Converting technological innovations into new products: The role of CEO general skills

Shukrat Nasirov  
De Montfort University  
Leicester Castle Business School  
Shukrat.Nasirov@dmu.ac.uk

Cher Li  
University of Nottingham  
Nottingham University Business School  
lizcl2@nottingham.ac.uk

Richard Harris  
Durham University  
Business School  
r.i.d.harris@durham.ac.uk

Abstract

Technological innovations represent a key input into the new product development (NPD) process. However, technological diversity often tends to be greater than the diversity of product portfolios, largely due to difficulties related to the commercialization of inventions through the product development route. Departing from this observation, our work assesses the extent to which general skills accumulated by chief executives over their professional careers help companies convert technological innovations into new products. This emphasis reflects the fact that the involvement of top managers in the NPD process is a critical success factor as well as that generalist CEOs demonstrate greater ability to encourage riskier decisions, make better capital allocation decisions, and facilitate cross-functional communication?all this holds the key to NPD and its technology conversion part. Our statistical analysis is based on studying 455 chief executives in 139 U.S. publicly-traded companies over the period of 1992-2013. We use trademark data to measure a company's NPD performance, while patent quantity and quality indicators are employed to capture technological innovations. Our results suggest that generalist CEOs do have a positive effect on NPD outcomes as do they positively condition the relationship between technological and product development. Furthermore, the facilitation effect is more pronounced for NPD aimed at new markets. As such, our work puts an emphasis on CEO general skills as yet another mechanism that companies can leverage to increase the efficacy of invention conversion and, hence, to deliver more value via new product offerings.
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Keywords: technological innovations, product development, technology conversion, CEO general skills, patents, trademarks.

1 INTRODUCTION

New product success or failure is determined by multiple factors, both external and internal (Rothwell, 1992; Zirger and Maidique, 1990). The new product development (NPD) literature emphasizes such factors as the way in which the product development process is organized and managed; organizational culture, including the support of senior managers; and the strategic focus on product development (see Cooper, 1999; Ernst, 2002; Krishnan and Ulrich, 2001).

In this study, we are particularly interested in how to help companies to convert technological innovations into product innovations. Since the creation of new technologies is costly, product development represents a potentially useful channel for recouping these costs. However, risks associated with innovations, the lack of resources, functional disintegration, and other similar issues usually impede the conversion of inventions into new product offerings. One potential solution is to invoke corporate leaders to bridge this gap, especially given their influence on the decision-making process in organizations. In particular, CEOs and their skill composition should be considered as a factor that companies can use to bridge the gap between invention generation and product development.

There have been multiple studies that look at top management commitment and its role in achieving the success in product development (e.g., Calantone et al., 1995; Zirger and Maidique, 1990; for a review, see Felekoglu and Moultrie, 2014). This commitment is deemed to be twofold: on the one hand, top managers approve human and financial resources necessary for developing new products; on the other, they create the organizational culture that supports innovation and entrepreneurial behavior (Poolton and Barclay, 1998; Zirger and Maidique, 1990). With only few notable exceptions (see Caridi-Zahavi et al., 2015; Chen et al., 2014; Nadkarni and Chen, 2014; Stock et al., 2018), the literature has however very little to say about the characteristics top managers should possess in order to perform these functions effectively.
Our research aims to fill this gap by studying the impact of technological innovations on NPD, with a specific focus on the moderating effect of CEO general skills on this relationship.

This paper is organized as follows. It begins with reviewing the literature on product development, including the role played by technologies and top managers in the NPD process, and then formulates testable hypotheses. This is followed by the section presenting the data for the empirical analysis as well as describing its methodology. Finally, it proceeds to the overview of results and the discussion of their practical implications and limitations.

2 THEORETICAL BACKGROUND AND LITERATURE REVIEW

Technological innovations as a factor affecting the product development process

The impact of technologies on product development has been a matter of continuing concern (e.g., Eggers, 2014; Frankort, 2016; Nerkar and Roberts, 2004; Zirger and Maidique, 1990). According to Rothwell (1992), earlier studies regarded technological knowledge as the major source of ideas for product development, thus putting much emphasis on the R&D function, while assigning to the market the role of a passive recipient of technological advances. This view was subsequently revisited to account for the ability of the market to generate product ideas, too. Modern theories, however, go beyond these dichotomizations and conceptualize technological development in terms of constant interactions among producers, consumers, suppliers, rivals, and other parties within the marketplace, value chain, or industry platform, with the purpose of laying the foundation for the NPD process (Adner and Kapoor, 2010; Gawer and Cusumano, 2014).

From the engineering perspective, a product is the fruit of the fusion of technologies that firmly underpin its physical characteristics, production methods, and performance levels. In practical terms, this implies that when designing a new product, the company’s selection of attributes to incorporate in it has to be coordinated with the technological competences this
company possesses (Krishnan and Ulrich, 2001). With more and more sophisticated customer needs, companies expand their investments in technological knowledge and expertise so as to "influence time to market, quality, innovativeness, and market share [...], thereby enhancing new product sales and future cash flows" (Bond and Houston, 2003:122; Iansiti, 1995a; Poolton and Barclay, 1998). After all, technological expertise and competence are repeatedly named among the key factors impacting NPD success rates (see Zirger and Maidique, 1990). However, there are dramatic differences among companies when it comes to technological knowledge. One potentially fruitful way to study the contribution of these differences to NPD performance is by looking at two technological dimensions — quantitative and qualitative.

