0.059)
Young age	0.049 (0.080)	0.049 (0.079)	0.063 (0.078)	0.059 (0.078)	0.060 (0.078)
Firm size	0.107* (0.051)	0.109* (0.050)	0.103* (0.050)	0.104* (0.050)	0.104* (0.050)
Marketing intensity	0.754*** (0.088)	0.573*** (0.092)	0.523*** (0.093)	0.511*** (0.093)	0.511*** (0.093)
Marketing intensity^2	−0.537*** (0.121)	−0.541*** (0.119)	−0.400** (0.126)	−0.379** (0.126)	−0.378** (0.126)
DOI		−0.001 (0.001)	−0.001 (0.001)	−0.001 (0.001)	−0.001† (0.001)
R&D intensity (H1)		0.399*** (0.070)	0.627*** (0.100)	0.620*** (0.100)	0.620*** (0.100)
R&D intensity^2 (H1)			−0.450** (0.141)	−0.456** (0.141)	−0.458** (0.141)
R&D intensity × DOI (H2)				0.004* (0.002)	0.005† (0.003)
R&D intensity^2 × DOI (H2)					−0.001 (0.004)
Country dummies	Yes	Yes	Yes	Yes	Yes
N	947	947	947	947	947
R^2	0.153	0.183	0.192	0.197	0.197
Adjusted R^2	0.122	0.151	0.160	0.164	0.163
F	4.999***	5.816***	5.994***	6.013***	5.849***
Sig F change	***	***	**	*	n.s.

DOI: degree of internationalization; R&D: Research and Development; SD: standard deviation; SME: small and medium-sized enterprise.
Significance levels: †$p < 0.1$; *$p < 0.05$; **$p < 0.01$; ***$p < 0.001$.
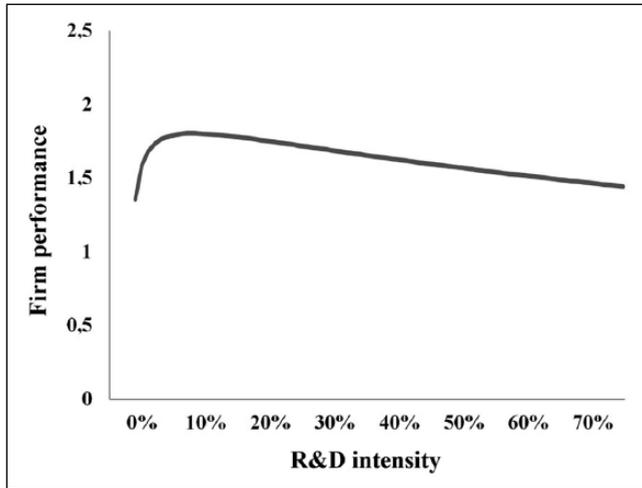
Figure 1. The effect of R&D intensity on the performance of non-high-tech SMEs.[a]
[a]Based on the regression results of Model 3 without country dummies, we derived the equation: [1.408 + 0.091(0.58) + 0.074(0.28) + 0.080(0.12) + 0.079(1.27) + 0.547(0.000) + −0.497(0.000^2) + −0.001(0.000) + 0.601(X) + −0.449(X^2)]. Subsequently, we de-centered and antilogged the X to create meaningful numerical percentages. Finally, we graphed the line for illustrative purposes.
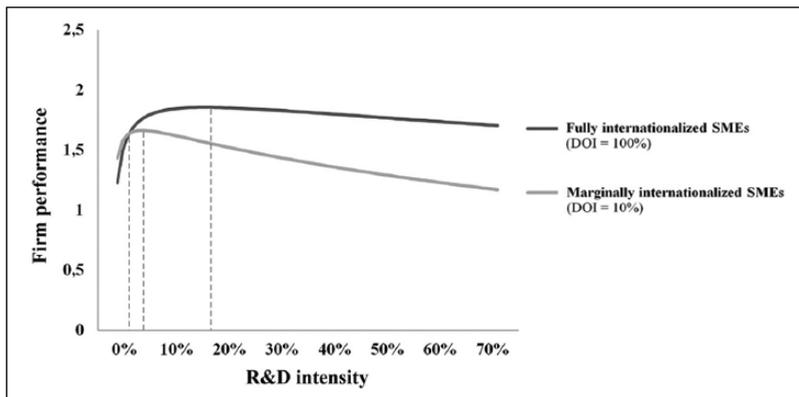
Figure 2. The effect of R&D intensity and DOI on the performance of non-high-tech SMEs.[a]
[a]Based on the regression results of Model 4 without country dummies, we derived the equation for *fully internationalized SMEs* [1.401 + 0.090(0.58) + 0.074(0.28) + 0.077(0.12) + 0.081(1.27) + 0.534(0.000) + −0.473(0.000^2) + −0.001(51.28) + 0.594(X) + −0.454(X^2) + 0.005(X) (51.28)] and for *marginally internationalized SMEs* [1.401 + 0.090(0.58) + 0.074(0.28) + 0.077(0.12) + 0.081(1.27) + 0.534(0.000) + −0.473(0.000^2) + −0.001(−38.72) + 0.594(X) + −0.454(X^2) + 0.005(X) (−38.72)]. Subsequently, we de-centered and antilogged the X to create meaningful numerical percentages. Finally, we graphed both lines for illustrative purposes.

Poland, Romania, Italy, Portugal and France show worse firm performance compared to Germany. These countries tend to exhibit less favourable structural conditions for conducting business (see the benchmarking exercise by the European Commission (2013b)).

Hypothesis 2 predicts that with increasing levels of DOI, the impact of R&D intensity on firm performance will be more positive. Higher levels of DOI will lift the entire R&D intensity curve

Table 3. NACE code demarcation of (non-)high-tech SMEs.

