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# From R&D to market: using trademarks to capture the market capability of top R&D investors

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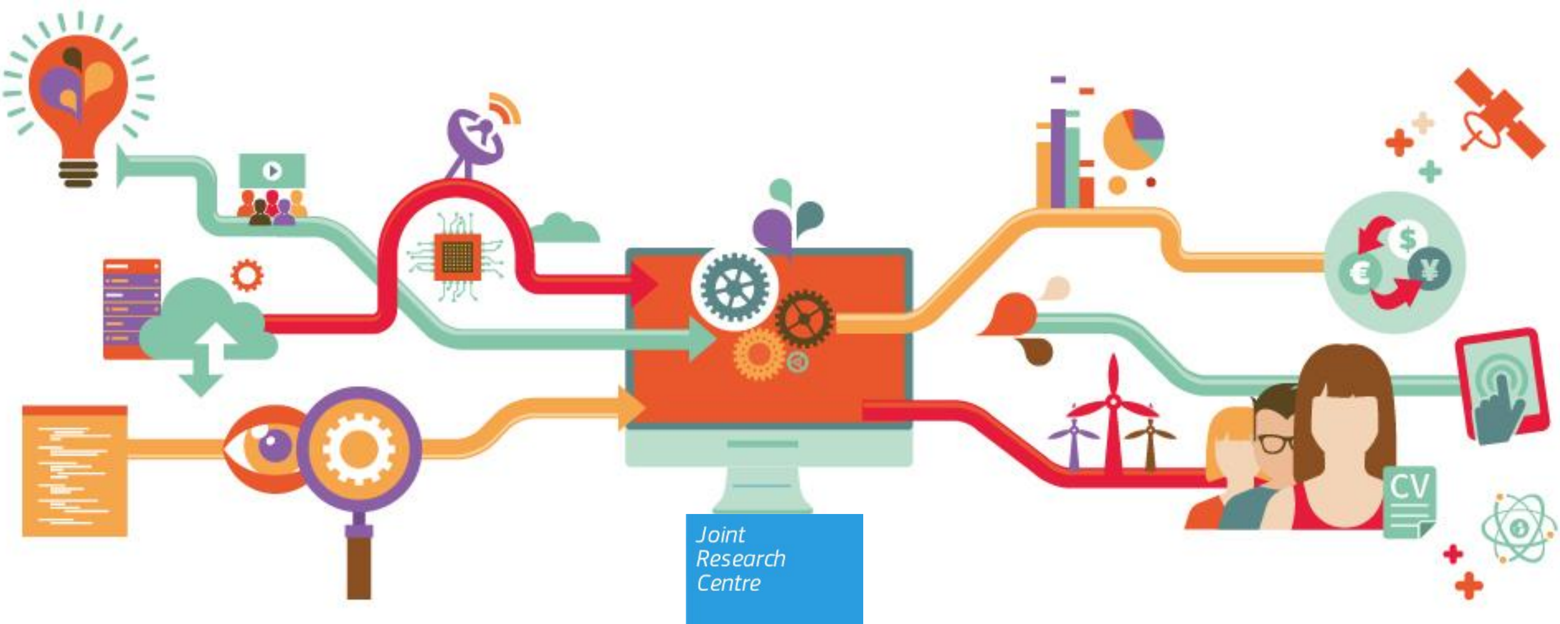


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# From R&D to market:
# using trademarks to capture the market capability of top R&D investors[1]

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## Abstract

This paper investigates the links between the market capability of top corporate R&D investors (EU Industrial R&D Investment Scoreboards), as captured by trademark data and their economic performance in terms of net sales growth. It provides empirical evidence to better understand the extent to which companies, operating in different industrial sectors, combine technological capabilities with commercialization efforts to generate and appropriate the economic returns of their R&D investments. This paper shows how different dimensions of firms' market capabilities can be captured through trademark indicators. The results suggest that complementing R&D efforts and patenting activities with strong and specific market capabilities can indeed yield significant growth premiums. Moreover, offering services seems to pay off depending on the intensity of R&D investments. Yet, a quantile regression approach and a series of robustness checks indicate that such effects differ across the quantiles of the conditional sales growth distribution.

*Keywords*: R&D, trademarks, innovation, sales, services

*JEL Classification:* O32, O34, L10

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## 1. Introduction

Corporate R&D activities are highly concentrated, and the EU Industrial R&D Investment Scoreboards identify those key companies driving R&D efforts worldwide[2]. The economic fates of these companies are strongly linked to their R&D budgets, as closely followed by market analysts. To have a real impact in their respective markets, these firms eventually have to turn their R&D into innovation output: new ideas, but also new products and services that successfully make it to the market and translate into increased sales revenues (Datta et al., 2015). Typical econometric studies investigating the impact of innovation on firm performance often include a direct link from R&D expenses to economic performance and assume an underlying mechanism of R&D translating into new ideas and then eventually new market offerings (Greenhalgh and Rogers, 2010). Yet, the road from R&D to market is a perilous one, even for the large companies with conspicuous R&D and marketing budgets. Companies' R&D efforts may fail to generate revenues from actual market sales, as firms differ in their capability to turn those inventions into actual new products and services sold in the marketplace. The latter capability entails very different skills from the ones relevant for R&D activities instead (Janssen et al., 2016). Eventually, innovation is a product of both technological and market capabilities of firms (Arora and Nandkumar, 2012). While patents have been used widely and meaningfully to gauge the inventive output of R&D investors and their technological capabilities in econometric studies, less attention has been given in these studies to the innovation output of R&D.

A recent empirical research strand has turned to trademarks as a way to capture downstream capabilities in general (Giarratana and Fosfuri, 2007; Arora and Nandkumar, 2012; Huang et al., 2013) and specifically the market introduction of innovation (Mendonça et al, 2004; Flikkema et al., 2014). Trademarks[3] are distinctive signs (words, graphics, sounds, colours, etc.) associated with a good or service (WIPO, 2004). They fulfil two complementary roles. The first one is an identification role: they indicate the source or origin of a product. The second one is a differentiation role: they distinguish a good from competing offers by other entities in a given market (Ramello, 2006). A trademark owner has the exclusive right and also the obligation to use it in the market, the so-called 'use in market' requirement (Graham et al., 2013). While there is neither a novelty (as for patents) nor originality (as for copyrights) requirement to register a trademark, a new mark has to fulfil the main condition of 'distinctiveness' (WIPO, 2004). It must have a distinctive character from the viewpoint of the consumers, in such a way that it allows distinguishing and differentiating the products from the focal company among products in the market.

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[2] For more information on the sample of companies included in the EU Industrial and R&D Investment Scoreboard, see http://iri.jrc.ec.europa.eu/scoreboard.html

[3] Here we use the term trademarks to refer to both trade and service marks.

Trademark counts have been shown to be positively correlated to innovative capabilities at the firm level (Schautschick & Greenhalgh, 2016) and evidence at the trademark level also indicates that a large portion of trademarks does refer to innovation (Flikkema et al, 2014). Firstly, trademarks can capture innovation in later stages of the innovation process, namely commercialization (Nam and Barnett, 2011). A typical example is the standard strategy of pharmaceutical companies of protecting new chemical entities with patents and then building strong brands for the produced new drugs with trademarks and related marketing expenses (Reitzig, 2004). Here trademarks act as complements to R&D and patents. Secondly, trademarks can help identify non-patentable innovations, such as non-technological forms of innovation or service innovation (Flikkema et al, 2014). In this case, trademarks are really used as substitutes to patents.

Departing from this background, we aim at exploiting trademark data to capture the ability of top R&D investors to turn R&D into new market offerings. Our research question is: *to what extent does the market capability of top R&D investors, as captured by trademark data, explain their differential growth performance?*

Our analysis makes several original contributions to the innovation literature at the firm level. Firstly, we consider the combined effect of technological and market capabilities, capturing the latter with original indicators based on trademark data. Secondly, we investigate the effect of specific qualities of trademark portfolios, in particular their diversification and service intensity, thereby we extend recent studies that have only exploited trademark stocks. We also discuss how the indicators we propose have the potential to be used in the wider management research as well. Thirdly, we offer a new methodological approach by relying on quantile regressions, which allow us to gauge how the relation of our key variables to sales growth differs at different levels of the variables.

The remaining of the paper is organised as follows. Section 2 reviews the research background, focusing on recent studies exploiting trademark data. Section 3 details the methodological approach adopted for the study. Section 4 presents the results of the empirical analyses on the links between trademarks and economic performances. Section 5 concludes.

## 2. Research background

The economic rationale behind trademark systems rests upon the market failures that typically arise in case of information asymmetries between buyers and sellers (see the classical reference of Akerlof, 1970 and his market for 'lemons'). Trademarks can help overcome such market failures through two mechanisms (Economides, 1988). Firstly, they help reduce transaction costs by signalling the origin of the good, thereby reducing consumers' search costs. Secondly, they provide incentives for producers to invest in the quality of their products (Milgrom and Roberts, 1986). In this interpretation, trademarks basically fulfil an informational function (Ramello and Silva, 2006).