The number of technological innovations. As Wheelwright and Clark (1992:29) note, "[the] growing breadth and depth of technological and scientific knowledge has created new options for meeting the needs of an increasingly diverse and demanding market". Simply put, companies that are capable to generate more technological innovations as well as to integrate and re-integrate them are expected to show better performance in terms of offering products with novel characteristics, and possibly ahead of competition, than companies that lack such a capability (Gao and Hitt, 2012; Iansiti, 1995a).

However, it has been reported that an increase in technological diversity is not always followed by a pro rata increase in the diversity of product portfolios (Patel and Pavitt, 1997). Several arguments can be mustered to explain this discrepancy. First of all, while expanding market opportunities, vast technology pools also pose potential threats to NPD performance due to difficulties that the use of new technologies and especially their combinations creates. For example, the need to integrate several core technologies is likely to reduce the speed of product development because designing inter-technological interfaces is itself a complex task (Meyer and Utterback, 1995). Choosing the "right" technological combination among many available options is challenging as well: since each technology has an idiosyncratic effect on
the outcome of an NPD project, it becomes difficult to accurately predict the market performance of multi-technology solutions (Torkkeli and Tuominen, 2002). Another plausible explanation is that companies with extensive technological bases may encounter a resource coordination problem. The idea here is that although resources, both financial and attentional, are limited, the number of technologies and their combinations to introduce in the product development process is potentially very large. Hence, after reaching a certain technological diversity level, adding an extra technology may not necessarily lead to an increase in the NPD performance because of the so-called "bottleneck" effect, when simultaneously sharing resources among multiple tasks impairs each individual task (Chandy et al., 2006).

The above arguments seem to suggest that NPD performance can be maximized when the number of technologies in a company's portfolio is moderate, thus pointing to a nonlinear relationship between the two. With this reasoning in mind, we propose the following hypothesis:

**Hypothesis 1:** The number of technological innovations has an inverted U-shaped relationship with NPD performance.

*The quality of technological innovations.* Quality represents another dimension along which the impact of a company's technological base on NPD performance can be evaluated.¹ The way forward here is to acknowledge that the flow of technological innovations is highly heterogeneous in the sense that some inventions are more valuable than others, which should also be reflected in the spectrum of market opportunities they are able to provide (Ernst, 2001; Lanjouw and Schankerman, 2004). Empirical evidence broadly corroborates this intuition by showing that companies with higher-quality technologies have faster sales growth and better financial performance (Ernst, 1995). Furthermore, the quality of technological innovations is found to be positively related to variations in the stock market value of companies (Lanjouw

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¹ In this research, we follow Lanjouw and Schankerman (2004:443) and "use the term quality to emphasise both the technological and value dimensions of an innovation".
and Schankerman, 2004). A possible interpretation of the latter finding is that external investors perceive the development or acquisition of a higher-quality technology as a credible signal of future cash flows stemming from its commercialization, be this commercialization achieved through product development or licensing.

By contrast, the use of lower-quality technologies poses a threat of fewer repurchases or even a complete boycott, as soon as the technology choice becomes observable by buyers, with a likely negative effect on NPD performance (Liebeskind and Rumelt, 1989). Granting patent protection to such technologies can, in turn, "create considerable uncertainty among inventors or would-be commercializers of inventions and slow either the pace of innovation or investment in the commercialization of new technologies" (Hall et al., 2004:120).

So, our next hypothesis can be formulated as follows:

**Hypothesis 2:** The quality of technological innovations has a positive relationship with NPD performance.

*From technological innovations to product innovations*

As we have already mentioned, not all technologies progress to the commercialization stage. Xerox Corporation is often referred to as a notable example of how a lack of strategic focus on the technological knowledge the company possesses may lead to adverse effects on product development and, ultimately, to value losses (Rivette and Kline, 2000). Despite being one of the world's top innovators, Xerox struggled to leverage its profound technological expertise in the marketplace: among the technologies that the company failed to patent, let alone to commercialize, was the graphical user interface, which later became a cornerstone of modern operating systems. Moreover, while the development of new technologies required significant resources, financial returns to the knowledge embedded in patents were markedly moderate: with respect to license royalties, Xerox was generating around USD 1,000 per patent, which
was 75 times less compared to its principal rival — IBM Corporation, thereby providing little financial reinforcement for value-adding activities. So, this and other related strategic pitfalls eventually contributed to a decline in Xerox’s profit margins and market capitalization.

The need for aligning technological development with market opportunities has been studied in the academic literature as well, yet viewed from different angles. At a granular level, the term "conversion ability" is used to describe a company's ability to turn a given idea into a launched product (Chandy et al., 2006). Although this perspective sheds light on technology-specific factors that influence the commercialization process, it falls short in accounting for organizational aspects of converting inventions into innovations. This caveat is partially filled by the "technology integration" concept denoting "the set of knowledge-building activities through which novel concepts are explored, evaluated, and refined to provide the foundation for product development" (Iansiti, 1995b:521-522). Here, the primary emphasis is placed on the systemic impact of new technologies and, hence, the importance of implementing certain processes and routines that allow companies match their existing capabilities to technological possibilities. More in the fashion of the recourse-based view, there is also the so-called "valley of death" perspective that refers to a mismatch between a relative abundance of resources at the research stage and a relative lack of resources at the commercialization stage of the NPD process (Frank et al., 1996; Markham et al., 2010). In its basic form, this perspective only highlights the gap between research and marketing units, while having little to say about how a project can be moved from one side of the valley to the other. However, its extensions have made attempts to identify supporting mechanisms that can facilitate this movement, including the use of informal roles and activities for transference purposes (see Markham et al., 2010).