Category	Sector	NACE code	Description
High-tech SMEs	Manufacturing	21, 26	High-tech
		20, 27–30	Medium-high-tech
	Services	50, 51, 58–63, 64–66, 69–75, 78, 80, 84–93	Knowledge-intensive
Non-high-tech SMEs	Manufacturing	19, 22–25, 33	Medium-low-tech
		10–18, 31, 32	Low-tech
	Services	45–47, 49, 52, 53, 55, 56, 68, 77, 79, 81, 82, 94–96, 97–99	Less knowledge-intensive

Source: Eurostat (2014).
SME: small and medium-sized enterprise.

upwards. As can be observed in Model 2, the main effect of DOI on SME performance is negative and nonsignificant ($p > 0.05$). More importantly, the results of Models 4 and 5 indicate that the interaction term including linear R&D intensity is positive and significant ($p < 0.05$), whereas the interaction term including quadratic R&D intensity is nonsignificant ($p > 0.05$). This implies that increasing DOI has a positive impact on the performance gains attributable to R&D intensity for non-high-tech SMEs.

Figure 2 provides further support for Hypothesis 2. With increasing DOI, the positive impact of R&D intensity on firm performance is stronger, provided that the R&D intensity levels exceed the critical threshold of 2.1%. Below this threshold, the negative direct effect of DOI overrides the positive moderation effect. Therefore, Hypothesis 2 is partly supported. This implies that, with increasing DOI, the advantages of increasing R&D intensity are enhanced for those SMEs who exhibit R&D intensity levels that exceed 2.1%. In addition, Figure 2 shows that the optimum firm performance level of fully internationalized SMEs requires a higher level of R&D intensity than that required by marginally internationalized SMEs (18.1 vs. 5.8%, respectively).

Robustness checks

We tested our data using several alternative specifications to verify the robustness of our results. The results of these tests were largely consistent with those presented in the main analyses and provided further support for the hypotheses. First, we checked whether the regression slopes prior to, and beyond, our turning points in the R&D intensity–performance relationship conformed to the predicted slopes of the curves (see Haans et al., 2016). Specifically, our inverted U-shaped model is built on the premise that two separate linear relationships between R&D intensity and firm performance exist: (1) a positive relationship before the turning point and (2) a negative relationship after the turning point. We checked for this by splitting the data into two sets by using the empirically determined regression coefficients of our optimal U-shaped model (Model 4) to compute the exact turning points. Next, we performed regression analyses on these two separate datasets and confirmed that (1) prior to the turning point, the relationship was positive and (2) beyond the turning point, the relationship was negative. These subsample findings provide additional empirical evidence for the existence of an inverted U-shaped relationship between R&D intensity and SME performance.

Second, we controlled for the finding that high-tech SMEs obtain performance benefits from R&D investment (Nunes et al., 2012) and the synergistic combination of R&D investment and internationalization (e.g. Lu and Beamish, 2006; Musteen et al., 2010; Pangarkar, 2008). Thus, we

aimed to validate our results for all SMEs. First, we incorporated a dummy variable to distinguish high-tech SMEs from non-high-tech SMEs (e.g. Andries and Faems, 2013) by drawing on Eurostat's (2014) NACE Rev. 2 distinction between high-tech or knowledge-intensive sectors and non-high-tech or non-knowledge-intensive sectors (see Table 3).

Subsequently, we added all 419 high-tech SMEs from Eurobarometer to our sample, totalling 1366 SMEs. Drawing on this sample and the construction of several interaction terms including a high-tech dummy, we tested our results for *Hypotheses 1* and *2* (see Appendices 1 and 2). To test *Hypothesis 1*, we used Model 3 as the base model and added a linear high-tech term and an interaction term, including R&D intensity and high-tech (see Models 6 and 7). The results indicate that all directional and significant effects are similar to those in Model 3. Both high-tech main and interaction terms are nonsignificant ($p > 0.05$). Thus, we provide evidence for the existence of a similar inverted U-shaped relationship between R&D intensity and firm performance for high-tech and non-high-tech SMEs. To assess Hypothesis 2, we used Model 4 as the base model and included a linear high-tech term and interaction terms, including R&D intensity and high-tech, R&D intensity-squared and DOI, DOI and high-tech, and R&D intensity and DOI and high-tech (see Models 8 and 9). The results indicate that all directional and significant effects are similar to Model 4. All high-tech main and interaction terms are nonsignificant ($p > 0.05$). Thus, we confirm that with increasing DOI, the positive impact of R&D intensity on firm performance is stronger, provided that the R&D intensity levels exceed a critical threshold for both high-tech and non-high-tech SMEs.

As R&D intensity and DOI levels are both firm-specific strategic choices, we performed endogeneity tests of R&D intensity and DOI in relation to firm performance (Semadeni et al., 2014). This enabled us to check for the potential adverse effects of (1) reverse causation, (2) measurement error in variables, (3) autoregression and (4) omitted variables. These phenomena can lead to biased variable coefficients in regression models (Haans et al., 2016). Following Wooldridge (2009), we used two-stage least squares (2SLS) to test for endogeneity. This procedure involves the identification of multiple instrumental variables specific to the endogenous variables in the calculation of residuals, which are then regressed together with the optimal model variables on firm performance. Since the residuals were not ($p > 0.1$) related significantly to firm performance for each endogenous variable, we concluded that neither R&D intensity nor DOI causes endogeneity problems in our optimal regression model.

Fourth, we controlled for the location boundedness of marketing advantages (Banalieva and Dhanaraj, 2013) by regressing interaction terms, including marketing intensity and internationalization on SME performance. Model 3 is used as the base model. The results indicate that both interaction terms are nonsignificant ($p > 0.05$). This implies that marketing advantages are indeed location bounded, whereas R&D advantages are non-location bounded (Nocke and Yeaple, 2007) as is indicated by our optimal Model 4 ($p < 0.05$). Thus, we provide support for the superiority of R&D advantages in the internationalization context.

Finally, to correct for the effect of any outliers (data points with standardized residuals that exceed the threshold value of ±3 (Miocevic and Crnjak-Karanovic, 2011)), we performed casewise diagnostics for our regression models. The lack of outliers resulted in an empty casewise diagnostics table, indicating that our results were not driven by outliers.

