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Novel but too complex? The importance of marketing innovation for new product performance

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Abstract

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innovative marketing, i.e. innovative design, packaging, pricing, promotion, and/or distribution. We argue that the combination of investments in technological and marketing innovation will lead to overall lower product innovation performance. We ground this prediction in behavioural theory by arguing that clients will not reward novelty originating from two different domains (technology and marketing) because of the increase in complexity. This effect is particularly pronounced for small firms and in high-tech industries. Based on the analysis of a dataset of 866 firms from a representative set of industries in Germany, we find empirical support for our hypotheses.

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ABSTRACT

For many modern firms, performance is tied to the continuous creation of novel products. In this article, we separate technological novelty based on R&D from novelty which originates from innovative marketing, i.e. innovative design, packaging, pricing, promotion, and/or distribution. We argue that the combination of investments in technological and marketing innovation will lead to overall lower product innovation performance. We ground this prediction in behavioural theory by arguing that clients will not reward novelty originating from two different domains (technology and marketing) because of the increase in complexity. This effect is particularly pronounced for small firms and in high-tech industries. Based on the analysis of a dataset of 866 firms from a representative set of industries in Germany, we find empirical support for our hypotheses.

Keywords: Innovation, complexity, marketing innovation, technological innovation, R&D

INTRODUCTION

The concept of novelty is central to many management theories which explain differences in performance among firms (Katila, 2002). Especially resource and knowledge based theories of firm strategy emphasize the role of novel products, knowledge or processes within firms and link it with uniqueness and consequently superior firm performance (Spender & Grant, 1996; Ceccagnoli, 2009). Novel products lead to higher firm performance because they enable an innovative firm to charge higher prices based on a temporary monopoly position (Arrow, 1962). Managers have strong incentives to extend this temporary monopoly position for as long as possible and to avoid imitation from competitors. However, since the protection from imitation is typically incomplete or ineffective, for example not more than roughly one third of all firm innovations is ever patented (Arundel & Kabla, 1998), firms have to invest continuously into producing more novel products.

Within these existing theoretical models there is no downside to novelty in a firm's product offerings. We challenge this assumption by delineating novelty into two components. The first component is the more traditional connotation of technological novelty based on firm investments in R&D (Helfat, 1994). We separate this component of novelty from novelty based on how products are marketed and refer to it as *marketing innovation*. The novelty of marketing innovation originates exclusively from the way in which technologically unchanged products are designed, priced, distributed, and/or promoted – the often quoted "4 Ps" of the marketing mix (Waterschoot & Van Den Bulte, 1992). Both technological and marketing innovations have the potential to create temporary monopoly positions since the opportunity to charge higher prices originates from the client's perspective, i.e. his or her inability or unwillingness to switch to a substitute product.

In this article, we will suggest that combining technological with marketing innovation harms innovation performance. We draw from behavioural theory (e.g., Kahneman & Lovallo, 1993) and attribute this effect to the role of complexity in innovation, arguing that the complexity of a firm's innovations will increase if their novelty originates from both technological and marketing innovation. Complexity renders customer decision making more risky, particularly if customers have to aggregate risks from different domains, such as technology and marketing. Complexity also requires higher effort which customers may wish to avoid (Dawes, Faust, & Meehl, 1989). As a result, the positive effect of technological innovation on performance decreases in the presence of marketing innovation and vice-versa.

Additionally, we explore the negative interaction between technological and marketing innovation in more detail, and argue that the trade-off between technological innovation and marketing innovation is particularly pronounced for (a) small firms, which are especially challenged by legitimacy and resource constraints, relative to large firms, and (b) for firms in high-tech (versus low-tech) industries, owing to greater risk due to rapid technological change and greater uncertainty in the high-tech environment. We empirically test our hypotheses on a sample of 866 firms in Germany representing a cross-section of industries, which provides us with the unique opportunity to rule out industry-specific effects.

Our research contributes to the literature in at least two ways. First, we focus on novelty originating from marketing innovation as an innovation strategy which is separate from technological innovation and aimed at achieving novelty in a firm's product innovations. There seems to be abundant anecdotal evidence about the success of novel marketing strategies but their relationship with technological innovation is largely absent in the theoretical and virtually completely in the empirical literature. Recent successful examples of product novelty originating from marketing innovation include calorie-based packaging (e.g. “100 calorie packs”) or purpose-based packaging (e.g. “Lunchables” as pre-packaged lunches for parents to give to their school kids) of otherwise unchanged food products. Innovative store designs, e.g. of Starbucks, have generated important competitive advantages. Pre-paid and flat-rate pricing as well as mobile phone price subsidies have proven to be crucial for the performance of telecommunication service providers. The same is true for music, news, and book publishers who have found effective and profitable ways to distribute their content digitally. While some of these innovations in the elements of the marketing mix have been enabled by technological developments such as the internet, their success is typically not dependent on particular proprietary technologies developed by the firm. In this regard, existing studies linking technological R&D with marketing envision the latter mostly as an exploitation strategy for the former, not as a source of novelty in itself and can therefore not explain negative interaction effects (Teece, 1986; Song, Droge, Hanvanich, & Calantone, 2005; Webb, Ireland, Hitt, Kistruck, & Tihanyi, 2011).

Second, we adopt a contingency view and identify two important boundary conditions for the substitutive relationship between technological and marketing innovation: firm size and industry affiliation. In that sense, our study strongly suggests that firms must be cautious about a dual strategy that pursues both types of innovation simultaneously, especially in case of legitimacy deficits and if resources are limited (as for smaller firms) or if the industry is characterized by rapid change and technological uncertainty (as for firms in high-tech industries).

Our studies have immediate implications for management practice. We find that the average firm does not benefit from pursuing product novelty based on simultaneous technological and marketing innovation. We find evidence that especially small and high-tech firms are better off when investing into one source of product novelty, i.e. marketing or technology, but not a combination of both.

The remainder of this paper is organized as follows. The next section provides the theoretical background and develops a set of hypotheses. Our third section describes the data, measures and the empirical model, while the following section presents the results. These results and their implications are then discussed in the next section. We then conclude with a summary of our research, its limitations, and direction for future research.

THEORY AND HYPOTHESES

We start the development of theory by integrating marketing innovation into the traditional model linking technological innovation through a firm's R&D investment with innovation performance. We will present arguments for why the link between R&D investment and innovation performance differs when firms simultaneously invest into innovative marketing techniques such as new distribution channels, pricing policies or advertising methods. To do so, we lay out the basic mechanism connecting R&D investment with innovation performance. Since R&D allows firms to create new products, product novelty can translate into an at least temporary monopoly-like market position in which competitors may not succeed in imitating or substituting the innovation (Schumpeter, 1942). This isolation from competition originates from a high degree of differentiation and the associated imitation costs or lead time advantages (Mansfield, Schwartz, & Wagner, 1981). Firms may also be able to extend the duration of these advantages through other strategies such as patenting (Suarez & Lanzolla, 2007). Resource based theories of the firm often times consider R&D activities as a strategic capability underlying competitive advantage because it has the potential for creating firm resources that are valuable, inimitable, non-substitutable, and rare (e.g., Wernerfelt, 1984; Barney, 1991).