Firms have several motives to register trademarks. These can be grouped into protection, marketing and exchange motives (Flikkema et al., 2014; Block et al., 2015, Castaldi, 2018). First, trademarks are used for their primary function of intellectual property rights, namely to protect from imitation (Hurmelinna-Laukkanen and Puumalainen, 2007). Second, they are used to support differentiation strategies (Ramello and Silva, 2006), which ultimately allow companies to earn excess returns thanks to the possibility of charging higher prices for branded products. In this sense, trademarks are the legal basis for building valuable brands and brand equity (Keller, 1993; Keller and Lehmann, 2006). Thirdly, trademarks can also be traded and used as leverage in external relations with suppliers, licensor, etc. (Graham et al., 2015).

## 2.1 Trademarks and innovation

A link between trademarks and innovation was convincingly put forward by Mendonça et al. (2004) a decade ago. Since then, several innovation researchers have picked up the challenge of developing innovation indicators based upon trademark data. Trademark-based indicators are now increasingly included in innovation rankings at the country level, such as the Innovation Union Scoreboard (EC, 2015) and policy reports (Dernis et al., 2015, OECD STI, 2015,).

Mendonça et al (2004) already discuss several reasons why trademark data could be used to construct meaningful indicators of innovation. Firstly, while patents refer more to inventions than innovations, trademarks can capture the commercialization of innovations. Trademarks are a tool for companies to signal new products in the market and marketing efforts can weigh as heavy as R&D efforts in the innovation value chain. This claim relies upon the informational role that trademarks fulfil. Whenever companies have invested in developing a new product, they will have the incentive to inform consumers in the marketplace of the quality of this innovation. Hipp and Grupp (2005) suggest indeed that trademarks may be a particular useful indicator for later stages of the innovation process, thereby providing complementary information to patent-based indicators (Llerena and Millot, 2013).

Secondly, trademarks are widely used across sectors (EPO-OHIM, 2013), and they can help to capture innovation activities in low-tech sectors as well. While patents always refer to technological innovation, trademarks can indicate non-technological innovation such as marketing innovation or organizational innovation (Millot, 2009), but also service innovation (Schmoch, 2003). In this perspective, trademarks can be considered as substitutes for patenting, since they offer an alternative formal tool available to protect non-patentable forms of innovation (Flikkema et al, 2014, 2015).

Thirdly, trademarks can be collected systematically from trademark offices[4] and are classified as protecting a good/service or a combination thereof following the Nice classification system (WIPO, 2013a), often complemented with a detailed description of the type of goods/services covered (Schmoch and Gauch, 2009). They also represent a meaningful indicator at different levels of aggregation, firm, sector or country, which makes them suitable for use also in aggregate indicators of innovation such as the EU Innovation Scoreboard.

When focusing on services, early evidence of the opportunities of using trademarks to proxy for innovation is presented in Schmoch (2003). His measure of innovation is taken from the Community Innovation Survey (CIS) and refers to the share of sales coming from new products and new services. He does not only look at simple correlations between innovation and trademarks, but also considers control variables including sector, firm size and measures of firm human capital, that might affect the firms' innovative success. He finds that the correlation between trademarks use and innovation is particularly significant in knowledge-intensive services, where patents are instead less related to innovation.

The above studies are illustrative but they are typically not based on multivariate testing (except for Schmoch, 2003). Instead, a handful of other studies (Allegrezza and Guard-Rauchs 1999, Millot, 2012, Götsch and Hipp, 2012) have engaged in developing testable models of the firm-level propensity to trademark. The question is then: are innovative firms more likely to use trademarks, after controlling for other factors?

Allegrezza and Guard-Rauchs (1999) provides an early attempt based upon a sample of Benelux firms. Their measure of trademark use is a binary variable indicating whether the firms have registered trademarks at all. While confirming the positive correlation between trademark use and R&D activities at the firm level, they introduce a number of interesting additional explanatory factors. They find that firms are more likely to use trademarks when they are large, when they gauge the risk of imitation by competitors to be high and when they are active in terms of exports. More recently, Millot (2012) shows theoretically and empirically that innovating firms have more economic incentives to trademark than imitating ones. Given that consumers have to recognize and value the innovation, her model predicts that the positive effect of trademarking are mostly there for product and marketing innovation and less so for process or organizational innovation. As far as the empirical results, she considers the use of patents and finds that the correlation of trademark use and product innovation only disappears in high-tech manufacturing after controlling for patent use. This suggests that in all sectors except high-tech manufacturing trademarks do bear additional informational content with respect to new products.

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[4] Since 1996, European firms can apply for the EU trademark (previously named Community Trademarks) at the EUIPO (previously OHIM) and an online database allows searching all registered or pending marks. The American office (USPTO) also offers an online search with a complete coverage going back to 1984.

Another empirical strategy to establish the link between trademarks and innovation is to perform trademark-level research and investigate whether individual trademarks refer to innovation or not. This is the strategy followed by Flikkema et al (2014) and Flikkema et al. (2015). A complementary strategy is to combine information on trademark registrations and new products announcements to also study to what extent individual product innovations are protected by a trademark. This labour-intensive type of research can only be conducted for selected sectors and this is indeed what Malmberg (2005) did. He reports significant heterogeneity in trademark use across sectors, when looking at manufacturing only. He finds that trademarks are poorly linked to new products in the electromechanical and automotive industry, while a consistently high share of new products in the pharmaceutical industry are protected with trademark registration. His main recommendation is that trademark-based indicators of innovation are only relevant for sectors with intensive use of trademarks and with products targeted at consumers and professional end-users.

## 2.2 Trademarks, market capabilities and economic performance

If one takes seriously the claims that trademarks capture innovation capabilities of firms, then a positive relation between trademarks and firm performance will be expected. In this case, the main implication is that trademarks signal product and service innovation, which in turn allows firms to reap economic benefits from sales of novel, improved offerings in the marketplace (Greenhalgh and Rogers, 2012). More generally, several studies have also used trademarks to proxy for different forms of intangible assets, including reputation and brand equity (WIPO 2013b). Brands easily account for half or more of the market value of the some of the large global enterprises such as Apple or Google (Corrado and Hulten, 2010) and brand equity is found as a key driver of economic performance across sectors (Vomberg et al., 2015). Trademarks can be seen as a weapon in the 'semiotic struggle' (Mendonça, 2014) where companies increasingly engage in persuading consumers of their value propositions.

Schautschick and Greenhalgh (2016) offer a comprehensive review of empirical studies of trademarks in the economic literature. They discuss three main approaches for studying the relation between trademarks and economic performance: *(1)* market value studies, *(2)* profitability studies *(3)* survival studies. Most existing studies are market value studies, therefore we will focus on those here.

The overall picture stemming from these studies is that trademarks are positively related to market value, albeit under some conditions. For instance, Greenhalgh and Rogers (2012) systematically investigate a large sample of UK firms and study both the effect of trademark activity as such (comparing companies owning at least a trademark and companies owning none) and of trademark intensity. While they do find a strong effect on market value for the trademark activity dummy, the results for trademark intensity are less clear cut and suggest in fact a non-linear relation, with decreasing returns appearing at higher levels of trademark intensity.

Sandner and Block (2011) look at the combined effects of R&D, patents and trademarks and find a strong effect of trademark stocks on firms' valuations. Information on trademark stocks partly overlaps with information on patent counts, suggesting complementarity of the two indicators. Measures of value of trademarks are also used. Interestingly, trademark breadth, as measured by the number of Nice classes covered by companies' trademark portfolios seem to imply a discount in market valuations for highly diversified companies. In more recent work, Block, Sandner and co-authors suggest going beyond merely counting trademarks and propose a classification of new trademark filings under different brand strategies, such as brand extending, modernizing and creating (Block et al, 2014). The empirical results show that market value is positively affected by trademark filings aimed at extending existing brands, while the effect is negative for creation of new brands. This might be inconsistent with the idea that new trademarks refer to innovation, but could also be taken as the starting point for further research on the linkages between trademark families and types of innovation, as Flikkema et al. (2015) attempt to do.

Dosso and Vezzani (2017) examine the impact of patents and trademarks on the financial markets' valuation of R&D-driven innovative firms. Their study is particularly relevant for our purposes here since they also investigate top R&D investors worldwide and accounts for the interactions between patents and trademarks. Their original contribution lies in distinguishing the effects of an increase in market value deriving from additional innovative output (labelled within-effects) with respect to the premium received for being more innovative than their competitors (labelled between-effects). In line with Zhou et al (2016)[5], their study confirms the existence of patent-trademark complementarities in relation to the financial performance of top R&D investors, although specific industry patterns are observed.

In sum, the emerging empirical literature linking trademarks to economic performance provides clear evidence that trademarks entail positive returns to companies. The econometric studies rest, more or less explicitly, on a combination of theoretical mechanisms highlighted in the management and marketing literature, suggesting that trademarks capture reputational assets, innovation and downstream capabilities.

The main methodological limitations of this literature are two. First, most studies are market value studies, thereby they focus on intellectual property rights as intangible assets of companies and on valuation in financial markets. In our study we will shift attention to sales growth, to directly capture the impact of trademarks on changes in market sales. Second, the current studies have mostly used trademark stocks or even binary variables of trademark use, with only rare attempts towards extracting more information from trademark records. In our study, we develop novel firm-level

[5] Zhou et al (2016) exploit a sample of start-ups to show the existence of complementary effects of patents and trademarks on the venture capital funding.

indicators able to shed light on the quality rather than the quantity of trademark portfolios.