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2 This is not to say that such a misalignment cannot be due to strategic considerations. For example, the decision to keep the existing technology is often justified by companies’ desire to preserve network benefits it provides (Kretschmer, 2008).
Barriers associated with aligning technological and product developments are generally well understood. Bond and Houston (2003) suggest grouping them into three categories, such as technology and market barriers; strategy and structure barriers; and also social and cultural barriers. The major challenges imposed by the first set of barriers are assessing the availability of a new technology and, when available, utilizing it to satisfy customer needs in a way that is competitive and creates value. Strategy and structure barriers affect a range of strategic choices, from the decision on which technology to invest in to the selection of business units that will be using that technology. In turn, effective communication is the principal concern in the latter category: to be more specific, matching technological to market opportunities can be hindered by functional silos as well as by differences in beliefs that functional units have regarding the NPD process and its constituting elements. Overall, the analysis of barriers to technology conversion reveals a great number of internal issues that have to be addressed before a new technology makes the leap to the marketplace.

Having technology integration successfully implemented enables organizations not only to design superior products that help them achieve and maintain their competitive levels but also to benefit from more efficient execution of NPD projects, the shorter time necessary to move to the development stage, and higher productivity of R&D activities (Iansiti, 1995a; 1995b). Moreover, since technology integration requires the use of a systemic, organization-wide perspective, the knowledge accumulated about various combinations of new technologies and the environment in which they are deployed should be of significant value when it comes to deciding on "a set of elements that represent the best match with future properties of the system" (Iansiti, 1995a:268). By contrast, organizations applying the sequential approach that consists of first solving a technological problem and then seeking opportunities to incorporate the solution into a new product are likely to exhibit poorer product innovation performance. Being predominantly reactive, this approach may result in a persistent mismatch between what
the producer can achieve with the new technology and what customers expect regarding the product's quality, functionality, or costs, given the alternatives available in the marketplace (Iansiti, 1995a; Tomes et al., 2000).

The role of CEOs in aligning technological innovations with product development

Considering the difficulties associated with converting technological competences into market opportunities, finding mechanisms that are able to facilitate this process is of great importance. Clearly, the efficiency of technology conversion is likely to be maximized when several tasks are meticulously orchestrated. These include encouraging a dialogue between engineering and marketing functions to identify buyers' needs and ways to satisfy them; ensuring the allocation and reallocation of resources to make this dialogue substantive; and promoting the acceptance of risk-taking activities to induce a product development effort. When taken together, it appears that the corporate level is the only company level where these tasks can be handled at once.

Indeed, the involvement of corporate leaders in product development activities has been extensively studied in the NPD literature (for a review, see Felekoglu and Moultrie, 2014). This involvement can be of two kinds. On the one hand, top managers are often engaged with individual projects (Cooper, 1999). At this level, they tend to perform the screening function, deciding on which projects to give priority, which projects to keep, and which ones — to kill. Most likely, senior managers are also solely responsible for committing and guaranteeing the availability of resources necessary for each project.³ Other duties may include setting goals for project reviews and defining standards for the quality of project execution, as well as mentoring project teams. On the other hand, there is top management involvement at the corporate level, too (Poolton and Barclay, 1998). The objective here is to create such organizational culture that sustains the NPD process. So, the key part is expected to be risk acceptance: inasmuch as

³ Some studies accentuate the importance of resource allocation, while treating non-material support as secondary to it. For example, Ernst (2002:24) states that "support for NPD projects must be reflected through the appropriateness of resources, otherwise non-material support may soon be nothing more than lip-service".
innovating is a risky endeavor, one must create the atmosphere where failures are seen as an opportunity for organizational learning rather than deterrence from devoting more effort. This type of organizational culture also builds on a reward system that motivates individuals to pursue long-term goals; a strategic outlook that prioritizes investment benefits stemming from NPD projects, not just the burden of project costs; and cross-functional communication.

While the aforementioned aspects are undoubtedly valuable for our understanding of what actions top managers should commit to in order to improve the chances of NPD success, the question remains: are different managerial types equally efficient in bringing technological achievements closer to the marketplace? To answer this question, we draw on upper echelons theory (see Hambrick, 2007; Hambrick and Mason, 1984), which states that managers differ considerably in their ability to assess all potential outcomes of a strategic situation they face. The underlying reason for this difference is that they often act not as fully rational agents, but rather in accordance with some personal norms and beliefs guiding their interpretation of how the situation should be handled. Therefore, "if we want to understand why organizations do the things they do, or why they perform the way they do, we must consider the biases and dispositions of their most powerful actors — their top executives" (Hambrick, 2007:334).

When this logic is applied to the analysis of top management involvement in product development, there is one managerial type that has certain qualities necessary for performing the outlined tasks in a rather effective way: we particularly refer to CEOs with general skills. Recent studies have found that companies nowadays put a much greater emphasis on general skills and abilities in executives than they did a few decades ago (Murphy and Zabojnik, 2004). This trend reflects, inter alia, the elevation of more problem-solving activities to the corporate level, a significant increase in the diversity of functions that CEOs have to supervise, as well as

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4 We follow Becker (1962) in defining general skills as being useful in many organizations in addition to the one where they were developed. At the same time, special skills are assumed to have no effect on the individual's productivity in other organisations and, hence, are of little value outside the source company.
the growing complexity of business operations (Betzer et al., 2016; Ferreira and Sah, 2012). All this requires a well-rounded chief executive who can ensure productive interaction among various stakeholders. Furthermore, the accumulation of general skills is shown to enhance top managers' cognitive flexibility, thus making them better suited for resolving potential conflicts that result from the mismatch between the company's strategic goals and constraints set by external forces (Furr et al., 2012; Miller and Friesen, 1983).