Unless customers are resistant to innovation (e.g., Kleijnena, Leeb, & Wetzelsc, 2009), there is, within this simple model, no downside to the degree of novelty of a firm's innovations. More novel products should always be more desirable for costumers and more difficult to imitate for competitors. However, we argue that the two factors, customer attractiveness and protection from imitation, diverge if the novelty of the underlying innovation originates from a combination of technological and marketing novelty. We trace this trade-off back to the role of complexity in innovation and argue that the complexity of a firm's innovations will increase if their novelty originates from both technological and marketing novelty. This conceptualization depends crucially on the assumption that marketing can add novelty to an innovation.

The role of marketing for innovation performance

Large parts of the existing literature define the path to generating novel products with superior value to customers rather narrowly. Most studies more or less explicitly conceptualize a knowledge production function with R&D expenditures as the crucial input (for a comprehensive review see Ahuja, Lampert, & Tandon, 2008). In that sense, innovation opportunities for technological innovation typically stem from scientific discovery and R&D effort. This can occur within a firm's own laboratory but is frequently developed by applying research generated by other organizations such as universities. Such innovation processes require highly educated scientists and engineers operating in specialized laboratories. The research component of R&D is thus comparable to scientific discovery (Cohen, Nelson, & Walsh, 2002).

Marketing innovation processes are fundamentally different. Innovation opportunities arise largely from knowledge gathered from customers and competitors. Market research is the process of collecting and analysing market data (Moorman, Deshpandé, & Zaltman, 1993). Such research covers an understanding of customer behaviour, including identification of emerging needs, and studying competitors to predict their moves (Slater & Narver, 1998, 1999). New technologies can facilitate marketing innovation, e.g., the ability to sell books electronically or digital supermarket displays enabling flexible pricing, but they are rarely distinctive or proprietary to the innovative firm. Competitors may use identical technologies from similar or identical suppliers. Innovative marketing solutions originate from personnel with expertise in such areas as advertising, customer management, market research or sales.

This conceptualization of marketing innovation takes a sharply different perspective from the extant literature linking innovation and marketing. Marketing has traditionally been viewed as a mechanism for exploiting technologically novel products commercially (for a recent review, see Krasnikov & Jayachandran, 2008). Another stream of literature questions the overly strong technology focus of firms and asks for greater market orientation via a stronger focus on customers and competitors when firms set and develop strategy (e.g., Day, 1994; Slater & Narver, 1998, 1999). In this conceptualization, the marketing function is the driving force behind identifying promising market opportunities, and all other firm functions, such as R&D, follow its lead (Danneels, 2002; Morgan, Vorhies, & Mason, 2009). The marketing function provides links with customers to build durable relationships with them, thereby enabling a more accurate prediction of changes in customer behavior (Day, 1994). More recent studies envision an interplay between R&D and marketing, with marketing identifying customer needs, R&D

developing products, and marketing subsequently enabling the value capture of R&D's development efforts (Song *et al.*, 2005; Webb *et al.*, 2011).

We deviate from the perspective of marketing adding value to the innovation process only through its role in the commercialization of technology-driven inventions by explicitly separating the innovative from the non-innovative marketing activities of a firm. In that sense, we narrow the definition of marketing innovation to "the implementation of new marketing methods involving significant changes to a firm's marketing mix in product design or packaging, product placement, product promotion or pricing" (OECD, 2005).

Hypotheses

While extant literature has frequently stressed the complementary nature of firm R&D and non-innovative marketing (e.g., Song *et al.*, 2005; King, Slotegraaf, & Kesner, 2008), our reasoning suggests a substitutive relationship instead, since the combination of R&D and innovative marketing increases the complexity of resulting new products. Complexity has been defined in multiple ways. For the purpose of this article we adopt the crucial features of complexity that most definitions have in common: They describe a system as more complex if it comprises an increasing number of elements in which the interaction between these elements is difficult to predict (Simon, 1962; Anderson, 1999). The complexity of innovations in particular has been described based on the dispersion of their underlying knowledge (Dougherty & Dunne, 2011).

Technological and marketing innovation pertain to different domains. We argue that the complexity originating from a combination of technological and marketing domain influences the value perception of customers negatively. This phenomenon is sometimes described as "feature fatigue" among customers (Thompson, Hamilton, & Rust, 2005). Drawing from behavioural theory, the acquisition of a technologically new product implies at least some level of risk for the customer because innovative features, materials or functions are by definition unknown. Kahneman and Lovallo (1993) show that decision makers become more risk-averse if they have to aggregate risks. This effect is especially strong if the decision requires the aggregation of risks which are very different from one another. In such cases, the description of the potentially positive outcome of the decision becomes less specific and more abstract. What is more, the aggregation of information across domains is difficult and requires effort (Dawes *et al.*, 1989). Consequently, a potential customer would like to avoid the effort. Within our setting, we conclude that potential customers will be less likely to aggregate the potential utility gains from purchasing an innovation that features both technological and marketing innovation. Instead, they may overestimate the risks originating from the innovation not fitting their needs or not superseding the utility of existing products. Both mechanisms imply that the combination of technological and marketing innovation will have comparatively lower effects on innovation performance than when they would be offered in isolation. We propose:

Hypothesis 1 (H1): The effect of investments in technological novelty on product innovation performance is lower if it is combined with investments in marketing novelty.

Operationally, this means that we expect a negative interaction between technological and marketing innovation on innovation performance.

Firm size

Our arguments suggest increased complexity originating from a combination of technological and marketing novelty to negatively influence the value perception of customers. Adopting a contingency view, we focus on the size of the firm as a factor influencing this relationship. We suggest that the negative effect of marketing innovation on the relationship between technological innovation and firms' innovation performance is stronger for small firms compared to large firms for two reasons. First, our reasoning builds on the observation that small firms have often times been viewed as lacking legitimacy (Rao, Chandy, & Prabhu, 2008). Legitimacy can be defined as "a generalized perception or assumption that the actions of an entity are desirable, proper, or desirable within some socially constructed systems of norms, values, beliefs, and definitions" (Suchman, 1995: 574). The lack of legitimacy of small firms can also be characterized as a liability of smallness. Higher legitimacy reduces the risks for a customer of transacting with a particular firm. It also facilitates the aggregation of information across domains since legitimacy reduces the effort to gather and process information about both the firm and the product innovation. As a consequence, small firms are more likely to possess lower reputational capital than large firms and the negative interaction between technological and marketing innovation in their new products should be especially pronounced.

Second, large and established firms with proven marketing and R&D capabilities are likely to find it easier combining both technological and marketing innovation effectively. Lower firm size may imply higher resource constraints (Rao *et al.*, 2008), and pursuing both technological and marketing innovation at the same time could overstretch the resources of small firms. Ocasio (1997) suggests management attention to be one of the most important resources of the firm. Since small firms need to manage many different activities with limited personnel capacity, combinations of technological and marketing innovation could become more error-prone and perceived as being managed unprofessionally. As a result, customers will find it difficult to understand and to value the innovation. Taking both arguments together suggests the trade-off between technological and marketing innovation to be particularly pronounced for small firms compared to large firms. Our second hypothesis therefore reads as follows:

Hypothesis 2 (H2): The effect of investments in technological novelty on product innovation performance is lower if it is combined with investments in marketing novelty, and this effect is particularly pronounced for small firms compared to large firms.