## 3. Hypotheses development

Based upon the previous discussion, new trademarks can be used to capture the ability of Scoreboard companies to introduce new offerings in the market, what we will refer to as 'market capability'. We take stock of the ideas, reviewed in the previous section, that new trademark applications reveal process efforts (actual activities and commitments) related to the market introduction of innovation. In this interpretation, trademark portfolios of companies can proxy for underlying market capabilities. While some companies may be particularly skilled at developing technical inventions, they may have weaker capabilities when it comes to turning those inventions into new offers in the market. Company growth measured in net sales growth is well-suited to test for the effect of market capabilities. We propose the following:

> *Hypothesis 1: Market capability, as captured by trademark stocks, is positively related to top R&D investor's sales growth.*

Yet, market capabilities can also be thought of as enhancing the effect of technological capabilities on sales growth. This is in relation with the interpretation that technological and market capabilities should be thought as complementary in innovation processes: they reinforce each other and refer to different phases of the innovation processes (Sandner and Block, 2011).

> *Hypothesis 2: For top R&D investors, market capability strengthens the relation between corporate technological capabilities and sales growth.*

Firms can be compared in terms of their trademark counts, yet, an important caveat when working with trademark data is that trademark counts depend as much on firm-specific strategies as they depend on sectoral level specificities. Sectoral differences tend to be strongest in explaining differences in trademark strategy (Malmberg, 2005; Flikkema et al., 2014, Dosso and Vezzani, 2017), as there are sectors where it is common to trademark each new product model (like in the Automotive sector) and other sectors where companies will only trademark the company name (typically in low-tech service sectors). The idea that sectoral differences matter resonates with the broader debate within the innovation literature (Srholec and Verspagen, 2012). All in all, meaningful cross-firm comparisons are only possible within given sectors with similar tendencies to trademark.

> *Hypothesis 3: For top R&D investors, the relation of market capability with sales growth depends upon the industry considered.*

While the size of their trademark portfolio may shed light on the strength of companies' market capabilities, the quality of the trademark portfolio also reveals salient information about the company's route to the market. We focus here on the diversification of the trademark portfolio. The top R&D investors are large companies with a significant level of product diversification. Related diversification, i.e. diversification that can rely to a large extent upon forms of economies of scale/scope, is typically seen as a driver of firm level economic performance (Teece, 1982; Teece et al, 1994). Empirical studies have looked at corporate diversification along different dimensions. One typical way is by considering the technological diversification of companies, as captured by the patent classes where firms own patents (Breschi et al 2003). Concentration in patent classes is the antagonist measure, indicating the extent to which companies focus their patenting efforts in a limited set of technological fields (Dernis et al, 2015). For technological diversification of the top R&D investors holds: first, average company diversification differs substantially across sectors; second, technological diversification is positively correlated to subsidiary diversification as measured by the number of industries covered by the companies' subsidiaries (Dernis et al, 2015, p. 34-35). An additional dimension of diversification can refer to the actual markets where companies are active, which can be traced by the market coverage of the trademarks owned by the companies. Measures of diversification using trademarks are rather novel, but there are seminal attempts in specific sectors (Gao and Hitt, 2012, Castaldi and Giarratana, 2018). There are two different ways in which we envision capturing trademark diversification:

a. Diversification across Nice classes: trademarks are registered for specific market segments, classified in 45 Nice classes. Because of the 'use in market' requirement, Nice classes coverage is highly correlated to the actual markets where companies introduce their products. This study focuses on trademark portfolios breadth, indicating the number of Nice classes covered.
b. Goods-service diversification: Nice classes cover both goods and services. Single trademarks can cover both goods and service classes. While goods classes are the traditionally preferred classes for R&D intensive firms, coverage of service classes indicates that the companies are also active in developing complementary services next to their new product development efforts. This study looks at the trademark portfolios service intensity.

As for trademark portfolio breadth**,** theories on corporate diversification suggest that diversification tends to have a curvilinear relation to economic performance (Palich et al., 2000). Diversification is positively related until a threshold after which diseconomies of scale/scope emerge. There is evidence for this mechanism when it comes to technological diversification, but testing this hypothesis using trademark diversification has not happened yet.

*Hypothesis 4: There is an inverted-U relation between corporate trademark diversification and top R&D investors' sales growth.*

As for trademark portfolios service intensity, services are increasingly seen as a source of additional profits for manufacturing firms: while profit margins on manufactured goods tend to be small due to strong competition and high product turnover, margins on services are higher (Vandermerwe and Rada, 1989; Cusumano et al., 2015). Manufacturing firms able to develop business models where services are involved are found to enjoy higher revenues and higher customer satisfaction (Janssen et al., 2016, Janssen and den Hertog, 2016). This study exploits the trademark portfolios service intensity as a measure of the market capability of offering services.

> *Hypothesis 5: There is a positive relation between the service intensity of trademark portfolios and sales growth for the top R&D investors.*

# 4. Methods and data

## 4.1 Data

The starting point for this study is the list of Top R&D investors worldwide from the 2013 edition of the *EU Industrial R&D Investment Scoreboard* (European Commission, 2013). This data source includes historical economic and financial information on the world's largest R&D investing companies, accounting for more than 80% of business R&D expenditures worldwide. Data are collected from the companies' annual reports and accounts from Bureau van Dijk Electronic Publishing GmbH. The main variable is the R&D investment which corresponds to the cash investment funded by companies themselves. In addition to R&D figures, data such as net sales, operating profits and market capitalisation are provided. Companies are assigned to the country of registered office and refer to the ultimate parent company. Consistently, the industrial affiliation of parent companies is reported according to the 3-digit level of the Industry Classification Benchmark (ICB).[6]

In collaboration with the OECD, the European Commission-Joint Research Centre has collected patents and trademarks of the Scoreboard (SB) companies (about 2000 companies), edition 2013, relying on the companies and their structure of subsidiaries (more than 500. 000 subsidiaries) as reported in the ORBIS database.[7] The report presenting the dataset (Dernis et al, 2015) offers a comprehensive view of the intellectual property rights (IPR) bundles of top R&D investors. As that report is essentially descriptive in nature, this study complements it by offering a first explanatory analysis taking stock of their matching efforts.

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[6] More details about the ICB classification can be found at http://www.ftse.com/products/indices/icb

[7] ORBIS is a commercial database of Bureau van Dijk, which provides economic and financial company information.

In particular, we exploit here the matched data on all new trademarks applications filed between 2005 and 2012 at the USPTO[8]. This office is the preferred one for the trademark applications of most companies, except for Japan. This holds true also for their patenting activities (Dernis et al, 2015). We consider only new trademarks filed by the top R&D investors in the years considered, not all existing 'live' ones. This choice allows us focusing both on innovation-related activities and on current capabilities.

Trademarks are classified according to the Nice classification of goods and services, covering 45 classes: classes from 1 to 34 cover goods and classes 35-45 cover services (WIPO, 2013a). Each trademark can be applied for use in several markets, thus it can cover multiple classes. There are two reasons why companies do not file trademarks covering all classes. First, they have to show that the trademarks will actually be used in those markets. Secondly, fees typically increase with the number of trademarks.[9]

Dernis et al (2015) warn about a caveat when using the IPR data. The matching of patent and trademark data to top R&D investors has been done by assuming the 2012 corporate structure for all years. The authors suggest that this assumption might be easily fulfilled for the years 2010-2012, but for earlier years the matching of company and controlled subsidiaries to IPR data is likely to be less reliable. Because of this, this study will focus on explaining growth in the years 2010-2012 with trademark-based variables in 2010. Earlier years will nonetheless be used for the calculation of stock variables.

For the top R&D investors worldwide as listed in SB 2013 edition, the JRC has several company data available. This study will focus on the information on the main sector of activity, the year net sales figures and the R&D investment and patents all available for the years 2005-2012. Finally, it should be noted that trademarks are salient data for top R&D investors since these firms are all active in the registration of intellectual property rights.

## 4.2 Econometric strategy

The aim of the econometric analysis is to find empirical evidence supporting or rejecting the theoretical hypotheses on market-related antecedents of growth. We

[8] The USPTO and EUIPO are the two main offices for the trademark application of top R&D investors. Given the different institutional requirements and market-specific corporate strategies, exploiting information from the two offices make sense, assuming that the related variables should bear explanatory power. However, when including patents and trademarks from the two offices, the EUIPO variables turned out to be non-significant, suggesting that their additional informational value is negligible. Therefore, we focus on USPTO applications only and include a US dummy to control for home-market bias.

[9] Notice though that the European office has a system where the basic fee covers up to 3 Nice classes and proportional fees only apply from the fourth class.

follow the standard modelling approach of growth regressions where the Gibrat law of proportionate growth is taken as the baseline model. In Gibrat type of regressions, the logarithmic growth at time t is modelled as a function of the initial value of the relevant size. Greenhalgh et al. (2011) already applied this approach in an empirical study on the effect of trademarking and branding, on a sample of UK firms.