Discussion

This study examines the role of R&D investment in the performance of non-high-tech SMEs to account for the 'neglected' non-R&D performers that are often subject to policy bias (Hervas-Oliver et al., 2011). Rather than arguing that non-high-tech SMEs resort to non-technological

approaches to upgrade their performance (Piva and Vivarelli, 2002), we show that the technological approach through R&D explains the high performance of non-high-tech SMEs until an optimum level, and that this performance is strengthened by the international activities of such SMEs. Our findings contribute to SME performance debates in two ways. First, we challenge the predominant view in the field that R&D intensity is detrimental to non-high-tech SME performance. This has led us to hypothesize on a nonlinear R&D-based approach that non-high-tech SMEs take to achieve high performance. Second, we demonstrate that the positive impact of R&D intensity on the performance of non-high-tech SMEs is accentuated by their international network linkages. We elaborate on these contributions below.

First, while the size of R&D investments is, by definition, limited in the non-high-tech sector, our study shows that such investments are still important for non-high-tech firms. Product innovativeness among non-high-tech SMEs is significantly influenced by R&D investments (De Beule and van Beveren, 2012; Hervas-Oliver et al., 2011). Our study complements this argument by demonstrating an inverted U-shaped relationship between R&D investment and performance. Greater investments in R&D lead non-high-tech SMEs to improve their performance up until the critical threshold of 2.1%. Below this threshold, diminishing returns set in. This suggests that the more non-high-tech SMEs extend their R&D knowledge base beyond this threshold, the more likely they are to accrue R&D knowledge that has an increasingly marginal contribution. With the acquisition of new knowledge, resource investments and collaborations are likely to become progressively less efficient (Wales et al., 2013). SMEs may face constraints on human capital and complexity in managing increasing numbers of collaborations. Therefore, competitive advantage in non-high-tech SMEs does indeed require firm strategies that capitalize on R&D investments. This challenges the linearity assumption in the SME performance literature to deepen our knowledge of the critical role of R&D in low-technology sectors. Empirical findings in this area have been ambiguous regarding the magnitude of R&D activities, in particular, given that most samples are based only on high-tech SMEs (e.g. Del Monte and Papagni, 2003; Lee, 2009). Furthermore, R&D intensity is argued to hinder the growth of non-high-tech SMEs owing to increased risks and incapacity due to 'liabilities of smallness' or constrained endowment of tangible assets (Avermaete et al., 2003; De Jong and Marsili, 2006; Laforet, 2009).

Second, we demonstrate that non-high-tech SMEs seek technological developments in international collaborations to better exploit their R&D investments to attain higher performance. In line with more recent studies (Evers, 2011; Hervas-Oliver et al., 2012a; Teixeira et al., 2013), we confirm that the orientation of non-high-tech SMEs to access R&D knowledge internationally contributes positively to their performance. However, in contrast to these studies, we confirm a positive moderation effect of internationalization on the relationship between R&D investment and performance of non-high-tech SMEs. Non-high-tech SMEs can rely on international network linkages to access external sources of knowledge to complement their limited R&D capabilities (Hervas-Oliver et al., 2012a). Such firms are shown to compete on the basis of differentiated products that offer value through innovative technology and product design despite the non-high-tech nature of the business (Evers, 2011). They can seek support from technology intermediaries (Spithoven and Knockaert, 2012) and participate in formal international R&D networks (Teixeira et al., 2013) to upgrade their capabilities and accelerate innovation. The international networks of non-high-tech SMEs can compensate for a lack of knowledge capabilities, as well as leverage resources for knowledge of opportunities (Evers, 2011). This finding also clarifies the role of R&D networks in the international business literature in the performance of non-high-tech SMEs. Although there is a plethora of evidence for the role of networks and the benefits accrued from internationalization in high-tech SMEs (Crick and Spence, 2005; Filatotchev et al., 2009; Ojala, 2009), we know less about how international R&D networks influence non-high-tech SME performance.

Given our findings, we suggest that past contributions have overstated the lack of tangible resources of non-high-tech SMEs to build competitive advantage. Non-technological approaches alone cannot explain the performance of non-high-tech SMEs. We emphasise the role of R&D investment in a nonlinear relationship with non-high-tech SME performance. Non-high-tech SMEs seek complementary assets domestically and internationally to enhance their learning capabilities, increase their innovation performance (Wu, 2012) and mitigate their small-sized burdens up to a point. Beyond this point, diminishing returns set in owing to inefficiencies in the management of resources and collaborations (Wales et al., 2013). Consequently, our findings challenge the assertion that non-high-tech firms (Del Monte and Papagni, 2003; Lee, 2009) or non-high-tech SMEs (Nunes et al., 2012) do not obtain performance benefits from R&D investment due to imitability of their innovations or the substitution of R&D activity by alternative practices such as HRM, teamwork and collaboration with external partners (Rammer et al., 2009). This calls for a more eclectic theory building that considers both technological and non-technological approaches to explaining non-high-tech SME performance.

Conclusion

This study contributes to the literature on SME performance by demonstrating the significance of a nonlinear technological approach to assessing the performance of non-high-tech SMEs. We believe that this approach can be useful not only to academics but also to managers and practitioners. First, non-high-tech SMEs that operate internationally can reap substantial performance benefits if their executives decide to increase their R&D intensity to 5.8% and 18.1% for marginally versus fully internationalized SMEs, respectively. Beyond these critical thresholds, SME executives are encouraged to reduce their investments to the aforementioned levels. These implications are equally relevant for European policy makers who develop R&D support schemes such as the Horizon 2020,[5] since we show that only certain R&D intensity ranges of non-high-tech SMEs lead to increased firm performance with the potential to increase competitiveness of European firms, in general. Therefore, European policy makers are advised to tailor their R&D support schemes, so that they benefit firms maintaining an R&D intensity level proximate to, but not exceeding, 5.8 and 18.1% for the respective SMEs. This also suggests that European policy makers would benefit from terminating R&D support to non-high-tech SMEs that exhibit R&D intensity levels that exceed these critical thresholds.