Encouraging riskier projects. Turning back to the analysis of the role that generalist CEOs play in aligning technological innovations with product development, we should start with evidence pointing to differences in risk taking between top managers with general skills and their specialist counterparts (see Custódio et al., 2017; Mishra, 2014). More specifically, generalist CEOs are likely to pursue new and, hence, riskier projects because of the awareness that the human capital they have is equally applicable somewhere else, should the failure of an innovative project yield a credible threat of dismissal (Custódio et al., 2017). Effectively, their diverse expertise acts as an insurance policy, providing them with still enough career opportunities even after failing in one professional area. Since risk-taking atmosphere is among the main factors determining whether technology conversion is going to occur, let alone to be successful, having an individual at the corporate level who can facilitate the creation of such atmosphere should be beneficial for this process and, correspondingly, for NPD performance.

Achieving efficiency in resource allocation. Conversely, a peculiar characteristic of specialist executives is that they are more biased in how they distribute internal resources, thus demonstrating lower allocation efficiency (Xuan, 2009). Unlike generalists, specialist CEOs may use the budget as a bridge-building instrument in order to induce cooperation from less familiar, yet more powerful divisions. Top managers who specialize in one professional area may also develop favoritism towards it, with a corresponding effect on the level of confidence and optimism about investment in this area. By accumulating area-specific investment, such
CEOs often seek to reinforce the value of their human capital for shareholders and, therefore, solidify their leadership position in the company. At the same time, "a generalist CEO's ability to evaluate investment projects in all segments of the firm on an equal footing, without being biased by the bridge-building tendencies, might allow her to allocate funds more efficiently across divisions than a specialist CEO" (Xuan, 2009:4923). It should be mentioned, however, that along with greater allocation efficiency, having a generalist CEO is also associated with value losses for company shareholders due to a higher pay and benefit package these managers demand as well as a higher cost of equity capital financial markets impose on companies with generalist CEOs (Mishra, 2014; Murphy and Zabojnik, 2004). Nonetheless, it is expected that chief executives with the abundance of general skills tend to be less susceptible to functional area biases when first selecting NPD projects, including their technological content, and then distributing resources across them.

Solving the communication problem. Finally, the seemingly better ability of generalist CEOs to tackle the efficiency problem in cross-functional interactions is of importance for seizing market opportunities with technological innovations as well. As product development is a joint responsibility of multiple functional areas, leadership and encouragement from top management are needed to ensure that building blocks of the NPD process generate a high performance outcome (Calantone et al., 1995). However, the detrimental effect of functional silos on technology conversion can be mitigated when managers, along with "the depth of knowledge necessary to understand technical options, [...] also have experience of how their discipline base interacts with other knowledge bases and context-specific factors" (Iansiti, 1995b:536). CEOs with diverse expertise and experience would be better able to overcome functional disintegration (Betzer et al., 2016) and, as such, to build the decision-making framework that puts together various competences in order to ensure NPD success.

5 Despite agency theories suggesting this type of managerial behaviour, Xuan (2009) finds empirical confirmation of the bridge-building hypothesis.
This leads us to conclude that generalist CEOs are likely to influence the relationship between technological innovations and product development in the following way:

**Hypothesis 3:** Generalist CEOs positively moderate the technological innovation–NPD performance link.

When examining the moderation effect of generalist chief executives on the efficiency of technology conversion, a clear distinction has to be made between leveraging technological competence in new and existing markets. Unlike serving current and, hence, familiar markets, a company seeking to deploy or redeploy its inventions in a new market needs first to acquire enough knowledge about that market (Rubera et al., 2012). According to Danneels (2007:528), this knowledge includes "assessing the potential of new markets, building relationships in new markets, setting up new distribution and sales channels, leveraging brand/company reputation to new markets, researching new competitors and new customers, developing new advertising or promotion strategies, and developing new pricing strategy". Needless to say, the required expertise should be obtained well before the commercialization stage because it increases the chances of NPD success, no matter how new the technology or market is, as well as the speed with which the resulting product will reach customers (Dougherty, 1990; Rubera et al., 2012). Given that for most companies learning about new markets is a time and cost consuming task, an alternative is to compensate the lack of market knowledge, at least in part and temporarily, by drawing on the human capital embedded in generalist executives. Their wider expertise and connections to external parties coupled with the risk-taking attitude and often strong influence over the decision-making process should provide the company with a comprehensive outlook on how new technologies can best be deployed in an unfamiliar environment.

So, our final hypothesis is as following:

**Hypothesis 4:** The moderation effect of generalist CEOs is more pronounced in exploratory than exploitative NPD.
3 DATA AND METHODS

Data collection

The above hypotheses were tested with a longitudinal sample consisting of U.S. publicly-traded companies observed over a 22-year period. A multistage approach was designed to construct the sample. We started by examining the Standard & Poor's ExecuComp database, where we first identified manufacturing companies (SIC code 2000–3999) and then extracted executive compensation statistics for each of them. To obtain firm financial data, we linked selected companies to the Standard & Poor's Compustat North America database. In the merged dataset, we retained only those companies that had complete financial and executive information for the entire period of interest. For comparability reasons we adjusted all monetary variables to constant 2009 U.S. dollars with the GDP deflator from the U.S. Bureau of Economic Analysis. Finally, we added CEO demographic data, which were hand-collected from such sources as Marquis Who's Who directories, Bloomberg database, BoardEx database, companies' SEC filings, press releases, official web-sites, university yearbooks, and obituaries.