Firm growth rates, however measured, are well known to exhibit highly skewed distributions (Bottazzi and Secchi, 2006). This skewness makes the application of OLS estimates problematic since extreme values are misrepresented. One way to deal with a skewed distribution in the dependent variable is to exploit quantile regressions and rely on Least Absolute Deviation (LAD) estimation techniques to obtain better coefficient estimates (Coad and Rao, 2008). LAD estimates are based on minimizing the absolute deviation from the median instead of the squared deviation from the mean as in the case of Ordinary Least Squares (OLS) estimates. The median is a better reference for skewed distributions than the average and quantile regressions also allow checking how estimated coefficients vary across quantiles. After inspecting the growth distribution of Top R&D investors to establish non-normality, quantile regressions will be exploited. As noted by Yaffee (2002), standard errors of LAD estimates tend to be underestimated. To overcome this issue, we bootstrap the estimates based on 100 replications. Unless otherwise noted all estimates reported in the results are obtained from bootstrapping.

## 4.3 Definition of variables

<u>Dependent variable</u>

In this study we focus on growth of net sales as the variable of theoretical interest. As already explained, this definition of growth fits well with the theoretical mechanisms behind the proposed hypothesis. In particular, firms active in applying trademarks are expected to be better able to introduce products and services in the market and this ability should translate directly in above average growth in sales.

The dependent variable will be the logarithmic growth of net sales measured in the last three years of data available.

$GROWTH_{2010\text{-}2012} = \ln(NET\ SALES_{2012}) - \ln(NET\ SALES_{2010})$

<u>Independent variables</u>

Following the structure of Gibrat regressions, the first independent variable to be included is the initial value of net sales for the period considered, in logarithmic terms, *ln(NET SALES* $_{2010}$*).*

Another key independent variable included is the *R&D stock*, capturing investment in technological capabilities. Following the widely accepted definitions by Hall and Oriani (2006), we use a depreciation rate of 15%.

Variables of theoretical interest.

*Market capability (H1, H2 and H3):* the strength of market capability is operationalized by trademark stock in 2010. Trademark stocks are preferred to simple trademark counts since new trademarks are accumulated in trademark portfolios (Sandner and Block, 2011) and often more specifically in trademark families (Block et al., 2014; Flikkema et al. 2015). Given the availability of counts of new trademarks from 2005, the stocks rely on six years of data. In line with Greenhalgh et al. (2011), trademark stocks are calculated similarly to R&D stocks, with a depreciation rate of 15%. Depreciation of trademarks can be thought to happen for two main reasons. First, trademarks can be abandoned, either actively (by requesting so) or passively (by failing to pay renewal fees). A second reason relates to actual loss of value and relevance because of a new market focus. In this sense, trademarks bear similar properties to other knowledge assets, but the knowledge involved is of a different nature, namely market-related and symbolic (Ramello and Silva, 2006). According to Sandner and Block (2011), who opt instead for a null depreciation rate, trademark abandonment is a rare event. Yet, we consider the second mechanism, i.e. the loss of relevance for the company to be a much more likely process and we stick to the 15% depreciation rate.

$\text{TM stock}_{2010} = \text{new TMs}_{2009} + (1\text{-depreciation rate}) * \text{TM stock}_{2009}$

*Trademark diversification (H4 and H5):* in this study we focus on two measures of diversification.

The first is the average breadth of trademark portfolios, as measured by the average number of Nice classes covered by the trademarks filed by the top R&D investors for each year. The actual variable included in the model is the 3-years average in the period 2008-2010, $BREADTH_{2008\text{-}2010}$, to limit the effects of important annual variability. We refer to Haans et al. (2016) for a robust empirical test of curvilinear relations.

As for H5, we exploit the distinction of goods *vs* services classes in the Nice classification. For each trademark we can record whether it covers at least a Nice service class. Next, we can count the number of trademarks by company and by year that covers at least a service class. The service intensity of the trademark portfolio of a company in a given year is simply the share of trademarks covering at least one service class on the total trademarks filed. Notice that this is a rather lenient measure of service intensity and it includes also the cases of trademarks covering service classes only.

For all independent variables, sectoral means are included as well, to control for cross-sectoral heterogeneity in R&D levels, trademarking, trademark breadth and service propensity.

# 5. Results

## 5.1 Descriptives

We start by investigating the statistical features of the distribution of net sales growth rates, the dependent variable of this study. As expected from previous literature, we find that this distribution is not Normal (see p-p plots comparing the distribution with a Normal one, Figure 1). Of course our sample is to a certain extent a relatively more homogenous set of companies than representative national samples of companies on which most industrial dynamics studies are based. Yet, the skewness of the growth rates distribution is confirmed, in this case mostly a negative skewness, possibly due the 2009 financial crisis.

**Figure 1** – Normality Q-Q plot of the dependent variable, GROWTH *2010-2012*

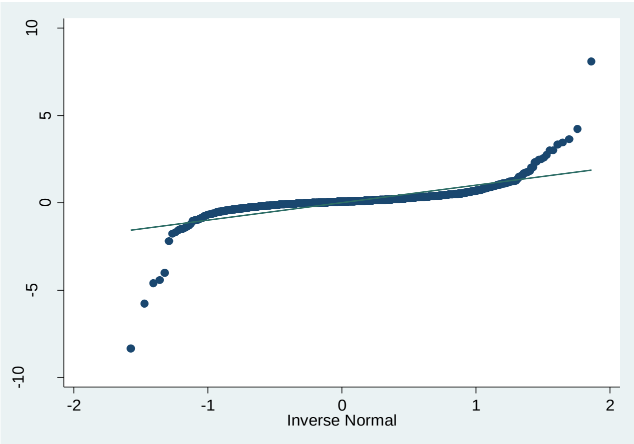
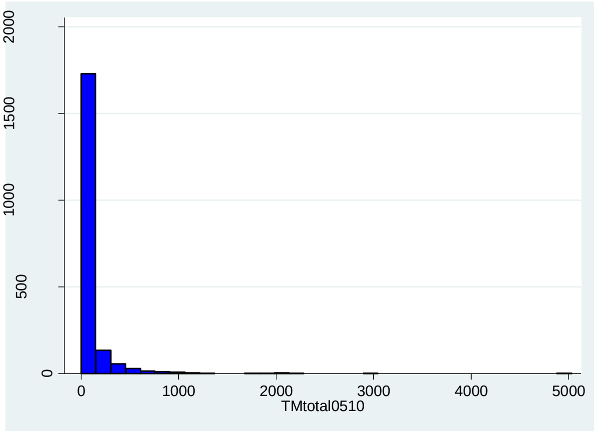
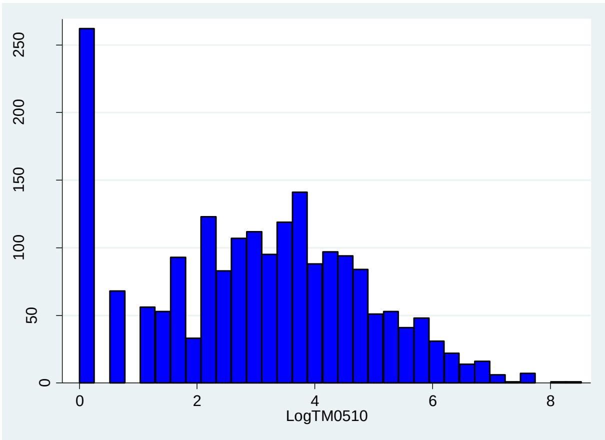



Figure 2 clearly shows that the distribution of trademark applications across companies is highly skewed, with very few companies filing a substantially higher number of trademarks. This will be taken into account in the analysis by including only logarithmic versions of the trademark counts and stocks variables. Moreover, trademarking is highly sector-specific (Dernis et al 2015); this calls for including sectoral averages of all trademark-based independent variables as controls in the regression models.

**Figure 2** – Distribution of USPTO trademarks applications, 2005-10: total number of trademarks (top) and its log (bottom).




**Notes:** LogTM=ln (1+TM).

**Source:** EC-JRC/OECD, IP bundle of top corporate R&D investors, internal database.

Table 1 shows sectoral differences in our measure of service intensity, as defined earlier. For manufacturing sectors the shares of trademarks covering service classes is typically not higher than 30%. For service sectors the shares are generally higher. Table 2 summarizes all the firm-level variables defined for use in the regression models and Table 3 provides the related descriptive statistics.