Second, we show that the optimum level of R&D investment for fully internationalized SMEs requires a higher level of R&D investment than that required by marginally internationalized SMEs. This can be explained by the fact that fully internationalized SMEs are more directly exposed to global market pressures. Inherently, innovation is more fundamental to their survival than it is for marginally internationalized SMEs. This suggests that managers of firms that exhibit high rates of international exports could substantially boost firm performance by simultaneously maintaining high rates of R&D investment. Although low rates of international exports can lead to some performance gains attributable to R&D investment, the real performance potential of non-high-tech SMEs can be realized only if R&D investment and internationalization rates are combined synergistically.

Recommendations for future research

This study raises several potentially interesting questions for future research. First, given the historical bias in support for innovation towards technological innovation by high-tech SMEs (Love and Roper, 2015), it is worth continuing the line of research on non-high-tech SMEs. A question of relevance is how the innovations of non-high-tech SMEs are protected. For instance, European

SMEs tend to use 'secrecy, complexity of design, and lead-time advantage' (Spithoven et al., 2010: 367) rather than patents as protection mechanisms due to the high costs associated with patent validation in Europe (Holgersson, 2013). In relation to this, it is also of significance to investigate which strategic protection and appropriability mechanisms are the most efficient and effective in protecting non-high-tech SME innovations from being copied by competitors? Second, given the line of demarcation drawn in the approaches advocated to achieving growth by high-tech and non-high-tech SMEs, it would be timely to examine which combinations of technological (R&D intensity) and non-technological approaches such as HRM practices to performance allow non-high-tech SMEs to attain a competitive advantage.

Limitations of the study

Some limitations need to be taken into account when considering our results. First, we conducted research on European internationalized SMEs operating in a non-high-tech setting, but we were not able to fully control for the percentage of cases per EU-28 country. This is due to the fact that Eurostat does not provide statistical information on the number of European non-high-tech and/or internationalized SMEs per EU-28 country. Although our sample does include cases from each EU-28 country, we recognize that we cannot ensure full representativeness. As a consequence, we need to exercise caution when generalizing our results as they may be more relevant for internationalized non-high-tech SMEs in over-represented than in under-represented EU countries. Future research should consider controlling for the percentage of cases per EU-28 country to increase sample representativeness and generalizability of the results. This requires an extensive effort from Eurostat since they are responsible for collecting statistical information on EU-28 topics and making it available to the broader public, including scholars.

Second, we examine firm performance with a two-year lagged variable but do not consider other performance variables that span multiple years, given the limitation of our dataset. We recognize that the performance implications of R&D investment cannot be fully grasped by our fixed performance variable. For instance, the performance implications of R&D projects exhibit varying time lags (1) among industries, (2) among firms within the same industry and (3) within firms (Naik, 2014). Future research should consider taking a longer time perspective and multiple year-lagged variables to more accurately assess the performance implications of R&D investment over time. This would also allow for more accurate assessment of the varying time lags among and within industries and firms.

Third, we examine firm performance by using a subjective composite variable, given the absence of objective measures of performance in our dataset. Future research should consider using both subjective and objective measures of firm performance, such as return on assets (ROA) and turnover growth (Miller et al., 2013), to increase validity (O'Sullivan and Abela, 2007). Although evidence suggests that subjective measures correlate highly with objective measures of firm performance (Subramanian et al., 2009), especially in the case of SMEs (Khan and Khalique, 2014), the adoption of both subjective and objective measures of firm performance is recommended to strengthen validity (O'Sullivan and Abela, 2007).

Finally, we examine R&D from a traditional 'closed innovation' perspective rather than from an 'open innovation' perspective. In an 'open innovation' perspective, R&D activities are still organized and exercised in-house, but it is acknowledged that (1) knowledge inflows accelerate innovation processes and (2) external knowledge outflows can serve the firm in the long term by stimulating future knowledge inflows (Chesbrough, 2003). We recognize that the traditional 'closed innovation' perspective is becoming increasingly unsustainable for SMEs (Wynarczyk, 2013). Hence, future research should consider the performance implications of R&D investment by discriminating between firms taking a 'closed innovation' versus an 'open innovation' perspective.

Despite the aforementioned limitations, we believe that our study contributes to an enhanced understanding of the effects of R&D investment and internationalization on the performance of non-high-tech SMEs. As our robustness checks confirm, non-high-tech SMEs, similar to high-tech SMEs, are able to synergistically combine R&D investment and internationalization to achieve superior firm performance. Contrary to the common belief, we show that non-high-tech SMEs are not the 'black sheep' of the SME performance debates.

Funding

Notes

1. Non-high-tech small to medium-sized enterprises (SMEs) pursue virtually none of their own Research and Development (R&D) activities (Hirsch-Kreinsen, 2008). Given the limited formalization of knowledge generation and use, innovation activities tend to take the form application-oriented practical knowledge. Hence, 'on the whole, the knowledge base of non-research-intensive enterprises can be characterized as a "distributed knowledge base"' (Hirsch-Kreinsen, 2008: 28).
2. Technology centres are technology institutes that provide services to firms in order to complement their knowledge, offering services such as training, information, intermediation, technological assessment and consulting, or R&D and innovation projects (Hervas-Oliver et al., 2012a).
3. The following categories are computed to class means as shown in parentheses: *0%* (0%), *Less than 1%* (0.5%), *1%–5%* (2.5%), More than 5%–15% (10%), more than 15%–25% (20%), More than 25–50% (37.5%), *More than 50%* (75%).
4. According to the Innovation Union Competitiveness Report (European Commission, 2011: 318), young firms are defined as firms less than five years old, whereas old firms are equal to or more than five years old.
5. Recently, the European Commission (2010) acknowledged the important role of SMEs in improving the competitiveness of European firms, in general. To emphasize this, the European Commission (2010) developed a long-term research policy strategy to promote R&D investment in SMEs termed *Horizon 2020*.