Operationally, this means that we expect a stronger negative interaction between technological and marketing innovation in their effect on innovation performance for smaller, compared to larger firms.

High-tech industries

Similarly to the arguments put forward regarding the influence of a firm's size, we suggest that the industry affiliation of the innovating firm, as a conduit for the nature of technological development, is an important contingency to consider. We now invoke the magnitude of uncertainty to argue that for firms in high-tech industries, marketing and technology innovation act as stronger substitutes than for firms in low-tech industries.

High-tech industries share the common characteristics of high technological uncertainty, market uncertainty, and competitive volatility (Moriarty & Kosnik, 1989). Product life cycles are typically short (Pisano & Wheelwright, 1995), and the product-market environment tends to be relatively dynamic and turbulent. Technological uncertainty springs from "not knowing whether the technology – or the company providing it – can deliver on its promise to meet specific needs" (Moriarty & Kosnik, 1989: 8). This in turn leads to higher sensitivity to complexity in the customer's decision making as product innovations in high-tech imply a higher level of risk due to ex ante unknown innovative features, materials or functions. The rapidly changing competitive landscape further aggravates the situation facing firms in high-tech industries. As a consequence, customers' value perception of innovations combining technological and marketing novelty in a high-tech context will be lower than in a low-tech context. Hence, our third hypothesis reads as follows:

Hypothesis 3 (H3): The effect of investments in technological novelty on product innovation performance is lower if it is combined with investments in marketing novelty, and this effect is particularly pronounced for firms in high-tech industries compared to firms in low-tech industries.

Operationally, this means that we expect a stronger negative interaction between technological and marketing innovation in their effect on innovation performance for high-tech, compared to low-tech firms.

DATA AND METHODS

Data

We test our hypotheses empirically using data from the "Mannheim Innovation Panel" (MIP), which is the German contribution to the Community Innovation Survey (CIS) of the European Union focusing on innovation activities at the firm level. Ideally, one would like to test our hypotheses at the product level, i.e. by tracking innovation performance as well as the relative contributions of technological and marketing innovation for each product. We are not aware of a dataset which would provide information at this detailed level across a meaningful number of firms with different sizes and from different industries, i.e. the prerequisite for testing hypotheses 2 and 3. We will instead use aggregated information at the firm level. Hence, we make the explicit assumption that a firm's average success with new products as well as its average investments into technological and marketing novelty are valid measurements of our theoretical constructs. Using the firm-level average reduces the variance in our empirical model because it reduces the influence of extreme products with excessively large technological or marketing innovation components. Hence, this induces a downward bias to our estimation results because it makes it less likely to find empirically significant results. It also implies that we can only interpret results and draw conclusions at the firm level, not at the product level.

The methodology and questionnaire used for compiling our data comply with CIS standards and follow the Oslo manual of the OECD (OECD, 2005). CIS surveys target the decision makers for a firm's innovation activities. Typical respondents are CEOs, heads of innovation management units or R&D departments. Decision makers provide direct, importance-weighted measures for a comprehensive set of questions on innovation inputs, processes and outputs (Criscuolo, Haskel, & Slaughter, 2005). Several contributions to recent management, strategy and innovation literature have relied on the self-reported information provided by CIS surveys (e.g., Laursen & Salter, 2006; Grimpe & Kaiser, 2010; Leiponen & Helfat, 2011).

CIS surveys are unique compared to most other surveys because of their multinational application for more than a decade within the European Union member states. Experience and feedback cycles with regard to quality management and assurance are extensive. CIS surveys are subject to substantial pre-testing and piloting in various countries, industries and firms with regards to interpretability, reliability and validity (Laursen & Salter, 2006). The questionnaire contains detailed definitions and examples to increase response accuracy. Moreover, a comprehensive non-response analysis provides no evidence of any systematic distortions between responding and non-responding firms (Rammer, Peters, Schmidt, Aschhoff, Doherr, & Niggemann, 2005).

The core of our dataset stems from the MIP survey conducted in 2007 covering the three years prior to the survey. The 2007 MIP questionnaire is the first one containing questions on a firm's marketing innovations. Firms were surveyed again in 2008. We draw the dependent variable on innovation performance from the following observation year (t+1). This limits the coverage of our dataset to firms which participated in both surveys (2007 and 2008), but provides clarity in interpretation by eliminating potential simultaneity issues. We complement this dataset with industry concentration data for the year 2005 provided by the German Monopolies Commission. We also add patent statistics derived from the European Patent Office (EPO). After dropping incomplete observations, we end up with a final sample of 866 firm observations.

Variables

Dependent variable. Researchers have used a variety of constructs for measuring innovation performance (for an overview, see OECD, 2005). They range from innovation inputs such as R&D expenditures to a broad range of output measures such as the number patents or new products. We adopt the latter approach. However, the existence of a novel product is hardly a good predictor for the economic performance of an innovation. It is the market acceptance that turns a novelty into a successful product innovation. In that sense, we follow other literature and take the sales from new products normalized by the firm's total sales (Laursen & Salter, 2006) as our measure for innovation performance in t+1. It is important to keep in mind that our dependent variable captures the sum of sales achieved with both marketing innovations and technological innovations that the firm had introduced.

Focus variables. The focus variables are the investments of firms into marketing innovation and technological innovation. To measure investments in marketing innovation, the survey first asks for the firm's total marketing expenditure in 2006 based on the following definition:

> Marketing expenditures include all internal and external expenditures for advertisement (incl. trade marketing), for the conceptual design of marketing strategies, market and costumer research, and the installation of new distribution channels. Pure selling costs do not count as marketing expenditures.

The survey then provides respondents with a detailed definition of marketing innovation:

> A marketing innovation is the implementation of a new marketing method which your enterprise has not used before. It involves significant changes in product design or packaging, product placement, product promotion or pricing and must be part of a new marketing concept or strategy that represents a significant departure from the firm's existing marketing methods. Please note that seasonal, regular and other routine changes in marketing instruments are not marketing innovations.

Respondents are subsequently asked to indicate whether their firm had introduced a marketing innovation in any of the following areas: product design, advertising/brands, sales channels, and pricing policy. If yes, respondents are instructed to estimate the share of their marketing expenditures dedicated to marketing innovation. We use this information to calculate a firm's investment in marketing innovation as a share of total sales. We are aware that this operationalization defines the novelty of a firm's marketing innovations from the perspective of the firm. These marketing innovations may be new to the firm but not necessarily to the customer since other firms may have introduced similar marketing innovations before. If this situation would be present in our sample, it would reduce the odds for finding significant main and interaction effects of marketing innovation because the customers would not face conditions of increased novelty or increased complexity respectively. Hence, our operationalization of marketing innovation can be considered a useful and conservative measure since it induces a downward bias in all estimation results.

Investment in technological innovation is correspondingly calculated as the firm's expenditure on R&D in 2006 as a share of total sales. This information is also taken from the survey.