**Table 1** – Average sectoral service intensity as measured by the number of USPTO trademarks covering at least one service class, 2008-10

| 3-digit code | Sector | % |
|---|---|---|
| 530 | Oil & Gas Producers | 26% |
| 570 | Oil Equipment, Services & Distribution | 30% |
| 580 | Alternative Energy | 26% |
| 1350 | Chemicals | 13% |
| 1730 | Forestry & Paper | 12% |
| 1750 | Industrial Metals & Mining | 12% |
| 1770 | Mining | 18% |
| 2350 | Construction & Materials | 21% |
| 2710 | Aerospace & Defence | 29% |
| 2720 | General Industrials | 10% |
| 2730 | Electronic & Electrical Equipment | 14% |
| 2750 | Industrial Engineering | 18% |
| 2770 | Industrial Transportation | 29% |
| 2790 | Support Services | 51% |
| 3350 | Automobiles & Parts | 14% |
| 3530 | Beverages | 10% |
| 3570 | Food Producers | 6% |
| 3720 | Household Goods & Home Construction | 11% |
| 3740 | Leisure Goods | 24% |
| 3760 | Personal Goods | 5% |
| 3780 | Tobacco | 1% |
| 4530 | Health Care Equipment & Services | 20% |
| 4570 | Pharmaceuticals & Biotechnology | 16% |
| 5330 | Food & Drug Retailers | 30% |
| 5370 | General Retailers | 42% |
| 5550 | Media | 47% |
| 5750 | Travel & Leisure | 29% |
| 6530 | Fixed Line Telecommunications | 53% |
| 6570 | Mobile Telecommunications | 51% |
| 7530 | Electricity | 25% |
| 7570 | Gas, Water & Multi-utilities | 28% |
| 8350 | Banks | 46% |
| 8530 | Non-life Insurance | 100% |
| 8570 | Life Insurance | 90% |
| 8630 | Real Estate Investment & Services | 61% |
| 8770 | Financial Services | 60% |
| 8980 | Equity Investment Instruments | 0% |
| 8990 | Non-equity Investment Instruments | 0% |
| 9530 | Software & Computer Services | 48% |
| 9570 | Technology Hardware & Equipment | 22% |

**Notes.** Details of ICB classification are available at http://www.ftse.com/products/indices/icb

**Table 2** – List of variables and their definition.

| Variable | Definition |
|---|---|
| Ln Net sales growth | Ln net sales in 2012-log net sales in 2010 |
| Ln Net sales 2010 | Ln of net sales, year 2010 |
| Ln R&D stock 2010 | Ln of R&D stock in 2010, data from 2005 |
| Ln Patent stock 2010 U | Ln of Patents stock in 2010, data from 2005, patents filed at USPTO (U) |
| Ln TM stock 2010 U | Ln of Trademark stock in 2010, data from 2005, trademarks filed at USPTO (U) |
| Breadth TM U | Average number of Nice classes covered by trademarks filed at USPTO, mean of years 2008-2010 |
| Service intensity U 2008-10 | Share of trademarks filed at USPTO in the period 2008-2010 that cover at least a service Nice class |
| Sectoral ln R&D 2010 | Ln of average level of R&D investment by 3-digit sectoral code |
| Sectoral Patent stock 2010 U | Average level of Ln Patent stock 2010 U by 3-digit sectoral code |
| Sectoral TM stock 2010 U | Average level of Ln Trademark stock 2010 U by 3-digit sectoral code |
| Sectoral breadth TM U | Average level of Breadth TM U by 3-digit sectoral code |
| Sectoral service intensity U 2008-10 | Average level of Service intensity U 2008-10 by 3-digit sectoral code |

**Table 3** – Descriptive statistics of the variables used in the regressions.

| Variable | Obs | Mean | Std. Dev. | Min | Max |
|---|---|---|---|---|---|
| Ln Net sales growth | 1960 | .1445485 | .52358 | -8.346049 | 8.08804 |
| Ln Net sales 2010 | 1966 | 14.2895 | 1.937299 | 3.513275 | 19.45742 |
| Ln R&D stock 2010 | 1546 | 12.73066 | 1.359978 | 8.253407 | 17.29352 |
| Ln Patent stock 2010 U | 2000 | 3.839361 | 2.157964 | 0 | 10.14685 |
| Ln TM stock 2010 U | 2000 | 2.726652 | 1.724485 | 0 | 8.091161 |
| Breadth TM U | 2000 | 1.279988 | 1.232801 | 0 | 14.66667 |
| Service intensity U 2008-10 | 2000 | .2204529 | .2757574 | 0 | 1 |
| Sectoral ln R&D 2010 | 2000 | 5.335257 | .5618382 | 3.365055 | 6.331671 |
| Sectoral Patent stock 2010 U | 2000 | 3.839361 | .8475246 | 0 | 5.142047 |
| Sectoral TM stock 2010 U | 2000 | 2.726652 | .5303333 | .6151857 | 4.72566 |
| Sectoral breadth TM U | 2000 | 1.279988 | .2950423 | .3333333 | 1.928428 |
| Sectoral service intensity U 2008-10 | 2000 | .2204529 | .1275155 | 0 | 1 |

Interestingly, sectoral trademark intensity, as measured by number of trademark applications divided by sales, seems to be positively correlated with sectoral R&D intensity. As reported in Table 4, pairwise correlation of the actual variables included in our model reveals that R&D stocks and TM stocks are significantly positively correlated but not very highly so.

**Table 4** – Pairwise correlation table among the variables used in the regressions

| | Ln Net sales growth | Ln Net sales 2010 | Ln R&D stock 2010 | Ln Patent stock 2010 U | Ln TM stock 2010 U | Breadth TM U | Service intensity U 2008-10 | Sectoral ln R&D 2010 | Sectoral Patent stock 2010 U | Sectoral TM stock 2010 U | Sectoral breadth TM U | Sectoral service intensity U 2008-10 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Ln Net sales growth | 1 | | | | | | | | | | | |
| Ln Net sales 2010 | -.2338* | 1 | | | | | | | | | | |
| Ln R&D stock 2010 | -.1041* | .6522* | 1 | | | | | | | | | |
| Ln Patent stock 2010 U | -.0996* | .3907* | .6800* | 1 | | | | | | | | |
| Ln TM stock 2010 U | -.0097 | .3761* | .5132* | .5771* | 1 | | | | | | | |
| Breadth TM U | -.0014 | .2864* | .3084* | .3505* | .6384* | 1 | | | | | | |
| Service intensity U 2008-10 | .0075 | .0043 | .0754* | .0164 | .2580* | .1899* | 1 | | | | | |
| Sectoral ln R&D 2010 | .0004 | -.1728* | .1675* | .0888* | -.0649* | -.1025* | -.0048 | 1 | | | | |
| Sectoral Patent stock 2010 U | -.0625* | .0096 | .0820* | .3927* | .0661* | .0165 | -.2324* | .2262* | 1 | | | |
| Sectoral TM stock 2010 U | .0185 | .0574* | -.0181 | .0845* | .3075* | .1525* | -.0071 | -.2111* | .2150* | 1 | | |
| Sectoral breadth TM U | .0041 | .2395* | -.0146 | .0271 | .1959* | .2393* | .0516* | -.4283* | .0690* | .6371* | 1 | |
| Sectoral service intensity U 08-10 | .0805* | -.1377* | -.0376 | -.213* | -.0051 | .0288 | .4287* | -.0113 | -.5420* | -.0166 | .1203* | 1 |

**Notes:** * denotes significant at 5% level or better

## 5.2 Hypotheses testing

In order to test the hypotheses presented in section 3, we estimate several models in which we include step-wise the different sets of variables of theoretical interest.

Testing for market capabilities

Table 5 reports coefficients from LAD quantile regression estimates of the models allowing testing for Hypotheses 1, 2 and 3 about market capabilities.

Model 1 is a baseline model where only prior level of net sales and technological capabilities are included, next to sectoral averages. The prior firm R&D stock already appears to be negatively related to net sales growth, similarly to the sectoral level of R&D. Large R&D investments seem to weigh heavily for these firms when we consider their relation to growth.

When we introduce the firm-level trademark stocks (Model 2), we find instead a positive and significant relation to sales growth. R&D stocks show negative significant relations, at the firm and at the sector level. Firm-level achievements in developing market capabilities as measured by the accumulation of new trademarks appear to give the top R&D spenders a clear growth premium.

**Table 5** – LAD quantile regression estimates for models testing Hypotheses 1, 2 & 3 (median regression estimates reported).

| VARIABLES | (1)<br>Model 1 | (2)<br>Model 2 | (3)<br>Model 3 |
|---|---|---|---|
| Ln Net sales 2010 | -0.00931 | -0.0156* | -0.0156* |
| | (0.00956) | (0.00935) | (0.00855) |
| Ln R&D stock 2010 | -0.0147 | -0.0228*** | -0.0385*** |
| | (0.00927) | (0.00846) | (0.00835) |
| Ln TM stock 2010 U | | 0.0175*** | -0.0313 |
| | | (0.00473) | (0.0242) |
| interaction R&D * TM stocks | | | 0.00381** |
| | | | (0.00181) |
| Sectoral ln R&D 2010 | -0.772*** | -0.310*** | -0.287*** |
| | (0.157) | (0.0648) | (0.0606) |
| Sectoral TM stock 2010 U | | 0.265*** | 0.244*** |
| | | (0.0619) | (0.0579) |
| US dummy | 0.0824*** | 0.0629*** | 0.0582*** |
| | (0.0125) | (0.0143) | (0.0136) |
| Constant | 4.591*** | 1.578*** | 1.701*** |
| | (0.851) | (0.180) | (0.175) |
| Sector dummies | YES | YES | YES |
| Pseudo $R^2$ | 0.0836 | 0.0897 | 0.0906 |
| Observations | 1,533 | 1,533 | 1,533 |

**Notes:** Standard errors in brackets, *** p<0.01, ** p<0.05, * p<0.1

Model 3 allows testing Hypothesis 3: interestingly the interaction effect of trademark stocks with R&D stocks is significant, while the direct effect of trademark stocks become insignificant. This supports Hypothesis 3 and at the same time casts doubts on

Hypotheses 2. In this model market capabilities appear to be enhancing the effect technological capabilities, in particular decrease the negative effect of R&D stocks.