References

Afshartous D and Preston RA (2011) Key results of interaction models with centering. *Journal of Statistics Education* 19(3): 1–24.

Andries P and Faems D (2013) Patenting activities and firm performance: Does firm size matter? *Journal of Product Innovation Management* 30(6): 1089–1098.

Avermaete T, Viaene J, Morgan EJ, et al. (2003) Determinants of innovation in small food firms. *European Journal of Innovation Management* 6(1): 8–17.

Banalieva ER and Dhanaraj C (2013) Home-region orientation in international expansion strategies. *Journal of International Business Studies* 44(2): 89–116.

Barkema HG and Vermeulen F (1998) International expansion through start-up or acquisition: A learning perspective. *Academy of Management Journal* 41: 7–26.

Barney JB (1986) Strategic factor markets: Expectations, luck and business strategy. *Management Science* 32(10): 1231–1241.

Brown TJ, Dacin PA, Pratt MG, et al. (2006) Identity, intended image, construed image, and reputation: An interdisciplinary framework and suggested terminology. *Journal of the Academy of Marketing Science* 34(2): 99–107.

Cerrato D, Crosato L and Depperu D (2016) Archetypes of SME internationalization: A configurational approach. *International Business Review* 25(1): 286–295.

Chen S and Tan H (2012) Region effects in the internationalization-performance relationship in Chinese firms. *Journal of World Business* 47(1): 73–80.

Chesbrough HW (2003) *Open Innovation: The New Imperative for Creating and Profiting From Technology*. Boston, MA: Harvard Business School Press.

Cohen WM and Levinthal DA (1990) Absorptive capacity: A new perspective on learning and innovation. *Administrative Science Quarterly* 35(1): 128–152.

Colombo MG and Grilli L (2007) Funding gaps? Access to bank loans by high-tech start-ups. *Small Business Economics* 29: 25–46.

Crick D and Spence M (2005) The internationalization of 'high performing' UK high-tech SMEs: A study of planned and unplanned strategies. *International Business Review* 14(2): 167–185.

Das A, Kumar V and Kumar U (2009) *Impact of R&D Expenditure on Financial Performance: A Study of Canadian IT Firms*. Ottawa, ON, Canada: Carleton University.

De Beule F and van Beveren I (2012) Does firm agglomeration drive product innovation and renewal? An application for Belgium. *Tijdschrift voor Economische en Sociale Geografie* 103: 457–472.

De Jong JPJ and Freel M (2010) Absorptive capacity and the reach of collaboration in high technology small firms. *Research Policy* 39(1): 47–54.

De Jong JPJ and Marsili O (2006) The fruit flies of innovations: A taxonomy of innovative small firms. *Research Policy* 35(2): 213–229.

Del Monte A and Papagni E (2003) R&D and growth of firms: Empirical analysis of a panel of Italian firms. *Research Policy* 32(6): 1003–1014.

Dierickx I and Cool K (1989) Asset stock accumulation and sustainability of competitive advantage. *Management Science* 35(12): 1504–1511.

Eisingerich AB, Rubera G and Seifert M (2009) Managing service innovation and interorganizational relationships for firm performance. *Journal of Service Research* 11(4): 344–356.

Erden Z, Klang D, Sydler R, et al. (2014) Knowledge-inflows and firm performance. *Journal of Business Research* 67(1): 2777–2785.

European Commission (2010) *Europe 2020: A Strategy for Smart, Sustainable and Inclusive Growth*. Brussels: European Commission.

European Commission (2011) *Innovation Union Competitiveness Report 2011: Analysis Part III: Towards an Innovative Europe – Contributing to the Innovation Union*. Brussels: European Commission.

European Commission (2013a) *Investing in Intangibles: Economic Assets and Innovation Drivers for Growth*. Brussels: European Commission.

European Commission (2013b) *Industrial Performance Scoreboard: A Europe 2020 Initiative*. Brussels: European Commission.

European Commission (2015) *Small and Medium Sized Enterprises and the Transatlantic Trade and Investment Partnership*. Brussels: European Commission.

Eurostat (2014) *Eurostat Indicators on High-Tech Industry and Knowledge – Intensive Services: Annex 3 – High-Tech Aggregation by NACE Rev. 2*. Luxembourg City: European Commission.

Evers N (2011) International new ventures in 'low tech' sectors: A dynamic capabilities perspective. *Journal of Small Business and Enterprise Development* 18(3): 502–528.

Falk M (2012) Quantile estimates of the impact of R&D intensity on firm performance. *Small Business Economics* 39(1): 19–37.

Filatotchev I, Liu X, Buck T, et al. (2009) The export orientation and export performance of high-technology SMEs in emerging markets: The effects of knowledge transfer by returnee entrepreneurs. *Journal of International Business Studies* 40(6): 1005–1021.

Fryges H (2009) Internationalisation of technology-oriented firms in Germany and the UK. *Small Business Economics* 33(2): 165–187.

Fryxel GE (1990) Multiple outcomes from product R&D: Profitability under different strategic orientations. *Journal of Management* 16(3): 633–646.

George G, Wiklund J and Zahra S (2005) Ownership and internationalization of small firms. *Journal of Management* 31(2): 210–233.

Gilsing V, Nooteboom B, Vanhaverbeke W, et al. (2008) Network embeddedness and the exploration of novel technologies: Technological distance, betweenness centrality and density. *Research Policy* 37(10): 1717–1731.

Goerzen A and Beamish P (2003) Geographic scope and multinational enterprise performance. *Strategic Management Journal* 24(13): 1289–1306.

Greve HR (1998) Performance, aspirations, and risky organizational change. *Administrative Science Quarterly* 43(1): 58–86.

Grimpe C and Sofka W (2009) Search patterns and absorptive capacity: Low- and high-technology sectors in European countries. *Research Policy* 38(3): 495–506.

Haans RF, Pieters C and He Z-L (2016) Thinking about U: Theorizing and testing U- and inverted U-shaped relationships in strategy research. *Strategic Management Journal* 37(7): 1177–1195.