To obtain patent and trademark statistics, we drew on the OECD patent databases and the USPTO Trademark Case Files dataset, respectively. Because of the absence of a unique identifier enabling us to link this information to the rest of our data, we decided to utilize company names — an approach widely accepted in research on intellectual property rights (see Thoma et al., 2010). That is, for each company in the preliminary dataset we determined the most distinguishing element in its name and searched for this element in both patent and trademark databases, while also controlling for such factors as country, state, city, and address so as to minimize false positives. To ensure data consistency and comparability, we excluded corporate, certification, and collective marks, and marks with non-US or individual owners.

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6 The OECD HAN database (September 2016 Edition) was first used to derive assignee names. We then employed the application identifier to link each entry to the OECD Patent Quality Indicators database (March 2017 Edition). Only applications submitted to the U.S. Patent and Trademark Office (USPTO) were considered.
Overall, this approach has resulted in the study sample that contains 3,058 firm-year observations of 455 CEOs in 139 U.S. manufacturing companies between 1992 and 2013. For these companies we were able to identify 254,520 patents and 26,076 trademarks.

Dependent variables

We measure NPD performance as the total number of trademarks introduced by a company in a given year. We rely on the first use in U.S. commerce year because it allows us to better identify the exact moment when a new product was released. The idea of examining trademark statistics to capture product innovation is not new: for example, Greenhalgh and Longland (2001:677) pointed out that "the timing of new applications for trade marks can be a good reflection of the bringing to market of new products, so these data provide another indicator of innovation". Subsequent studies that adopted trademark analysis have largely supported this suggestion (e.g., Flikkema et al., 2014; Jensen and Webster, 2009; Mendonça et al., 2004).

NPD performance in new markets is measured as the total number of trademarks introduced by a company in a given year each of which covers at least one new product class, compared to the company’s product class portfolio in the previous year. This approach seems to be in line with the notion that introducing trademarks in new product classes or expanding their use into complementary classes signals "strategic behavior by owners for such purposes as creating licensing opportunities, intensifying consumer associations and confidence in a brand, or easing entry into new product marks by leveraging consumer brand associations" (Graham et al., 2013:14). Similarly, while utilizing product class analysis to identify trademark filing strategies, Sandner (2009) also argues that changes in trademark product class coverage should reflect the market directions in which a company develops its brands.

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7 A product class can be defined as a category of goods or services in which the trademark is used for the purpose of differentiation. When applying for a trademark registration, the trademark owner must specify the product class or classes with which the trademark will be associated. The USPTO currently follows the International Classification of Goods and Services under the NICE Agreement, which was adopted in 1973.
Independent variables

To measure CEO general skills, we follow the approach proposed by Custódio et al. (2013) and calculate the so-called general ability index. This index intends to capture "the skills of the CEO that are transferrable across firms and industries, instead of being firm-specific" (Custódio et al., 2013:474). It particularly incorporates such elements as the numbers of (i) industries, (ii) companies, and (iii) positions where the chief executive has worked, and also (iv) his/her previous experience as a CEO at another company. Principal component analysis is used to combine the four elements into a one-dimensional index. As a result, each executive is assigned a score derived from this formula:

\[ GAI_{i,t} = 0.379 \times Y_{1,i,t} + 0.388 \times Y_{2,i,t} + 0.346 \times Y_{3,i,t} + 0.009 \times Y_{4,i,t}, \]  

(1)

where \( Y_1 \) is the number of industries where the chief executive has worked; \( Y_2 \) is the number of companies where the chief executive has worked; \( Y_3 \) is the number of positions that the chief executive has held; and \( Y_4 \) is a dummy variable that takes the value of one if the chief executive has previous experience in the CEO position. The index is standardized to have zero mean and a standard deviation of one. In our further analysis, we will follow Custódio et al. (2013:474) and regard "CEOs with an index above the yearly median as generalists and CEOs with an index below the yearly median as specialists".

To determine the number of technological innovations developed by a company in a given year, we count patent applications. This approach has been widely-accepted in the innovation literature (see Griliches, 1990), tracing its roots to Schmookler's (1962) work on economic sources of inventive activity. In turn, the quality of technological innovations is measured by averaging the six-component patent quality index initially proposed by Lanjouw and Schankerman (2004) and subsequently extended by Squicciarini et al. (2013). The index contains such elements as the number of forward citations (up to 5 years after publication); the number of backward citations; the number of claims; the size of the patent family; the
patent generality index; and also the grant lag index. As explained by Squicciarini et al. (2013:59), "[a]l[ll] components are normalised according to patent cohorts stratified by year and technological field and are given equal importance (no weights)". It should additionally be noted that our patent-based indicators cover only granted patents.

*Control variables*

*Individual-level controls.* Following previous studies, we control for other managerial factors that can also affect a company's NPD performance. In particular, we include *company tenure* to capture the accumulation by an individual of firm-specific knowledge (Finkelstein et al., 2009). This variable is calculated as the difference between the observation year and the year in which the individual joined the company; its squared term is added to allow for potential nonlinearities. There are several cases in our sample when individuals left and rejoined their companies — for those we summed up the terms. We then introduce the *founder CEO* dummy that equals one if the chief executive is the company's founder, and zero otherwise. Its aim is to distinguish between founding and professional managers due to disparities these two types have regarding personal objectives, entrepreneurial behavior, and firm-specific knowledge (Gedajlovic et al., 2004). Next, we control for the *amount of higher education* chief executives received by counting their university degrees. Some observations suggest that more educated managers show a greater receptivity to new ideas, are apt to encouraging experimentation and creativity, and, thus, have a positive impact on the adoption of innovation in their organizations (Kimberly and Evanisko, 1981). Given that the latitude of actions afforded to managers very much depends on internal forces (Wangrow et al., 2015), we also account for the ability of CEOs to influence organizational functioning and include the *CEO duality* dummy indicating if the chief executive doubles as the board chair or not. Relatedly, the level of managerial discretion that stems from having a share in the company's equity is captured by the *CEO ownership* variable, which is the percentage stock ownership held by the chief executive (Wu
Finally, the potential differences between men and women in risk perception are proxied by the male CEO dummy (Schubert et al., 1999).