Control variables. Several other factors have been identified in the literature as influencing a firm's innovation performance (for an extensive review see Ahuja *et al.*, 2008). Studies have highlighted the importance of continuous R&D engagement over time as opposed to one-time activities (e.g., Cohen & Levinthal, 1990). To account for differences in firms' past R&D activities we calculate the patent stock for each firm on all patents filed at the European Patent Office from 1978 to 2005 using the perpetual inventory method with a constant knowledge depreciation rate of 15 percent as is standard in the literature (e.g., Hall, Jaffe, & Trajtenberg, 2005). We normalize the patent stock by the number of employees to remove a potential firm size effect. Moreover, we include the firm's age (number of years since foundation, in logarithmic form), its number of employees (also in logarithmic form), whether it is part of a company group, and whether it also engages in process innovation (the last two operationalized as dummy variables). We control for different degrees of internationalization through the share of exports over total sales.

We also introduce several control variables at the industry level. First, differences in the level of competitive intensity may influence investment decisions for innovation (e.g., Aghion, Bloom, Blundell, Griffith, & Howitt, 2005). The German Monopolies Commission calculates a Herfindahl-Hirschman index on the degree of market concentration in Germany. We add its 2005 values at the three-digit NACE industry level to the model.[1] Second, we include industry expenditures in marketing as a share of industry sales to control for industry-level differences in marketing effort. This measure is calculated at the two-digit NACE industry level and based on projected data from the MIP survey, since the firms in the survey are drawn as a stratified random sample and can therefore be considered as representative for Germany (for a detailed description see Rammer *et al.*, 2005). Third, we add six industry dummy variables at the grouped two-digit NACE level to capture any remaining industry effects: low-tech manufacturing, medium high-tech manufacturing, high-tech manufacturing, distributive services, knowledge-intensive services and technological services. These industry dummy variables are at a higher aggregation level than the continuous industry level variables (competition and prevalence of marketing) described before and do therefore not cause multicollinearity concerns. Finally, we control for regional differences within Germany by including a dummy variable indicating whether a firm is located in eastern Germany, since these firms have been found to differ significantly from firms located in western Germany following reunification (e.g., Czarnitzki, 2005).

Model

Our dependent variable – the share of sales with new products in *t*+1 – is censored between 0 and 100, which requires a Tobit regression model. We estimate separate Tobit models to test our hypotheses. As a baseline, we estimate a model that only includes our control variables and subsequently a model including the firm's innovative marketing and R&D investments. We add

[1] NACE stands for "Nomenclature statistique des activités économiques dans la Communauté Européenne" and is similar in structure to the SIC or NAICS classification systems.

a multiplicative interaction term of innovative marketing and R&D investments to a separate model and finally split the sample by firm size and industry affiliation. In splitting the sample by firm size, we follow Eurostat, the statistical office of the European Union, which defines small firms as those with less than 50 employees.[2] For the split based on whether the firm belongs to a high-tech versus low-tech industry, we assign all firms belonging to high and high/medium tech manufacturing and knowledge-intensive and technological services (based on NACE classification) to the high-tech group, while the other firms (in low and medium-low tech manufacturing and distributive services) form the low-tech group. Moreover, we estimate three models as robustness checks. First, as an alternative to the number of employees we use a threshold of total firm sales of 10m Euros for the split sample regressions for firm size. Second, we re-estimate the models excluding two consumer goods industries (NACE 15: food and drinks; NACE 16: tobacco) since marketing innovation could be a predominant phenomenon in those industries. Third, we estimate a model that controls for a firm's non-innovative marketing expenditures as a share of sales. Since Tobit models are non-linear models, the correct interpretation of interaction effects requires the calculation of their marginal effects. We follow the procedure suggested by Wiersema and Bowen (2009) and report marginal effects in order to test the hypotheses.

RESULTS

Descriptive results

The average firm in our sample is 20 years old and has 345 employees. Table 1 provides descriptive statistics for the full sample, for firms with and without investments in marketing

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[2] See http://europa.eu/legislation_summaries/enterprise/business_environment/n26026_en.htm

innovation, as well as for small versus large firms and high-tech versus low-tech firms. We test for mean differences between the two groups as an initial empirical step. Firms in our sample derive an average of 21% of their sales from new products. Innovation performance is significantly higher for firms that invest in marketing innovation and also for firms in high-tech (versus low-tech) industries, as one might expect, but there is no difference for small versus large firms. The average firm spends two percent of its sales on marketing overall but only 0.4% on marketing innovation, with the remainder going into non-innovative marketing. Firms investing in marketing innovation, small (versus large) firms, and firms in high-tech (versus low-tech) industries spend significantly more on overall marketing and also on marketing innovation. R&D investment of the average firm in our sample is 5% of sales. Interestingly, while they do not differ significantly between firms with and without marketing innovation investment, it is again the small firms that spend significantly more on R&D than the large firms. Not surprisingly, firms in high-tech industries spend significantly (on average, 8 times) more on R&D than those in low-tech industries. Larger firms and firms in high-tech industries have a higher patent stock (normalized for firm size).

[Table 1 about here]

Table 2 shows the distribution of firms performing marketing and/or technological innovation. Most firms invest in both types of innovation activities at the same time, though substantial fractions of the sample only perform marketing or technological innovation. Table 3 and Table 4 show the distribution for small firms and for high-tech firms. Again, a majority invests in both types of innovation. Chi-square tests confirm for all tables that the number of firms performing both activities is significantly higher than we would expect if the two were independent. These descriptive findings reject the idea that small firms or firms in high-tech might focus entirely on one type of innovation while large firms or firms in low-tech adopt a more "generalist" approach with investments in multiple types of innovation.

[Table 2, Table 3 and Table 4 about here]

Table 7 in the appendix shows bivariate correlations and collinearity statistics. We do not find an indication of collinearity problems in our data by any conventional standard (e.g., Belsley, Kuh, & Welsh, 1980).

Regression results

Main results. Table 5 shows the results of the Tobit regression models. We estimate seven models with different specifications. All of them include our set of control variables, whose effects turn out to be largely consistent across the specifications. We describe the results for the control variables for all models at the end of this section. Model I only includes our control variables. Model II is our baseline model which includes the firm's investments into innovative marketing and R&D. As expected, we find that both variables are significantly and separately positively associated with innovation performance. Although R&D investments have frequently been shown to be an important determinant of innovation performance, the results indicate that investment in marketing innovation has a separate, large impact on innovation performance (the marginal effects on the expected value of innovation performance conditional on it being larger than zero are 1.558 and 0.279 for marketing innovation and R&D, respectively). This finding supports our baseline expectation for a positive effect of marketing innovation on innovation performance that is separate from technological innovation.

Model III includes the interaction between marketing innovation and R&D. While the main effects continue to be in line with the results in Model II, we find that the interaction effect is negative (at the 5 percent level), thus lending support to Hypothesis 1. The marginal effect (i.e. the secondary moderating effect, cf. Wiersema & Bowen, 2009) equals –0.075.[3] Investments in marketing and technological innovation are substitutes with regard to innovation performance.