Hair JF, Black WC, Babin BJ, et al. (2010) *Multivariate Data Analysis: A Global Perspective* (7th edn). Upper Saddle River, NJ: Pearson Prentice Hall.

Hall BH (2002) The financing of research and development. *Oxford Review of Economic Policy* 18(1): 35–51.

Hansen T and Winther L (2014) Competitive low-tech manufacturing and challenges for regional policy in the European context – lessons from the Danish experience. *Cambridge Journal of Regions, Economy and Society* 7: 449–470.

Harrison JS (2003) *Strategic Management of Resources and Relationships*. New York: Wiley.

Hawawini G, Subramanian V and Verdin P (2003) Is performance driven by industry- or firm-specific factors? A new look at the evidence. *Strategic Management Journal* 24(1): 1–16.

Hervas-Oliver J-L, Albors-Garrigos J and Baixauli J-J (2012) Beyond R&D activities: The determinants of firms' absorptive capacity explaining the access to scientific institutes in low-medium-tech contexts. *Economics of Innovation and New Technology* 21(1): 55–81.

Hervas-Oliver J-L, Albors-Garrigós J and Gil-Pechuan I (2011) Making sense of innovation by R&D and non-R&D innovators in low technology contexts: a forgotten lesson for policymakers. *Technovation* 31(9): 427–446.

Hervas-Oliver J-L, Albors-Garrigós J, de-Miguel B, et al. (2012) The role of a firm's absorptive capacity and the technology transfer process in clusters: How effective are technology centres in low-tech clusters? *Entrepreneurship & Regional Development: An International Journal* 24(7–8): 523–559.

Hirsch-Kreinsen H (2008) 'Low-tech' innovations. *Industry and Innovation* 15(1): 19–43.

Hirsch-Kreinsen H, Jacobson D and Robertson PL (2006) 'Low-tech' industries: Innovativeness and development perspectives – A summary of a European research project. *Prometheus* 24(1): 3–21.

Ho YK, Keh HT and Ong JM (2005) The effects of R&D and advertising on firm value: An examination of manufacturing and non-manufacturing firms. *IEEE Transactions on Engineering Management* 52(1): 3–14.

Hoffman K, Parejo M, Bessant J, et al. (1998) Small firms, R&D, technology and innovation in the UK: A literature review. *Technovation* (18)1: 39–55.

Holgersson M (2013) Patent management in entrepreneurial SMEs: A literature review and an empirical study of innovation appropriation, patent propensity, and motives. *R&D Management* 43(1): 21–36.

Huang CJ and Liu CJ (2005) Exploration for the relationship between innovation, IT and performance. *Journal of Intellectual Capital* 6(2): 237–252.

Johanson JJ and Vahlne JE (1990) The mechanism of internationalization. *International Marketing Review* 7(4): 11–24.

Jones MV (1999) The internationalization of small high-technology firms. *Journal of International Marketing* 7(4): 15–41.

Khan MWJ and Khalique M (2014) Exploring the measurements of organizational performance: Small and medium enterprises (SMEs) perspective. *Market Forces: Journal of Management Business and Economics* 9(2): 31–38.

Kindström D and Kowalkowski C (2009) Development of industrial service offerings: A process framework. *Journal of Service Management* 20(2): 156–172.

Laforet S (2009) Effects of size, market and strategic orientation on innovation in non-high-tech manufacturing SMEs. *European Journal of Marketing* 43(1/2): 188–212.

Lee C-Y (2009) Competition favors the prepared firm: Firms R&D responses to competitive market pressure. *Research Policy* 38(5): 861–870.

Lee SM and Lim S (2009) Entrepreneurial orientation and the performance of service business. *Service Business* 3(1): 1–13.

Li L (2005) Is regional strategy more effective than global strategy in the US service industries? *Management International Review* 45(1): 37–57.

Love JH and Roper S (2015) SME innovation, exporting and growth: A review of existing evidence. *International Small Business Journal* 33(1): 28–48.

Lu JW and Beamish PW (2006) SME internationalization and performance: Growth and profitability. *Journal of International Entrepreneurship* 4(1): 27–48.

Lu Y and Yao J (2006) Impact of state ownership and control mechanisms on the performance of group affiliated companies in China. *Asia Pacific Journal of Management* 23(4): 485–503.

McEvily B and Zaheer A (1999) Bridging ties: A source of firm heterogeneity in competitive capabilities. *Strategic Management Journal* 20(12): 1133–1156.

McFadyen MA and Cannella AA (2004) Social capital and knowledge creation: Diminishing returns of the number and strength of exchange. *Academy of Management Journal* 47(5): 735–746.

Miller CC, Washburn NT and Glick WH (2013) Perspective: The myth of firm performance. *Organization Science* 24(3): 948–964.

Miocevic D and Crnjak-Karanovic B (2011) Cognitive and information-based capabilities in the internationalization of small and medium-sized enterprises: The case of Croatian exporters. *Journal of Small Business Management* 49(4): 537–557.

Müller E and Zimmermann V (2009) The importance of equity finance for R&D finance. *Small Business Economics* 33(3): 303–318.

Musteen M, Francis J and Datta DK (2010) The influence of international networks on internationalization speed and performance: A study of Czech SMEs. *Journal of World Business* 45(3): 197–205.

Naik PK (2014) R&D intensity and market valuation of firm: A study of R&D incurring manufacturing firms in India. *Journal of Studies in Dynamics and Change* 1(7): 295–308.

Nieto MJ and Santamaría L (2010) Technological collaboration: Bridging the gap between small and large firms. *Journal of Small Business Management* 48: 44–69.

Nocke V and Yeaple S (2007) Cross-border mergers and acquisitions vs. greenfield foreign direct investment: The role of firm heterogeneity. *Journal of International Economics* 72(2): 336–365.

Nooteboom B (1994) Innovation and diffusion in small firms: Theory and evidence. *Small Business Economics* 6: 327–347.