**Firm-level controls.** Our choice of company-specific controls is guided by previous empirical studies that use patent and trademark data. First of all, we account for *company size*, calculated by taking the natural logarithm of the total number of employees. This variable is added to capture the differences existing between large and small companies, especially when it comes to the availability of financial resources, the importance of product innovation, and the costs of generating new patents or trademarks (Block et al., 2015; Hall and Ziedonis, 2001). In turn, *company age* is determined by subtracting the year to which the company traces its origin from the observation year. This factor aims to approximate the experience accumulated by companies in managing intellectual property rights (Hall and Ziedonis, 2001). Moreover, depending on the phase of the life cycle, the company may change its perception of the value it places on certain intellectual property rights, with a corresponding effect on their creation and acquisition (Block et al., 2015). To proxy the allocation of resources among the activities that are tightly linked to NPD, we include the *intensity of commercial expenditures*, derived as the ratio of selling, general, and administrative expenses to total assets (Knoeber, 1986). Finally, we also augment our model specifications with variables that reflect the company's prior financial performance, such as *return on assets* (ROA), calculated as the ratio of income before extraordinary items to total assets (to limit outliers, winsorized at -1 and +1); and *book leverage* that represents the ratio of long-term debt plus current liabilities to total assets (Custódio et al., 2017).

**Model selection and estimation**

Considering that the number of trademarks introduced by a company is a count variable, with an abundance of zeros, we can approximate it by using a discrete probability distribution. Having found strong evidence of overdispersion in both dependent variables, we choose to
adopt the negative binomial model, which essentially is a generalized version of the Poisson model, with a stochastic component used to handle overdispersion. Its probability density function can be written as (based on Allison, 2009):

\[
f(y_{i,t}) = P(Y_{i,t} = y_{i,t}) = \frac{\Gamma(\theta + y_{i,t})}{\Gamma(\theta)\Gamma(1+y_{i,t})} \left( \frac{\lambda_{i,t}}{\theta + \lambda_{i,t}} \right)^{y_{i,t}} \left( \frac{\theta}{\theta + \lambda_{i,t}} \right)^{\theta},
\]

where \(y_{i,t}\) is the number of trademarks introduced by company \(i\) in period \(t\); \(\lambda_{i,t}\) is the expected value of \(y_{i,t}\); \(\theta\) is the overdispersion indicator; and \(\Gamma(\cdot)\) is the gamma function. The expected value of \(y_{i,t}\) can then be represented by one of the following log-linear functions:

\[
\log(\lambda_{i,t}) = \mu_t + \beta_1 \times P_{i,t-1} + \beta_2 \times P_{i,t-1}^2 + \beta_3 \times GA_{i,t-1}^j + \beta_4 \times P_{i,t-1} \times GA_{i,t-1}^j + \beta_5 \times P_{i,t-1}^2 \times GA_{i,t-1}^j + \beta_6 \times X_{i,t-1}^j + \beta_7 \times M_{i,t-1} + \zeta_i + \eta_h + \tau_t,
\]

\[
\log(\lambda_{i,t}) = \mu_t + \beta_1 \times Q_{i,t-1} + \beta_2 \times GA_{i,t-1}^j + \beta_3 \times Q_{i,t-1} \times GA_{i,t-1}^j + \beta_4 \times X_{i,t-1}^j + \beta_5 \times M_{i,t-1} + \zeta_i + \eta_h + \tau_t,
\]

where \(\lambda_{i,t}\) is the expected number of trademark introductions; \(\mu_t\) is the intercept that varies over time; \(P_{i,t-1}\) is the number of new patent applications; \(Q_{i,t-1}\) is the average quality of new patent applications; \(GA_{i,t-1}^j\) is the general ability index; \(X_{i,t-1}^j\) is the vector of individual-level controls; \(M_{i,t-1}\) is the vector of firm-level controls; \(\zeta_i\) denotes unobservable time-invariant company-specific effects; \(\eta_h\) denotes unobservable time-invariant industry-specific effects; and \(\tau_t\) denotes year-specific effects to control for the general economic trend. All independent variables are lagged by one period to minimize simultaneity bias.

We estimate this model by using the unconditional specification with directly included fixed-effects proposed by Allison (2009). Unlike some prior studies, we decided not to adopt the conditional likelihood method devised by Hausman et al. (1984) because of its inability to control for all stable covariates (Guimarães, 2008). Moreover, instead of including a dummy variable for each company in our sample, we utilize the mean scaling estimator developed by
Blundell et al. (1999). One of the main advantages of this approach is that it "relaxes the strict exogeneity assumption and provides consistent estimates under the weaker assumption of predetermined [... regressors]" (Galasso and Simcoe, 2011:1476). We calculate this estimator as the five-year pre-sample mean of the total number of trademarks introduced by a company. We have also experimented with longer pre-sample periods, up to nine year, but did not find any significant differences in the results.