Testing for trademark diversification

Hypotheses 4 and 5 concern two distinct dimensions of firm diversification in trademarking.

Models 4 and 5 include measures of firm-level and sectoral-level breadth, accounting also for a curvilinear relation. None of these variables turns out to have a significant relation to net sales growth of top R&D investors. Model 6 includes our measure of service intensity and this turns out to be significantly related to net sales growth. This is mostly a sectoral effect, but even the firm level service intensity has a significant effect. In this final model, the effect of trademark stocks via the interaction with R&D is confirmed.

**Table 6** – LAD quantile regression estimates for models testing Hypotheses 4 & 5 (median regression estimates reported).

| VARIABLES | Model 4 | Model 5 | Model 6 |
|---|---|---|---|
| Ln Net sales 2010 | -0.0157* | -0.0156* | -0.0198** |
| | (0.00861) | (0.00911) | (0.00872) |
| Ln R&D stock 2010 | -0.0380*** | -0.0388*** | -0.0394*** |
| | (0.00795) | (0.00906) | (0.00908) |
| Ln TM stock 2010 U | -0.0323 | -0.0322 | -0.0446* |
| | (0.0266) | (0.0299) | (0.0243) |
| interaction R&D * TM stocks | 0.00387* | 0.00386* | 0.00480*** |
| | (0.00198) | (0.00211) | (0.00184) |
| Breadth TM U | -0.000479 | 0.00161 | |
| | (0.00562) | (0.0136) | |
| Breadth TM U squared | | -0.000304 | |
| | | (0.00190) | |
| ln_sectoralRDlevel | -0.132*** | -0.132*** | -0.134*** |
| | (0.0229) | (0.0225) | (0.0209) |
| Sectoral TM stock 2010 U | -0.114*** | -0.115*** | 0.0267** |
| | (0.0400) | (0.0415) | (0.0115) |
| Sectoral breadth TM U | 0.534*** | 0.537*** | |
| | (0.141) | (0.145) | |
| US dummy | 0.0596*** | 0.0586*** | 0.0560*** |
| | (0.0150) | (0.0148) | (0.0143) |
| Service intensity U 2008-10 | | | 0.0651*** |
| | | | (0.0241) |
| Sectoral service intensity U 2008-10 | | | 0.426*** |
| | | | (0.128) |
| Constant | 1.128*** | 1.138*** | 1.304*** |
| | (0.134) | (0.126) | (0.123) |
| Sector dummies | YES | YES | YES |
| Pseudo R2 | 0.0897 | 0.0898 | 0.0914 |
| Observations | 1,533 | 1,533 | 1,533 |

**Notes:** Standard errors in brackets, *** p<0.01, ** p<0.05, * p<0.1

Using the very last model (Model 6) as our final model, we exploit the possibilities of quantile regressions and investigate how the key estimated coefficients change when other quantiles than the median are used. Figures 3 reveal two interesting insights.

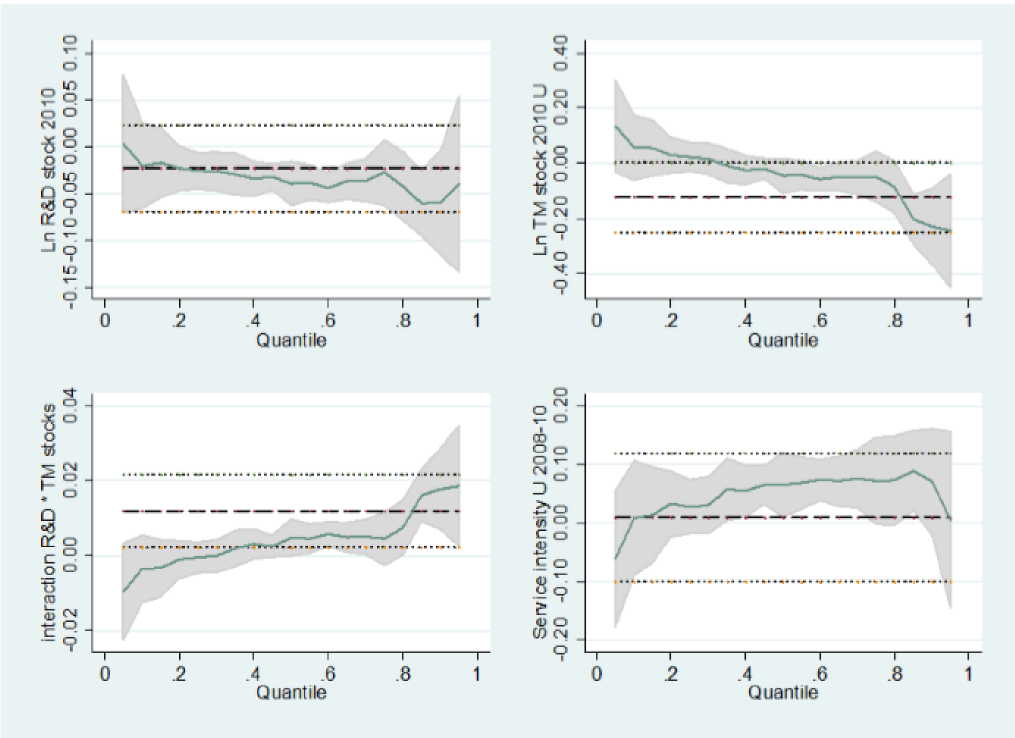
Firstly, OLS estimates would substantially overestimate the coefficients for R&D and underestimate the coefficients for TM stocks and service intensity. This confirms the relevance of using quantile regression techniques.

Secondly, while the estimated coefficients for R&D stocks show a relatively stable pattern across different quantiles, the picture stemming from the three other plots is quite different. In particular, the direct effect of trademark stocks is clearly declining and appears significantly negative for the top firms in terms of growth. Instead the moderating effect of trademark stocks captured by the interaction variable is increasing in importance and is particularly relevant for the same high growth firms. This suggests that it is this subset of the top R&D investors which mostly benefit from the complementarity between technological and market capabilities, but hardly benefit from focusing on higher levels of trademarking as such.

As for service intensity, the growth premium we already detected for the median firm seems to be there only for the in-between quantiles and completely disappear for the extreme quantiles, both top and low growth firms.

**Figure 3** – Estimated coefficients from LAD regressions for R&D and trademark stock variables evaluated at different quantiles, confidence intervals included.

*Dashed line represents OLS estimates with corresponding confidence intervals (dotted lines).*



## 5.3 Robustness checks

In the models estimated so far we have included R&D stocks as proxies for technological capabilities. R&D can be viewed as an input measure of technological innovation, while patents are instead more of an output measure. We also estimate models where we use patent stocks as proxies for technological capabilities. The key results remain essentially unchanged for the median regressions. The only difference seems to be how the effect of service intensity changes across quantile estimators (Figure 4). In particular, these estimates show that a service focus benefits a larger group of firms than it was the case in the previous plots.

**Table 7** – Using patent variables only: LAD quantile regression estimates for models testing Hypotheses 1, 2 and 3 (median regression estimates reported).

| VARIABLES | Model 1 | Model 2 | Model 3 |
|---|---|---|---|
| Ln Net sales 2010 | -0.0280*** | -0.0317*** | -0.0413*** |
| | (0.00602) | (0.00787) | (0.00647) |
| Ln Patent stock 2010 U | -0.00393 | -0.0115*** | -0.0231*** |
| | (0.00373) | (0.00385) | (0.00648) |
| Ln TM stock 2010 U | | 0.0175*** | 0.000278 |
| | | (0.00407) | (0.00754) |
| interaction Patent * TM stocks | | | 0.00472*** |
| | | | (0.00166) |
| Sectoral Patent stock 2010 U | -0.0952*** | -0.0565*** | -0.0537*** |
| | (0.0174) | (0.0142) | (0.0133) |
| Sectoral TM stock 2010 U | | 0.133*** | 0.118*** |
| | | (0.0434) | (0.0456) |
| US dummy | 0.0801*** | 0.0559*** | 0.0493*** |
| | (0.0103) | (0.0106) | (0.0120) |
| Constant | 0.838*** | 0.416*** | 0.613*** |
| | (0.0541) | (0.0849) | (0.0903) |
| Sector dummies | YES | YES | YES |
| Pseudo R2 | 0.0683 | 0.0728 | 0.0763 |
| Observations | 1,960 | 1,960 | 1,960 |