Models IV and V analyze split-samples of small firms (having less than 50 employees) and large firms (with 50 or more employees), respectively. According to our results, the negative interaction between marketing and technological innovation seen in Model III only holds true in the case of small firms (Model IV). The marginal effect equals –0.098 and is significant at the 5 percent level, and also turns out to be larger for small firms compared to the full sample. There is no significant interaction effect for larger firms. These results support Hypothesis 2.

We find an interesting connection between Hypotheses 1 and 2 with regard to the statistical significance of the main effects of marketing innovation for small versus large firms. The overall positive and separate effect of marketing innovation on firm performance (as suggested in Hypothesis 1) originates primarily from the small firms. Apparently, the performance potential from marketing innovation is especially pronounced for small firms while the significance of the main effect drops slightly below the 10 percent level for large firms. Of course, the latter effect could also be due to the smaller sample size in the split sample. Nevertheless, it also holds when we test alternative definitions of what constitutes a small firm (we discuss consistency check estimations below). Hence, we conclude that (a) the separate performance potential for

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[3] Wiersema and Bowen (2009) suggest plotting the secondary marginal effect to determine whether it is significant for all observations in the sample. We find this to be confirmed except for very few observations for which the marginal effect is not statistically different from zero. The results are shown in Figure 1 the appendix.

marketing innovation is especially strong for small firms and (b) small firms experience a significant drop in performance when they engage in marketing and technological innovation simultaneously.

We next turn to Models VI and VII, for a sample split on the basis of firms in high-tech industries (Model VI) and firms in low-tech industries (Model VII). The interaction between marketing innovation and R&D is negative and highly significant in the case of high-tech industries (the marginal effect is –0.102 and significant at the 5 percent level); for low-tech industries, the coefficient is not statistically significant. Thus, our results support Hypothesis 3.

We note the following with regard to the statistical significance of the main effects for marketing innovation in high- versus low-tech industries. Firms in high-tech industries have the highest potential to experience a positive and separate performance effect from marketing innovation. For the sub-sample of low-tech industries the main effect of marketing innovation drops slightly below the 10 percent significant level. Again, this may be due to the reduced sample size in the split sample estimation. However, the sample split provides evidence that firms in high-tech industries enjoy higher performance potentials from marketing innovation but also face more negative consequences when they invest in marketing and technological innovation simultaneously.

[Table 5 about here]

Control variables. Not surprisingly, the accumulated technological knowledge measured by the patent stock per employee matters as a positive impact on innovation performance. This measure also substantiates the high importance of absorptive capacity for innovation performance, since the patent stock can be assumed to mirror a firm's long-term commitment to R&D. Firm age is generally negatively associated with innovation performance while firm size (in terms of employees) has a positive effect. High international orientation of the firm (measured as the share of exports over sales) is positively associated with innovation performance, as is having an Eastern Germany location. The effects of firms being part of a group and being a process innovator turn out to be largely insignificant. Competitive intensity (as measured by the Herfindahl-Hirschman index) and the general marketing intensity of the industry both show positive and significant effects on innovation performance, suggesting that higher product-market concentration as well as higher marketing orientation at the industry level increase the innovation performance of firms. Regarding the industry effects, firms in high-technology manufacturing and technology-oriented services show higher innovation performance, as one would expect.

Consistency and sensitivity checks. Table 6 shows the results of our consistency checks. Using a sample split at a level of 10m Euros of firm sales does not alter our results. Moreover, the results remain robust if we exclude firms from consumer goods industries (NACE 15, 16) from our sample. Model XI includes the firm's investment in non-innovative marketing as an additional control variable. Interestingly, our results show that only the innovative component of marketing is important for innovation performance while non-innovative marketing expenditure turns out to have no effect at all. This result qualifies prior findings (Drechsler, Natter, & Leeflang, 2013) in that the role of marketing in new product development is only relevant for innovation performance when it concerns significant changes in the firm's marketing mix.

[Table 6 about here]

DISCUSSION

In this study, we delineate the novelty of a firm's product offerings into a component which is due to investments in technological R&D and investments in innovative marketing. We theorize and test the interaction between both, i.e. the effect that marketing innovation has on the relationship between technological innovation and product innovation performance.

Prior studies have largely concentrated on general marketing investments as a way to appropriate the returns from technological innovation (e.g., Krasnikov & Jayachandran, 2008). We deepen the understanding of how the marketing function itself may generate new products or services, how marketing innovation affects innovation performance, and how marketing innovation relates to technological innovation based on a firm's R&D capability. To do so, we isolate the investments in marketing innovation as a way to measure marketing innovation capabilities. Aside from anecdotal evidence – for example, the "100 Calorie Packs" – little is known about firms' efforts to introduce marketing innovations. Our research is one step in the direction of obtaining a clearer understanding of firms' marketing innovation activity and has several implications for management research and practice.

On the academic side, we find that investments in marketing innovation have at least the same potential to create superior innovation performance as R&D investments. Studies that focus exclusively on technological innovation as a source of competitive advantage (e.g. Helfat, 1997) may therefore not capture the full picture of a firm's innovation activities. This implies that findings derived from studies on technological innovation cannot be simply transferred to marketing innovation. However, a key finding of our study is the negative interaction between technological and marketing innovation which suggests that firms do not benefit from pursuing both technological and marketing innovation simultaneously. Drawing from behavioural theory (Kahneman & Lovallo, 1993) we attribute this effect to the role of complexity in innovation and argue that the complexity of a firm's innovations increases if their novelty originates from both technological and marketing innovation. Because complexity requires higher effort on behalf of the customers in assessing the value of a product innovation and because customers have difficulties aggregating risks from different domains, there is a negative effect on a customer's perceived value, leading to lower innovation performance.

Our study design allows us to examine a variety of firms and industries. We are not bound by patent statistics favoring technological innovation (e.g. Ceccagnoli, 2009) or single industry studies with peculiar technological and appropriability conditions such as in pharmaceuticals (e.g. Nerkar & Roberts, 2004). This empirical study allows us to substantiate the theoretical argument that technological and marketing innovation capabilities are distinct from each other. They increase the novelty of the resulting product innovations but also their complexity. Firms are better off when focusing on one of the two as a source of novelty than combining both. This is a major distinction from existing literature that sees marketing per se as a tool for commercializing technological innovation or R&D as the outflow of a firm's market orientation originating from its marketing activities.

Finally, we find that small firms with limited resources and legitimacy suffer especially when they try to combine technological and marketing innovation. This provides a link to the entrepreneurship literature (e.g., Brush, Greene, & Hart, 2001; Hewitt-Dundas, 2006). Based on our findings small firms are better off in focusing primarily on technological or marketing capabilities instead of taking a balanced approach. Similarly, firms in high-tech industries face the challenge of high uncertainty and turbulence. In such settings, customers do not reward novelty based on both marketing and technological innovation since they increase the level of complexity.

Recommendations for management practice follow from these theoretical insights. First, a firm would be short sighted in neglecting the potential for novelty originating from its marketing department. Innovative product design, packaging, pricing, promotion and distribution strategies can be a promising source of product innovation performance even if the new products are not based on technological innovation. Prudent managers would need to compare the potential of novelty originating from R&D as well as marketing departments and invest more heavily in innovation activities in the department with the higher potential. Neither is per se superior to the other when it comes to creating successful innovation. However, a strategy primarily focusing on one or the other will outperform a balanced strategy that splits resources evenly between the two, if resources are limited and/or uncertainty is high, which is the likely situation facing small firms and firms in high-tech industries.