4 RESULTS

The means, standard deviations, and correlations for the study variables are shown in Table 1. To assess the degree of multicollinearity, we calculated the variance inflation factor (VIF) with the independent variables from our baseline models, and this revealed no obvious problems.

Table 2 presents the results of the negative binomial regression analysis concerning the relationship between invention activities and NPD performance as well as the moderation effect of CEO general skills on this relationship. To ease interpretation, parameter estimates from these and other subsequent models have been converted to incidence rate ratios (IRRs) by exponentiating beta coefficients: that is, an IRR above one denotes a positive relationship and below one — a negative relationship, thereby representing the factor change in trademark introductions because of a unit change in a regressor, all else being equal. Overall, our analysis provides strong support for the idea that technological innovations have a significant impact on NPD performance, both quantity and quality-wise, with the number of new technologies the company generates having a curvilinear relationship with its product market performance (Hypotheses 1 and 2 confirmed). As expected, generalist chief executives facilitate invention conversion, but the moderating effect turns significant only when the quality of technological innovations is considered (Hypotheses 3 confirmed).
Given the difficulties with the interpretation of interaction terms in non-linear models (see Ai and Norton, 2003), we follow Greene (2010) and provide graphical representations of our findings. Figure 1 plots the marginal effects of patent activities on NPD performance for different CEO types. Clearly, chief executives possessing mainly general skills are associated with more product introductions, regardless of how many inventions the company generates. By contrast, the positive effect of generalist CEOs tends to become stronger when the quality of new technologies is at higher levels. In both cases, the results are statistically significant at the 0.1% level, thus reinforcing our conclusion regarding the validity of Hypothesis 3.

As Hypothesis 4 states, the moderating effect of generalist executives on technology conversion should be more pronounced in new than existing markets. We find full support for this hypothesis (see Table 3): our results particularly suggest that while generalist CEOs start out with lower NPD performance, they catch up to specialists executives and even surpass them in the upper groups, where the number or quality of technological innovations is higher (the differences are statistically significant at the 5% level or better). Interestingly, the moderating effect of specialist executives demonstrates the opposite dynamics. Another note to make here is that the direct effect of the number of new technologies on product development is linear, unlike the inverted U-shaped relationship we observed for the full sample.

Finally, some useful insights can be obtained from the analysis of control variables. For example, we have found that the effect of a CEO's company tenure on NPD performance is non-linear — it first increases and then decreases along with the accumulation of company-specific experience. This result seems to be broadly consistent with the "stale in the saddle" effect documented in previous research (see Finkelstein et al., 2009). In turn, founder CEOs are associated with fewer products introduced in the marketplace. A compelling explanation

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8 In particular, they argue that "[the] magnitude of the interaction effect in nonlinear models does not equal the marginal effect of the interaction term, can be of opposite sign, and its statistical significance is not calculated by standard software" (Ai and Norton, 2003:123).
Table 1. Descriptive statistics and correlations

<table>
<thead>
<tr>
<th>No.</th>
<th>Variable</th>
<th>Mean</th>
<th>SD</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
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<th>13</th>
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<th>15</th>
<th>16</th>
<th>VIF</th>
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<td></td>
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</tr>
<tr>
<td>2</td>
<td>NPD performance in new markets</td>
<td>0.276</td>
<td>0.750</td>
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<td></td>
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</tr>
<tr>
<td>3</td>
<td>Number of technological innovations</td>
<td>83.231</td>
<td>227.137</td>
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<td>1.00</td>
<td></td>
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<td>CEO general skills</td>
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<td>Founder CEO</td>
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<td>-0.01</td>
<td>-0.05</td>
<td>-0.12</td>
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<td>Amount of higher education</td>
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<td>9</td>
<td>CEO duality</td>
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<td>0.463</td>
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<td>0.07</td>
<td>0.12</td>
<td>0.17</td>
<td>0.19</td>
<td>0.08</td>
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<td>-0.01</td>
<td>-0.10</td>
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<td>-0.14</td>
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<td>11</td>
<td>Male CEO</td>
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<td>0.07</td>
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<td>0.10</td>
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<td>-0.03</td>
<td>-0.01</td>
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<td>Company size*</td>
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<td>1.491</td>
<td>0.40</td>
<td>0.08</td>
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<tr>
<td>14</td>
<td>Return on assets</td>
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<td>0.074</td>
<td>0.11</td>
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<td>-0.02</td>
<td>0.07</td>
<td>-0.06</td>
<td>0.07</td>
<td>0.05</td>
<td>-0.03</td>
<td>0.01</td>
<td>0.04</td>
<td>0.06</td>
<td>-0.01</td>
<td>-0.07</td>
<td>1.00</td>
<td></td>
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<td>1.21</td>
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<tr>
<td>15</td>
<td>Book leverage</td>
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<td>0.00</td>
<td>-0.04</td>
<td>0.02</td>
<td>0.06</td>
<td>0.01</td>
<td>-0.16</td>
<td>0.03</td>
<td>0.08</td>
<td>-0.13</td>
<td>-0.10</td>
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<td>0.31</td>
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<td>16</td>
<td>Intensity of commercial expenditures</td>
<td>0.222</td>
<td>0.136</td>
<td>0.12</td>
<td>0.06</td>
<td>-0.12</td>
<td>0.04</td>
<td>0.03</td>
<td>-0.06</td>
<td>0.03</td>
<td>-0.07</td>
<td>-0.02</td>
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<td>0.03</td>
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<td>0.22</td>
<td>-0.18</td>
<td>1.00</td>
<td>1.64</td>
</tr>
</tbody>
</table>