Nunes P-M, Sarrasqueiro Z and Leitao J (2012) Is there a linear relationship between R&D intensity and growth? Empirical evidence of non-high-tech vs. high-tech SMEs. *Research Policy* 41(1): 36–53.

O'Sullivan D and Abela AV (2007) Marketing performance measurement ability and firm performance. *Journal of Marketing* 71(2): 79–93.

OECD (2015) *OECD Bilateral Trade Database by Industry and End-Use Category*. Paris: OECD.

Ojala A (2009) Internationalization of knowledge-intensive SMEs: The role of network relationships in the entry to a psychically distant markets. *International Business Review* 18(1): 50–59.

Ortega-Argilés R, Piva M, Potters L, et al. (2010) Is corporate R&D investment in high-tech sectors more effective? *Contemporary Economic Policy* 28(3): 353–365.

Oviatt BM and McDougall PP (1994) Toward a theory of international new ventures. *Journal of International Business Studies* 25(1): 45–64.

Pangarkar N (2008) Internationalization and performance of small- and medium-sized enterprises. *Journal of World Business* 43(4): 475–485.

Peng J, Zhang G, Zhang S, et al. (2014) Effects of online advertising on automobile sales. *Management Decision* 52(5): 834–851.

Piva M and Vivarelli M (2002) Skill-bias: Comparative evidence and econometric test. *International Review of Applied Economics* 16(3): 347–357.

Qian G, Li L, Li J, et al. (2008) Regional diversification and firm performance. *Journal of International Business Studies* 39(2): 197–214.

Rammer C, Czarnitzki D and Spielkamp A (2009) Innovation success of non-R&D-performers: Substituting technology by management in SMEs. *Small Business Economics* 33(1): 35–58.

Raymond L and St-Pierre J (2010) R&D as a determinant of innovation in manufacturing SMEs: An attempt at empirical clarification. *Technovation* 30(1): 48–56.

Ren S, Eisingerich AB and Tsai H-T (2015) How do marketing, research and development capabilities, and degree of internationalization synergistically affect the innovation performance of small and medium-sized enterprises (SMEs)? A panel data study of Chinese SMEs. *International Business Review* 24: 642–651.

Rickne A (2006) Connectivity and performance of science-based firms. *Small Business Economics* 26(4): 393–407.

Ritter T and Gemünden HG (2004) The impact of a company's business strategy on its technological competence, network competence and innovation success. *Journal of Business Research* 57(5): 548–556.

Robinson JP, Shaver PR and Wrightsman LS (1991) Criteria for scale selection and evaluation. In: Robinson JP, Shaver PR and Wrightsman LS (eds) *Measures of Personality and Social Psychological Attitudes*. San Diego, CA: Academic Press, pp.1–16.

Rogers M (2004) Networks, firm size and innovation. *Small Business Economics* 22(2): 141–153.

Roquebert JA, Phillips RL and Westfall PA (1996) Market vs. management: What drives profitability? *Strategic Management Journal* 17(8): 653–664.

Santarelli E and Vivarelli M (2007) Entrepreneurship and the process of firms' entry, survival and growth. *Industrial and Corporate Change* 16: 455–488.

Semadeni M, Withers MC and Certo ST (2014) The perils of endogeneity and instrumental variables in strategy research: Understanding through simulations. *Strategic Management Journal* 35(7): 1070–1079.

Shankar V (2012) Marketing strategy and firm value. In: Shankar V and Carpenter GS (eds) *Handbook of Marketing Strategy*. Cheltenham: Edward Elgar Publishing, pp.415–439.

Som O (2012) *Innovation Without R&D: Heterogeneous Innovation Patterns of Non-R&D-Performing Firms in the German Manufacturing Industry*. Karlsruhe: Springer.

Som O, Kirner E and Jäger A (2015) Non-R&D-intensive firms' innovation sourcing. In: Som O, Kirner E and Jäger A (eds) *Low-Tech Innovation: Competitiveness of the German Manufacturing Sector*. Heidelberg: Springer, pp.113–144.

Spithoven A and Knockaert M (2012) Technology intermediaries in low tech sectors: The case of collective research centres in Belgium. *Innovation: Management, Policy & Practice* 14(3): 375–387.

Spithoven A, Frantzen D and Clarysse B (2010) Heterogeneous firm-level effects of knowledge exchanges on product innovation: Differences between dynamic and lagging product innovators. *Journal of Product Innovation Management* 27(3): 362–381.

Stam E and Wennberg K (2009) The roles of R&D in new firm growth. *Small Business Economics* 33(1): 77–89.

Subramanian R, Kumar K and Strandholm K (2009) The relationship between market orientation and performance under different environmental conditions: The moderating effect of the top management team's risk taking behavior. *Academy of Strategic Management Journal* 8(1): 121–135.

Teece DJ (1992) Competition, cooperation, and innovation: Organizational arrangements for regimes of rapid technological progress. *Journal of Economic Behavior & Organization* 18(1): 1–25.

Teece DJ, Pisano G and Shuen A (1997) Dynamic capabilities and strategic management. *Strategic Management Journal* 18(7): 509–533.

Teixeira AAC, Santos P and Delgado AP (2013) International regional patterns of R&D networks involving low tech SMEs. *Journal of Technology Management & Innovation* 8(2): 1–20.

Titus V, House JM and Covin JG (2017) The influence of exploration on external corporate venturing activity. *Journal of Management* 43: 609–1630.

Tsang EWK (2002) Learning from overseas venturing experience: The case of Chinese family businesses. *Journal of Business Venturing* 17(1): 21–40.

Tyler BB and Caner T (2016) New product introduction below aspirations, slack and R&D alliances: A behavioural perspective. *Strategic Management Journal* 37(5): 896–910.

Van Dijk B, Hertog RD, Menkveld B, et al. (1997) Some new evidence on the determinants of large- and small-firm innovation. *Small Business Economics* 9: 335–343.

Von Tunzelmann N and Acha V (2005) Innovation in 'low-tech' Industries. In: Fagerberg J, Mowery DC and Nelson RR (eds) *The Oxford Handbook of Innovation*. Oxford: Oxford University Press, pp.407–432.