CONCLUSION

This research takes an initial look at the role of marketing innovation in the relationship between firm's R&D investment and innovation performance. While we have demonstrated that marketing innovation is an important driver of product innovation performance, particularly when not combined with technological innovation, we need to acknowledge several limitations of our study. In that sense, our research does not provide deep insights into how firms successfully introduce marketing innovations, how they may be effectively protected against imitation, and at which point in the life cycle of the firm's product portfolio they should be introduced. We have suggested that if new products resulting from marketing innovation are based upon existing technology firms may effectively slow down the pace of technology evolution (Suarez & Lanzolla, 2007) in order to appropriate the value from technology resources (Mizik & Jacobson, 2003) that may otherwise have become obsolete. While marketing innovation could thus serve as an instrument to extend technology-based first-mover advantages (Lieberman & Montgomery, 1988, 1998), further research is needed to develop a better understanding of the appropriate timing in the introduction of such innovations. This issue is particularly important since marketing innovation could actually become very risky in case a firm stays with a technology for too long and thereby loses the opportunity to switch to a more advanced technology that might subsequently allow further marketing innovation. In order to investigate these questions, we would need longitudinal data, which would permit a more nuanced understanding of the interaction between marketing and technological innovation, in terms of the conditions under which the two might act as complements rather than substitutes.

Further work also needs to be done to improve the measure of marketing innovation which in this study captures the total amount spent on marketing innovation (as defined in the CIS survey), without specifics on how the money was spent. As noted, the topic of marketing innovation is under-researched. There is an opportunity to better understand what unique resources and capabilities marketing innovation entails, especially in contrast to traditional marketing, and what roles marketing innovation and traditional marketing play together in influencing the firm's innovation performance.

Finally, our analyses are limited to the firm level. We suspect that there are more complexity effects to explore at the product level and with regard to heterogeneity among customers. Dedicated studies are required to decompose these product and customer level mechanisms.

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TABLES

Table 1: Descriptive statistics and tests on mean differences

Variable	Full sample		Firms w/ inv. in mkt. innov.		Firms w/o inv. in mkt. innov.			Firms <50 empl.		Firms ≥50 empl.			High-tech firms		Low-tech firms		
	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.	T-test	Mean	Std. Dev.	Mean	Std. Dev.	T-test	Mean	Std. Dev.	Mean	Std. Dev.	T-Test
Share of sales w/ new prod. in t+1	21.35	24.03	23.67	24.11	18.86	23.73	***	21.38	25.68	21.33	22.44		26.49	25.49	15.14	20.52	***
Share marketing exp. of sales	1.98	3.74	2.84	4.66	1.06	2.02	***	2.39	4.38	1.62	2.99	***	2.34	4.33	1.56	2.81	***
Share innov. mkt. exp. of sales	0.38	1.07	0.74	1.40	0.00	0.00	***	0.54	1.39	0.24	0.62	***	0.48	1.27	0.26	0.77	***
Share non-innov. mkt. exp. of sales	1.60	3.09	2.11	3.75	1.06	2.02	***	1.85	3.53	1.38	2.60	**	1.86	3.55	1.30	2.38	***
Share R&D exp. of sales	5.01	13.05	4.69	9.97	5.35	15.70		6.89	15.10	3.27	10.54	***	8.32	16.75	1.00	2.73	***
Patent stock per 100 employees	1.34	10.30	1.21	5.91	1.48	13.53		0.58	3.36	2.03	13.88	**	1.87	13.05	0.70	5.30	***
Firm age (years)	20.47	17.76	20.99	18.23	19.90	17.24		16.11	11.03	24.48	21.46	***	18.70	14.48	22.60	20.87	***
No of employees	345	2572	511	3547	165	382	**	18	11	645	3540	***	330	3258	362	1341	
Share exports of sales	22.90	26.51	23.06	26.01	22.74	27.07		14.86	22.85	30.30	27.49	***	25.47	27.26	19.81	25.26	***
Location East Germany (d)	0.35	0.48	0.32	0.47	0.38	0.49	**	0.46	0.50	0.25	0.43	***	0.37	0.48	0.32	0.47	
Firm is part of group (d)	0.37	0.48	0.39	0.49	0.34	0.48		0.13	0.34	0.59	0.49	***	0.36	0.48	0.38	0.48	
Process innovation (d)	0.54	0.50	0.61	0.49	0.47	0.50	***	0.48	0.50	0.60	0.49	***	0.54	0.50	0.54	0.50	
Herfindahl index (*1000)	4.85	9.07	5.08	9.45	4.60	8.64		4.79	9.94	4.91	8.19		5.16	8.69	4.47	9.50	
Industry marketing int. (ratio)	1.31	0.61	1.37	0.64	1.24	0.58	***	1.40	0.59	1.22	0.62	***	1.42	0.45	1.18	0.75	***
Low-tech manuf. (d)	0.36	0.48	0.35	0.48	0.37	0.48		0.32	0.47	0.40	0.49	**			0.80	0.40	
Medium high-tech manuf. (d)	0.20	0.40	0.19	0.39	0.21	0.41		0.16	0.36	0.24	0.43	***	0.36	0.48			
High-tech manuf. (d)	0.13	0.34	0.16	0.36	0.11	0.31	**	0.14	0.35	0.13	0.34		0.24	0.43			
Distributive services (d)	0.09	0.29	0.09	0.29	0.09	0.29		0.09	0.29	0.09	0.28				0.20	0.40	
Knowledge-intens. services (d)	0.05	0.23	0.05	0.22	0.06	0.24		0.05	0.21	0.06	0.24		0.10	0.30			
Technological services (d)	0.16	0.37	0.16	0.37	0.15	0.36		0.24	0.43	0.08	0.27	***	0.29	0.45			
No. of obs.	866		449		417			415		451			474		392		

(d) dummy variable; * p<0.10, ** p<0.05, *** p<0.01

Table 2: Firms performing technological and/or marketing innovation (all firms)

Firm invests into technological innovation			Firm invests into marketing innovation		
			No	Yes	Total
No		Obs.	195	144	339
		Row %	*57.5*	*42.5*	*100.0*
		Column %	*46.8*	*32.1*	*39.2*
Yes		Obs.	222	305	527
		Row %	*42.1*	*57.9*	*100.0*
		Column %	*53.2*	*67.9*	*60.9*
Total		Obs.	417	449	866
		Row %	*48.2*	*51.9*	*100.0*
		Column %	*100.0*	*100.0*	*100.0*

Pearson chi2(1) = 19.6***

Table 3: Firms performing technological and/or marketing innovation (firms <50 employees)

Firm invests into technological innovation			Firm invests into marketing innovation		
			No	Yes	Total
No		Obs.	114	75	189
		Row %	*60.3*	*39.7*	*100.0*
		Column %	*51.8*	*38.5*	*45.5*
Yes		Obs.	106	120	226
		Row %	*46.9*	*53.1*	*100.0*
		Column %	*48.2*	*61.5*	*54.5*
Total		Obs.	220	195	415
		Row %	*53.0*	*47.0*	*100.0*
		Column %	*100.0*	*100.0*	*100.0*