**Notes:** Standard errors in brackets, *** p<0.01, ** p<0.05, * p<0.1

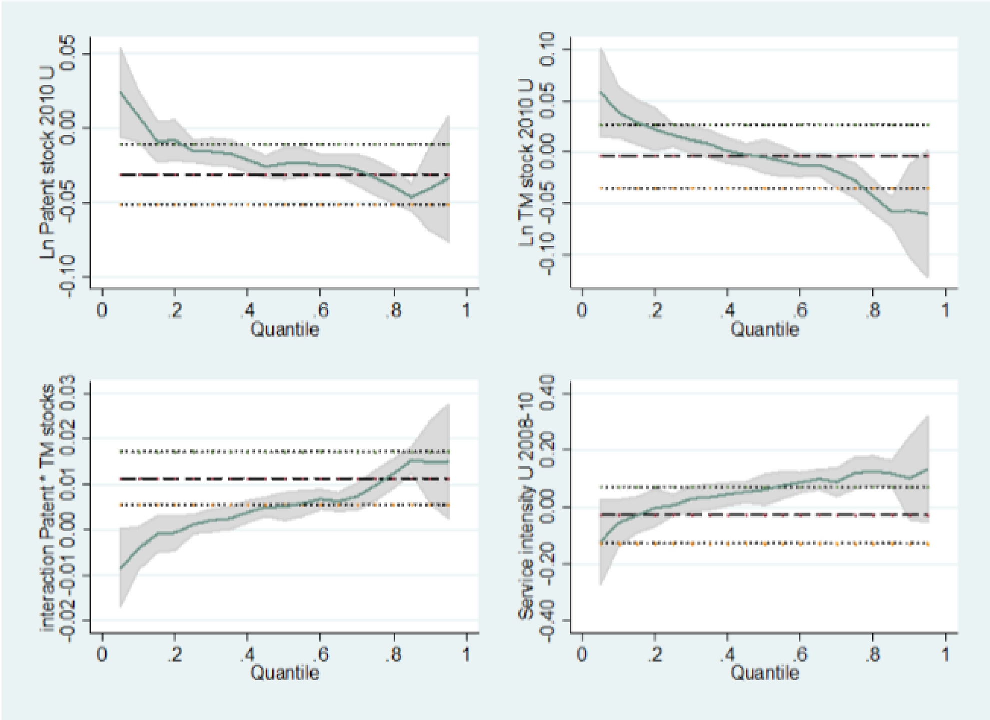
**Table 8** – Using patent variables only: LAD quantile regression estimates for models testing Hypotheses 4 and 5 (median regression estimates reported).

| VARIABLES | Model 4 | Model 5 | Model 6 |
|---|---|---|---|
| Ln Net sales 2010 | -0.0417*** | -0.0416*** | -0.0402*** |
| | (0.00612) | (0.00584) | (0.00567) |
| Ln Patent stock 2010 U | -0.0239*** | -0.0239*** | -0.0236*** |
| | (0.00630) | (0.00595) | (0.00867) |
| Ln TM stock 2010 U | -0.00436 | -0.00440 | -0.00452 |
| | (0.00796) | (0.00847) | (0.00863) |
| interaction Patent * TM stocks | 0.00493*** | 0.00493*** | 0.00508** |
| | (0.00138) | (0.00127) | (0.00216) |
| Breadth TM U | 0.00800 | 0.00807 | |
| | (0.00493) | (0.0107) | |
| Breadth TM U squared | | -1.36e-05 | |
| | | (0.00119) | |
| Sectoral Patent stock 2010 U | -0.0208** | -0.0207** | -0.0461*** |
| | (0.0102) | (0.0102) | (0.0134) |
| Sectoral TM stock 2010 U | 0.0585*** | 0.0585*** | 0.135*** |
| | (0.0120) | (0.0124) | (0.0404) |
| Sectoral breadth TM U | 0.243** | 0.243*** | |
| | (0.102) | (0.0941) | |
| US dummy | 0.0566*** | 0.0566*** | 0.0520*** |
| | (0.0105) | (0.0118) | (0.0133) |
| Service intensity U 2008-10 | | | 0.0607*** |
| | | | (0.0217) |
| Constant | 0.372* | 0.371* | 0.520*** |
| | (0.214) | (0.203) | (0.111) |
| Sector dummies | YES | YES | YES |
| Pseudo R2 | 0.0731 | 0.0731 | 0.737 |
| Observations | 1,960 | 1,960 | 1,960 |

**Notes:** Standard errors in brackets, *** p<0.01, ** p<0.05, * p<0.1

**Figure 4** – Estimated coefficients of Patent and trademark stock variables evaluated at different quantiles, confidence intervals included.

*Dashed line represents OLS estimates with corresponding confidence intervals (dotted lines).*




## 5.4 Results for High-tech, medium-tech and low-tech sectors

As a further analysis, we follow the strategy of Montresor and Vezzani (2015) and investigate whether the estimated effects differ across groups of sectors, namely high tech vs medium-high tech vs low tech sectors (including low tech and medium-low tech).

The results in Tables 9 clearly indicate that the validity of the hypothesis differs across groups of sectors. In fact, for low tech sectors, no significant effect is found for any of our variables of theoretical interest.

As for the hypotheses on market capabilities, a positive relation with net sales growth is found both for high tech and medium-high tech sectors, the only difference being that the sectoral effect of trademark stocks becomes negative for medium-high tech sectors.

As for the hypotheses on diversification, the relation between breadth and net sales growth is not significant, as it was in the overall sample. The results for Model 6 show how the service intensity is indeed positively related to net sales growth in high tech sectors. Instead, the variable is insignificant in medium-high tech sectors. What these results say is that the premium effect of providing services is mostly there for the most R&D intensive activities, notably manufacturing sectors where there is a strong focus on technology-based innovation.

**Table 9.1** – High-tech sectors only: LAD quantile regression estimates for models testing Hypotheses 1, 2 and 3.

| HIGH TECH | Model 1 | Model 2 | Model 3 | Model 4 | Model 5 | Model 6 |
|---|---|---|---|---|---|---|
| Ln Net sales 2010 | -0.0138 | -0.0171 | -0.0247 | -0.0166 | -0.0174 | -0.0246 |
| | (0.0174) | (0.0187) | (0.0195) | (0.0185) | (0.0185) | (0.0184) |
| Ln R&D stock 2010 | -0.0276* | -0.0411** | -0.0594*** | -0.0415** | -0.0410** | -0.0353** |
| | (0.0160) | (0.0166) | (0.0176) | (0.0163) | (0.0165) | (0.0160) |
| Ln TM stock 2010 U | | 0.0247*** | -0.0583 | 0.0256** | 0.0245** | 0.0230** |
| | | (0.00918) | (0.0459) | (0.0113) | (0.0124) | (0.00965) |
| Interaction R&D * TM stocks | | | 0.00643* | | | |
| | | | (0.00343) | | | |
| Sectoral ln R&D 2010 HT | -0.814*** | -0.444*** | -0.435*** | -0.455*** | -0.444*** | -0.401*** |
| | (0.143) | (0.0981) | (0.0985) | (0.0990) | (0.101) | (0.105) |
| Sectoral TM stock U HT | | 0.112*** | 0.0897** | 0.115*** | 0.111*** | 0.107** |
| | | (0.0416) | (0.0436) | (0.0415) | (0.0404) | (0.0422) |
| US dummy | 0.0799*** | 0.0508** | 0.0476** | 0.0505* | 0.0466* | 0.0517** |
| | (0.0195) | (0.0232) | (0.0238) | (0.0265) | (0.0264) | (0.0234) |
| Breadth TM U | | | | -0.00403 | 0.00887 | |
| | | | | (0.0117) | (0.0317) | |
| Breadth TM U squared | | | | | -0.00162 | |
| | | | | | (0.00592) | |
| Service intensity U 2008-10 | | | | | | 0.0787* |
| | | | | | | (0.0432) |
| Constant | 5.053*** | 2.923*** | 3.262*** | 2.980*** | 2.922*** | 2.720*** |
| | (0.775) | (0.479) | (0.461) | (0.487) | (0.501) | (0.520) |
| Sector dummies | YES | YES | YES | YES | YES | YES |
| Pseudo $R^2$ | 0.0750 | 0.0819 | 0.0843 | 0.0819 | 0.0821 | 0.0840 |
| Observations | 683 | 683 | 683 | 683 | 683 | 683 |