Wales WJ, Parida V and Patel PC (2013) Too much of a good thing? Absorptive capacity, firm performance, and the moderating role of entrepreneurial orientation. *Strategic Management Journal* 34(5): 622–633.

Whittaker DH (2016) Assembling capabilities for innovation: Evidence from New Zealand SMEs. *International Small Business Journal* 34(1): 123–143.

Wooldridge JM (2009) *Introductory Econometrics* (4th ed). Mason, OH: South-Western Cengage Learning.

Wu J (2012) Technological collaboration in product innovation: The role of market competition and sectoral technological intensity. *Research Policy* 41(2): 489–496.

Wynarczyk P (2013) Open innovation in SMEs: A dynamic approach to modern entrepreneurship in the twenty-first century. *Journal of Small Business and Enterprise Development* 20(2): 258–278.

Zahra SA and George G (2002) Absorptive capacity: A review, reconceptualization, and extension. *Academy of Management Review* 27(2): 185–203.

Zahra SA, Ireland RD and Hitt MA (2000) International expansion by new venture firms: International diversity, mode of market entry, technological learning, and performance. *Academy of Management Journal* 43(5): 925–950.

Zhou L, Wu W-P and Luo X (2007) Internationalization and the performance of born-global SMEs: The mediating role of social networks. *Journal of International Business Studies* 38(4): 673–690.

Author biographies

Lucas WA Booltink is a Practitioner in the semi-public sector who has graduated recently from Nijmegen School of Management, Radboud University with a cum laude degree in Business Administration. His research interests include the development of data-based models to support decision makers with a particular interest in disclosing data on the potentially disadvantaged.

Ayse Saka-Helmhout is an Associate Professor of International Management at Nijmegen School of Management, Radboud University. Her research focuses on responses of multinationals to multiple institutional pressures from a comparative perspective. She has published in journals such as the *Journal of International Business Studies*, *Journal of Management Studies*, *Organization Studies*, *Journal of World Business*, and *Management International Review*.

Appendix 1. Summary statistics and correlations.

	1	2	3	4	5	6	7	8	9
1. Firm performance	1								
2. Services	0.049	1							
3. BGM	0.047	−0.058	1						
4. Young age	0.019	0.110	−0.019	1					
5. Firm size[a]	0.043	−0.331	0.270	−0.185	1				
6. Marketing intensity[a,b]	0.211	0.120	−0.014	0.048	−0.056	1			
7. High-tech	0.106	0.065	0.068	0.010	0.032	−0.006	1		
8. DOI[b]	−0.041	−0.127	0.124	0.046	0.052	−0.083	0.019	1	
9. R&D intensity[a,b]	0.247	−0.037	0.029	0.006	0.008	0.398	0.163	0.051	1
Mean	1.50	0.60	0.30	0.12	1.28	0.00	0.31	0.00	0.00
SD	0.813	0.491	0.459	0.329	0.602	0.393	0.461	32.035	0.423
Min	0.00	0	0	0	0.00	−0.38	0	−38.72	−0.32
Max	3.00	1	1	1	2.39	1.50	1	51.28	1.56
N	1366	1366	1366	1366	1366	1366	1366	1366	1366

BGM: business group membership; DOI: degree of internationalization; R&D: Research and Development; SD: standard deviation.

[a]This variable is log-transformed.

[b]This variable is centred.

Country dummies are not included.

Correlations >|0.053| are significant at 5%.

Appendix 2. Multiple regression of R&D intensity and DOI on the performance of (non-)high-tech SMEs.

	Model 6	Model 7	Model 8	Model 9
Intercept	1.402*** (0.115)	1.403*** (0.115)	1.421*** (0.115)	1.413*** (0.115)
Services	0.080† (0.046)	0.080† (0.046)	0.081† (0.046)	0.080† (0.046)
BGM	0.036 (0.049)	0.036 (0.049)	0.037 (0.049)	0.037 (0.049)
Young age	0.056 (0.065)	0.055 (0.065)	0.053 (0.065)	0.054 (0.065)
Firm size	0.092* (0.041)	0.092* (0.041)	0.093* (0.041)	0.093* (0.041)
Marketing intensity	0.488*** (0.078)	0.487*** (0.078)	0.478*** (0.078)	0.476*** (0.078)
Marketing intensity^2	−0.400*** (0.110)	−0.405*** (0.111)	−0.388*** (0.111)	−0.384*** (0.111)
High-tech	0.089† (0.047)	0.092† (0.048)	0.091† (0.048)	0.092† (0.048)
DOI	−0.001 (0.001)	−0.001 (0.001)	−0.001† (0.001)	−0.001 (0.001)
R&D intensity *(H1)*	0.516*** (0.083)	0.528*** (0.088)	0.529*** (0.087)	0.523*** (0.088)
R&D intensity^2 *(H1)*	−0.258* (0.106)	−0.250* (0.109)	−0.267* (0.109)	−0.261* (0.109)
R&D intensity x High-tech *(H1)*		−0.043 (0.105)	−0.055 (0.105)	−0.038 (0.107)
R&D intensity × DOI *(H2)*			0.004* (0.001)	0.006* (0.003)
R&D intensity^2 × DOI *(H2)*				−0.002 (0.003)
DOI × High-tech *(H2)*				0.000 (0.001)
R&D intensity × DOI × High-tech *(H2)*				−0.003 (0.003)
Country dummies	Yes	Yes	Yes	Yes
N	1366	1366	1366	1366
R^2	0.165	0.165	0.169	0.170
Adjusted R^2	0.142	0.141	0.145	0.144
F	7.106***	6.919***	6.922***	6.448***
Sig F change	***	n.s.	*	n.s.

BGM: business group membership; DOI: degree of internationalization; R&D: Research and Development; SD: standard deviation; SME: small and medium-sized enterprise.
Significance levels: †$p < 0.1$; *$p < 0.05$; **$p < 0.01$; ***$p < 0.001$.