Pearson chi2(1) = 7.4***

Table 4: Firms performing technological and/or marketing innovation (high-tech firms)

Firm invests into technological innovation			Firm invests into marketing innovation		
			No	Yes	Total
No		Obs.	77	57	134
		Row %	*57.5*	*42.5*	*100.0*
		Column %	*34.4*	*22.8*	*28.3*
Yes		Obs.	147	193	340
		Row %	*43.2*	*56.8*	*100.0*
		Column %	*65.6*	*77.2*	*71.7*
Total		Obs.	224	250	474
		Row %	*47.3*	*52.7*	*100.0*
		Column %	*100.0*	*100.0*	*100.0*

Pearson chi2(1) = 7.8***

Table 5: Tobit results for the share of sales with new products

	Model I Full sample	Model II Full sample	Model III Full sample	Model IV Firms < 50 empl.	Model V Firms ≥ 50 empl.	Model VI High-tech firms	Model VII Low-tech firms
Patent stock per 100 empl.	0.21**	0.16*	0.16*	0.27	0.16**	0.17*	0.10
	(0.09)	(0.09)	(0.09)	(0.45)	(0.08)	(0.09)	(0.26)
Firm age (years, log)	-5.41***	-5.27***	-5.25***	-10.56***	-2.97**	-5.98***	-4.42**
	(1.34)	(1.29)	(1.28)	(2.61)	(1.40)	(1.73)	(1.91)
No of employees (log)	2.12***	2.31***	2.42***	3.65	0.98	1.97*	3.18***
	(0.77)	(0.74)	(0.74)	(2.25)	(1.12)	(1.01)	(1.11)
Share exports of sales	0.21***	0.17***	0.17***	0.25***	0.13***	0.19***	0.15**
	(0.04)	(0.04)	(0.04)	(0.07)	(0.05)	(0.06)	(0.06)
Location East Germany (d)	8.65***	6.00***	6.21***	4.97	5.87**	4.35	8.26**
	(2.19)	(2.14)	(2.14)	(3.33)	(2.92)	(2.86)	(3.24)
Firm is part of group (d)	2.26	2.86	2.7	1.18	3.36	1.77	4.26
	(2.38)	(2.29)	(2.29)	(4.75)	(2.48)	(3.05)	(3.46)
Process innovation (d)	2.53	2.05	1.95	1.12	2.78	2.18	0.54
	(1.98)	(1.91)	(1.91)	(3.17)	(2.34)	(2.53)	(2.91)
Herfindahl index (*1000)	0.19*	0.18*	0.18*	0.18	0.26*	0.22	0.14
	(0.11)	(0.11)	(0.11)	(0.17)	(0.14)	(0.15)	(0.15)
Ind. marketing int. (ratio)	6.23***	5.20***	5.04***	4.05	5.00**	5.00	5.31***
	(1.79)	(1.73)	(1.72)	(3.02)	(2.04)	(3.56)	(1.97)
Low-tech manuf. (d)							8.19**
							(4.00)
Med. high-tech manuf. (d)	6.61**	5.08*	5.09*	3.46	5.93**	-3.40	
	(2.76)	(2.67)	(2.66)	(4.87)	(3.00)	(3.86)	
High-tech manuf. (d)	12.42***	9.87***	9.69***	11.67**	6.79*	0.94	
	(3.30)	(3.20)	(3.19)	(5.30)	(3.92)	(4.26)	
Distributive services (d)	-8.36**	-8.52**	-8.42**	-29.12***	2.33		
	(4.07)	(3.92)	(3.91)	(7.81)	(4.50)		
Knowl.-intens. services (d)	-4.05	-4.04	-3.92	-3.03	-3.94	-11.69**	
	(4.84)	(4.65)	(4.64)	(8.19)	(5.42)	(5.39)	
Technological services (d)	18.75***	8.52***	8.54***	6.56	11.61**		
	(3.04)	(3.22)	(3.21)	(4.59)	(4.95)		
Share innov. mark. exp. of sales		2.98***	4.55***	5.01***	2.9	5.76***	2.32
		(0.88)	(1.15)	(1.55)	(1.97)	(1.47)	(1.90)
Share R&D exp. of sales		0.53***	0.59***	0.71***	0.35***	0.57***	1.86***
		(0.08)	(0.08)	(0.12)	(0.12)	(0.09)	(0.64)
Int. innov. mark. * R&D			-0.09**	-0.12**	0.31	-0.12**	-0.08
			(0.04)	(0.05)	(0.28)	(0.05)	(0.50)
Constant	-1.68	-1.09	-1.79	9.19	0.04	10.56	-16.38**
	(5.65)	(5.47)	(5.46)	(10.37)	(8.09)	(8.38)	(7.97)
Sigma	27.32***	26.29***	26.21***	29.11***	23.35***	26.13***	25.94***
	(0.80)	(0.77)	(0.77)	(1.34)	(0.88)	(0.98)	(1.22)
Pseudo R2 (Aldrich-Nelson)	0.21	0.26	0.26	0.34	0.19	0.25	0.18
N	866	866	866	415	451	474	392
LR Chi2	195.68	252.91	257.28	173.98	94.71	138.84	74.86
P-value	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Coefficients are shown; standard errors in parentheses; (d) dummy variable; * p<0.10, ** p<0.05, *** p<0.01

Table 6: Tobit results for the share of sales with new products (consistency checks)

	Model VIII Firms < 10m EUR sales	Model IX Firms ≥ 10m EUR sales	Model X NACE 15, 16 excluded	Model XI Control for non- innov. mark.
Patent stock per 100 employees	0.35	0.16*	0.15*	0.16*
	(0.45)	(0.08)	(0.09)	(0.09)
Firm age (years)	-7.65***	-4.04***	-5.58***	-5.30***
	(2.66)	(1.39)	(1.32)	(1.28)
No of employees (log)	1.18	2.08**	2.45***	2.41***
	(2.07)	(0.97)	(0.76)	(0.74)
Share exports of sales	0.33***	0.10**	0.18***	0.17***
	(0.08)	(0.05)	(0.04)	(0.04)
Location East Germany (d)	4.42	9.14***	6.24***	6.48***
	(3.44)	(2.80)	(2.21)	(2.15)
Firm is part of group (d)	7.84	0.13	2.59	2.84
	(5.28)	(2.39)	(2.34)	(2.29)
Process innovation (d)	0.71	3.57	1.98	2.09
	(3.32)	(2.25)	(1.95)	(1.91)
Herfindahl-Hirschman index (*1000)	0.16	0.17	0.18*	0.18*
	(0.18)	(0.13)	(0.11)	(0.11)
Industry marketing intensity (ratio)	5.42*	4.03**	4.72***	4.92***
	(3.12)	(2.03)	(1.74)	(1.72)
Medium high-tech manuf. (d)	0.66	7.86***	3.93	5.08*
	(5.29)	(2.88)	(2.73)	(2.66)
High-tech manuf. (d)	11.98**	7.87**	8.75***	9.54***
	(5.74)	(3.69)	(3.25)	(3.19)
Distributive services (d)	-28.73***	-1.22	-9.81**	-8.57**
	(8.63)	(4.20)	(3.99)	(3.91)
Knowledge-intens. services (d)	-5.82	1.96	-5.26	-3.86
	(7.12)	(6.89)	(4.72)	(4.64)
Technological services (d)	6.47	11.68**	7.49**	8.43***
	(4.67)	(5.13)	(3.28)	(3.21)
Share innov. marketing exp. of sales	4.85***	3.10	4.45***	4.09***
	(1.58)	(1.95)	(1.18)	(1.21)
Share R&D exp. of sales	0.68***	0.34**	0.58***	0.58***
	(0.12)	(0.13)	(0.08)	(0.08)
Interaction innov. marketing * R&D	-0.10*	0.31	-0.09**	-0.10**
	(0.05)	(0.28)	(0.04)	(0.04)
Share non-innov. mkt. exp. of sales				0.42
				(0.35)
Constant	5.3	0.63	0.56	-2.06
	(10.38)	(7.24)	(5.67)	(5.47)
Sigma	29.52***	23.12***	26.43***	26.19***
	(1.42)	(0.85)	(0.79)	(0.77)
Pseudo R2 (Aldrich-Nelson)	0.34	0.20	0.26	0.26
N	394	472	834	866
LR Chi2	166.07	101.03	244.79	258.75
P-value	0.00	0.00	0.00	0.00