**Notes:** Standard errors in brackets, *** p<0.01, ** p<0.05, * p<0.1

**Table 9.2** – Medium high-tech sectors only: LAD quantile regression estimates.

| MEDIUM HIGH TECH | Model 1 | Model 2 | Model 3 | Model 4 | Model 5 | Model 6 |
|---|---|---|---|---|---|---|
| Ln Net sales 2010 | -0.0145 | -0.0267** | -0.0238** | -0.0265** | -0.0262** | -0.0201** |
| | (0.0124) | (0.0104) | (0.0101) | (0.0104) | (0.0106) | (0.00940) |
| Ln R&D stock 2010 | -0.00203 | -0.0106 | -0.0406** | -0.0102 | -0.00964 | -0.0147 |
| | (0.0110) | (0.00990) | (0.0162) | (0.00969) | (0.0102) | (0.0107) |
| Ln TM stock 2010 U | | 0.0266*** | -0.0622 | 0.0224*** | 0.0207** | 0.0218*** |
| | | (0.00704) | (0.0454) | (0.00831) | (0.00819) | (0.00693) |
| Interaction R&D * TM stocks | | | 0.00696** | | | |
| | | | (0.00352) | | | |
| Sectoral ln R&D 2010 MT | 0.0511*** | 0.0541*** | 0.0529*** | 0.0560*** | 0.0549*** | 0.0442*** |
| | (0.00842) | (0.0101) | (0.0108) | (0.0106) | (0.00964) | (0.0118) |
| Sectoral TM stock U MT | | -0.0285** | -0.0243* | -0.0243 | -0.0231 | -0.0243* |
| | | (0.0144) | (0.0144) | (0.0152) | (0.0143) | (0.0143) |
| US dummy | 0.0990*** | 0.0628*** | 0.0690*** | 0.0696*** | 0.0709*** | 0.0564*** |
| | (0.0166) | (0.0213) | (0.0214) | (0.0210) | (0.0198) | (0.0211) |
| Breadth TM U | | | | 0.00603 | 0.0117 | |
| | | | | (0.00666) | (0.0180) | |
| Breadth TM U squared | | | | | -0.00077 | |
| | | | | | (0.00246) | |
| Service intensity U 2008-10 | | | | | | 0.0639* |
| | | | | | | (0.0365) |
| Constant | 0.0338 | 0.334*** | 0.658*** | 0.310*** | 0.301*** | 0.337*** |
| | (0.0798) | (0.115) | (0.199) | (0.112) | (0.110) | (0.1000) |
| Sector dummies | YES | YES | YES | YES | YES | YES |
| Pseudo $R^2$ | 0.0691 | 0.0868 | 0.0927 | 0.0873 | 0.0879 | 0.0888 |
| Observations | 614 | 614 | 614 | 614 | 614 | 614 |

**Notes:** Standard errors in brackets, *** p<0.01, ** p<0.05, * p<0.1

**Table 9.3** – Low-tech sectors only: LAD quantile regression estimates.

| LOW TECH | Model 1 | Model 2 | Model 3 | Model 4 | Model 5 | Model 6 |
|---|---|---|---|---|---|---|
| Ln Net sales 2010 | 0.00367 | 0.00399 | 0.00195 | 0.00602 | 0.00444 | 0.00615 |
| | (0.0140) | (0.0101) | (0.0135) | (0.0132) | (0.0114) | (0.0144) |
| Ln R&D stock 2010 | -0.0132 | -0.0136 | 0.0126 | -0.0142 | -0.0132 | -0.0147 |
| | (0.0173) | (0.0103) | (0.0235) | (0.0146) | (0.0149) | (0.0181) |
| Ln TM stock 2010 U | | -0.00099 | 0.0840 | -0.00458 | 0.00160 | -0.00277 |
| | | (0.00620) | (0.0708) | (0.00793) | (0.00836) | (0.00646) |
| Breadth TM U | | | | 0.00357 | -0.0200 | |
| | | | | (0.00748) | (0.0215) | |
| Sectoral ln R&D 2010 LT | -0.0128 | -0.0126 | -0.00541 | -0.00552 | -0.00606 | -0.0122 |
| | (0.0534) | (0.0278) | (0.0441) | (0.134) | (0.143) | (0.0638) |
| Sectoral TM stock U LT | | -0.00397 | -0.00793 | 0.000760 | -0.00021 | 0.00307 |
| | | (0.0248) | (0.0328) | (0.0928) | (0.0957) | (0.0351) |
| Sectoral breadth TM U LT | | | | -0.0215 | -0.0131 | |
| | | | | (0.418) | (0.433) | |
| US dummy | 0.0802*** | 0.0809*** | 0.0836*** | 0.0813*** | 0.0804*** | 0.0742** |
| | (0.0295) | (0.0253) | (0.0286) | (0.0283) | (0.0279) | (0.0291) |
| Interaction R&D * TM stocks | | | -0.00657 | | | |
| | | | (0.00541) | | | |
| Breadth TM U squared | | | | | 0.00355 | |
| | | | | | (0.00332) | |
| Service intensity U 2008-10 | | | | | | 0.0204 |
| | | | | | | (0.0603) |
| Constant | 0.239 | 0.251 | -0.0708 | 0.208 | 0.223 | 0.202 |
| | (0.339) | (0.203) | (0.365) | (0.579) | (0.604) | (0.377) |
| Sector dummies | YES | YES | YES | YES | YES | YES |
| Pseudo $R^2$ | 0.2437 | 0.2440 | 0.2503 | 0.2442 | 0.2474 | 0.2447 |
| Observations | 236 | 236 | 236 | 236 | 236 | 236 |

**Notes:** Standard errors in brackets, *** p<0.01, ** p<0.05, * p<0.1

## 6. Discussion and conclusions

This study has offered a novel and original analysis of the determinants of sales growth for top corporate R&D investors, exploiting the rich dataset on top R&D investors and their use of IPRs made possible by the joint efforts of EC JRC and OECD. This study contributes to an emerging literature analysing the economic value of intangibles for companies with an analysis of growth determinants, instead of market value antecedents.

Overall, the results indicate three key insights on the drivers of sales growth of top R&D investors. Firstly, companies that have filed more trademarks than the median firm do not enjoy a direct growth premium, but rather benefit from the positive effect that these market capabilities have on the relation between R&D investment and growth. This moderating effect overshadows the direct effect of trademark stocks on sales growth that we expected in the first place. What the results suggest is also that technological capabilities are high-demanding resources that are not directly linked to short-term changes in gains from market sales. Technological capabilities either measured by R&D or by patents, need to be further translated into actual market opportunities before realizing revenues in the marketplace. Companies with larger trademark portfolios appear to be better able to exploit their technological capabilities towards market growth.

Secondly, top R&D investors that have focused on service markets enjoy a clear growth premium. This is both a sectoral and a firm effect. In certain sectors, offering service is simply more valuable than in other sectors. In particular we find that the general results are driven by the effect of service intensity in high-tech sectors. Especially in these sectors, firms that own relatively more service marks than other firms in the same sector, enjoy a clear growth premium. These results confirm our expectations that top R&D investors, especially the ones focused mostly on delivering technology-based product innovations, benefit from designing service-centred offers as well. Earlier studies (Schmoch, 2003) have convincingly put forward the idea that trademark data can help in capturing service innovation. In this interpretation, the use of trademarks next to R&D and patents allows us to capture a broader notion of innovation, also including new services. We did not investigate the nature of the services: they may range from simple add-on services like repair solutions, to fully-fledged product-service solutions delivering high value to customers. Yet, these results are in line with recent literature stressing the benefits of organizational change towards a service-based logic, which ultimately is a more client-centred logic (Cusumano et al., 2015; Janssen, Castaldi and Alexiev, 2016). In doing so we also offer a novel measure of servitization, which has been measured so far in very different ways with no preferred indicator available yet (Gebauer, Fleisch and Friedli, 2005). This new measure can be widely applied within management studies.

Thirdly, using quantile regressions allowed us to gauge the differences in effects across the growth distributions. Indeed we found significant differences in the effects of some of our key variables of theoretical interest, reminding us that the baseline relations valid for median firms are hardly general laws applicable to firms experiencing variegated growth performances. We also found that our theoretical hypotheses are mostly confirmed in high-tech and medium-high tech sectors. Top R&D investors in low-tech sectors seem to follow very different dynamics and apparently require further theoretical efforts.

Our results offer insights from a managerial as well as a policy perspective. On the one hand, they indicate that both technological capabilities and market capabilities matter to improve the impact of firms' innovation activities on their growth performance. On the other hand the strategic management of innovation, as a key component of firm strategy (Hamel, 2000), also implies thinking both in terms of services as well as of delivering products in order to enhance the ability to meet market demand. Such dual approach is even more essential, also for high-tech manufacturing firms, as business value and consumer loyalty increasingly depends on the range of services offerings that come with the technology-based products. From a policy perspective, our study supports innovation policies that help companies to increase their service orientation; this is true also and maybe even more for companies from R&D-intensive manufacturing industries. Recent evidence on the experience of high-tech regions in Europe shows that several policy initiatives are already in place towards this end (Janssen and Castaldi, 2018). These regional policies could be inspirational for other regions.

Our results on the role of trademark breadth did not find any support for our hypothesis. With a different interpretation of breadth, namely as a measure of trademark value, also Sandner and Block (2011) find insignificant relation of trademark breadth and market value of companies. One problem with measures of breadth is that they depend very much on the branding strategies. Whenever companies opt for ‘umbrella’ type of brands, the related trademarks will tend to be ‘broader’, i.e. covering more classes, than in the cases of ‘house of brands’ strategies, when companies apply for new trademarks for single new products (or product families). Ideally, one should condition for these different types of strategies and they typically do not simply differ across sectors but rather across firms. With the available data, it was not possible to satisfactorily control for firm-level differences in branding strategies. This could partly explain the insignificant results. It is also the case that possibly better measures of diversification, based on Herfindhal indexes would have the same limitation even though exploiting the full information on the distribution of trademark applications over Nice classes. Castaldi and Giarratana (2018) explore a definition of branding strategies relying on both trademark breath and trademark intensity in a panel dataset of management consulting firms. Similar exercises for multi-sector samples of firms are trickier since a low number of trademarks could be a result of low sectoral trademark intensity, low firm trademark intensity or poor market capabilities. Nevertheless, further research should develop alternative indicators of diversification.

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