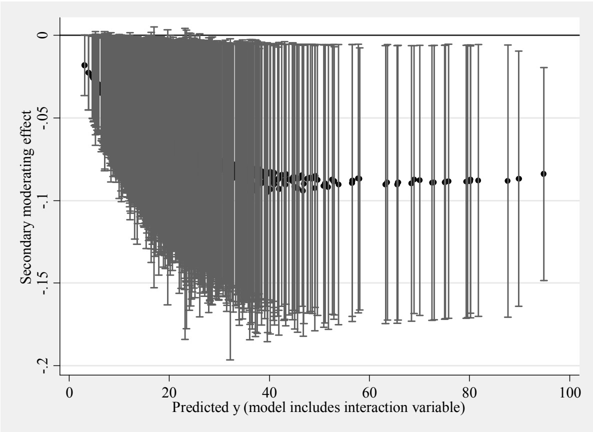
Coefficients are shown; standard errors in parentheses; (d) dummy variable; * p<0.10, ** p<0.05, *** p<0.01

APPENDIX

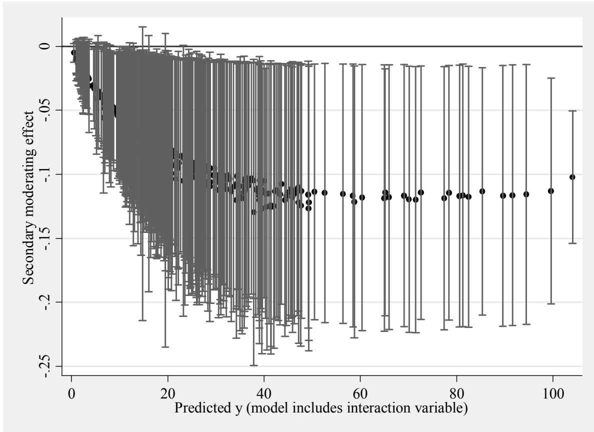
Table 7: Correlation table

	Variable	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)
(1)	Share innov. mkt. exp. of sales	1.00														
(2)	Share R&D exp. of sales	0.16	1.00													
(3)	Patent stock per 100 employees	0.01	0.07	1.00												
(4)	Firm age (years, log)	-0.08	-0.08	0.02	1.00											
(5)	No of employees (log)	-0.15	-0.14	0.09	0.20	1.00										
(6)	Share exports of sales	-0.02	0.00	0.05	0.09	0.33	1.00									
(7)	Location East Germany (d)	0.06	0.21	-0.04	-0.26	-0.25	-0.18	1.00								
(8)	Firm is part of group (d)	-0.08	-0.10	0.10	0.10	0.52	0.23	-0.19	1.00							
(9)	Process innovation (d)	0.00	0.01	0.00	0.01	0.15	-0.02	-0.01	0.09	1.00						
(10)	Herfindahl-Hirschman index (*1000)	-0.02	-0.02	0.00	-0.04	0.03	0.03	0.00	0.06	0.02	1.00					
(11)	Industry marketing intensity (ratio)	0.13	0.16	0.02	-0.02	-0.15	0.06	0.06	-0.07	-0.06	0.03	1.00				
(12)	Medium high-tech manuf. (d)	-0.04	-0.03	0.07	0.00	0.11	0.29	-0.10	0.06	0.00	0.01	-0.07	1.00			
(13)	High-tech manuf. (d)	0.01	0.05	0.02	-0.03	-0.01	0.18	0.00	0.08	-0.04	0.26	0.30	-0.20	1.00		
(14)	Distributive services (d)	-0.06	-0.11	-0.04	0.03	0.03	-0.18	-0.03	0.03	0.01	0.04	-0.29	-0.16	-0.12	1.00	
(15)	Knowledge-intens. services (d)	-0.04	-0.08	-0.02	0.00	-0.01	-0.19	0.05	-0.02	0.05	-0.10	-0.15	-0.12	-0.09	-0.08	1.00
(16)	Technological services (d)	0.20	0.42	0.00	-0.10	-0.26	-0.22	0.13	-0.14	0.01	-0.13	0.16	-0.22	-0.17	-0.14	-0.10
	VIF	1.07	1.32	1.03	1.11	1.67	1.41	1.19	1.42	1.04	1.10	1.29	1.34	1.43	1.25	1.16
	Mean VIF	1.28														
	Condition number	17.35														

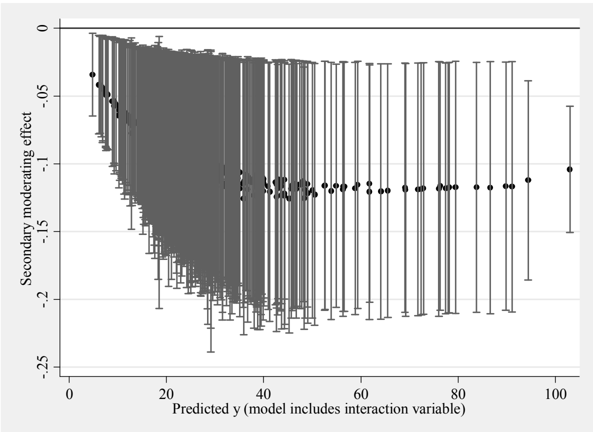
Figure 1: Secondary moderating effects



(a) full sample



(b) small firms



(c) high-tech firms

Note: Graphs show the secondary moderating effects (Wiersema & Bowen, 2009) at each observation for the interaction of technological innovation and marketing innovation in the three samples. The graphs also indicate the 95 percent confidence interval for each moderating effect. With few exceptions, the confidence interval does not intersect with the horizontal axis, indicating that the moderating effect is in fact significantly different from zero.