The table presents the means, standard deviations (SD), and Pearson's pairwise correlations for the study variables (n = 3,058). The asterisk (*) denotes the natural logarithm of a variable. VIF is the variance inflation factor calculated for each independent variable from Model 1.1 (for the quality of technological innovations Model 1.3 is used); the squared term of company tenure is excluded from both models.
### Table 2. Technological innovations, NPD performance, and CEO general skills

<table>
<thead>
<tr>
<th>Dependent variable:</th>
<th>Negative binomial models</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Model 1.1</td>
</tr>
<tr>
<td>Number of technological innovations (_{i,j,t})</td>
<td><strong>1.0003</strong> (0.0001)</td>
</tr>
<tr>
<td>Number of technological innovations(^2) (_{i,j,t})</td>
<td>0.9999** (0.0000)</td>
</tr>
<tr>
<td>Quality of technological innovations (_{i,j,t})</td>
<td>2.784* (0.557)</td>
</tr>
<tr>
<td>CEO general skills (_{i,j,t})</td>
<td>1.088 (0.045)</td>
</tr>
<tr>
<td>Number of tech. innovations (<em>{i,j,t}) × CEO general skills (</em>{i,j,t})</td>
<td>1.0003 (0.0004)</td>
</tr>
<tr>
<td>Number of tech. innovations(^2) (<em>{i,j,t}) × CEO general skills (</em>{i,j,t})</td>
<td>0.9999 (0.0000)</td>
</tr>
<tr>
<td>Quality of tech. innovations (<em>{i,j,t}) × CEO general skills (</em>{i,j,t})</td>
<td>2.850** (0.969)</td>
</tr>
<tr>
<td>Company tenure (_{i,j,t})</td>
<td>1.022** (0.008)</td>
</tr>
<tr>
<td>Company tenure(^2) (_{i,j,t})</td>
<td>0.9995** (0.0002)</td>
</tr>
<tr>
<td>Founder CEO (_{i,j,t})</td>
<td>0.829† (0.091)</td>
</tr>
<tr>
<td>Amount of higher education (_{i,j,t})</td>
<td>1.067* (0.028)</td>
</tr>
<tr>
<td>CEO duality (_{i,j,t})</td>
<td>1.220** (0.060)</td>
</tr>
<tr>
<td>CEO ownership (_{i,j,t})</td>
<td>0.558 (0.277)</td>
</tr>
<tr>
<td>Male CEO (_{i,j,t})</td>
<td>1.909** (0.383)</td>
</tr>
<tr>
<td>Company size (_{i,t})</td>
<td>1.326** (0.030)</td>
</tr>
<tr>
<td>Company age (_{i,t})</td>
<td>0.999* (0.001)</td>
</tr>
<tr>
<td>Return on assets (_{i,t})</td>
<td>1.998 (0.594)</td>
</tr>
<tr>
<td>Book leverage (_{i,t})</td>
<td>0.617 (0.102)</td>
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<td>Intensity of commercial expenditures (_{i,t})</td>
<td>2.845** (0.516)</td>
</tr>
<tr>
<td>Firm fixed effects</td>
<td>BGV</td>
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<tr>
<td>Industry fixed effects</td>
<td>Yes</td>
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<tr>
<td>Year fixed effects</td>
<td>Yes</td>
</tr>
<tr>
<td>Log likelihood</td>
<td>-7,980.3</td>
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<tr>
<td>ln(Alpha)</td>
<td>-0.257***</td>
</tr>
<tr>
<td>Number of observations</td>
<td>2,919</td>
</tr>
</tbody>
</table>

† 10% significance; * 5% significance; ** 1% significance; *** 0.1% significance.

All coefficients reported as incidence rate ratios (IRRs); robust standard errors (in parentheses) adjusted for overdispersion; firm fixed effects (BGV) based on including the five-year pre-sample mean of the dependent variable (see Blundell et al., 1999); industry fixed effects based on the Fama and French (1997) 48 industry classification.
Figure 1. The moderating effect of CEO general skills on the relationship between technological innovations and NPD performance

The number of technological innovations

The quality of technological innovations
Table 3. Technological innovations, NPD performance, and CEO general skills: The exploration of new markets

<table>
<thead>
<tr>
<th>Dependent variable:</th>
<th>Negative binomial models</th>
</tr>
</thead>
<tbody>
<tr>
<td>NPD performance in new markets i, t</td>
<td>Model 2.1</td>
</tr>
<tr>
<td>Number of technological innovations i, j, t</td>
<td>1.0004† (0.0002)</td>
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<tr>
<td>Number of technological innovations² i, j, t</td>
<td>0.9999 (0.0000)</td>
</tr>
<tr>
<td>Quality of technological innovations i, j, t</td>
<td>1.032 (0.111)</td>
</tr>
<tr>
<td>CEO general skills i, j, t</td>
<td>1.0101 (0.0172)</td>
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<tr>
<td>Number of tech. innovations i, j, t × CEO general skills i, j, t</td>
<td>0.9998 (0.0004)</td>
</tr>
<tr>
<td>Quality of tech. innovations i, j, t × CEO general skills i, j, t</td>
<td>1.355 (0.314)</td>
</tr>
<tr>
<td>Number of observations</td>
<td>2,919</td>
</tr>
</tbody>
</table>

† 10% significance; * 5% significance; ** 1% significance; *** 0.1% significance.

All coefficients reported as incidence rate ratios (IRRs); robust standard errors (in parentheses) adjusted for overdispersion; firm fixed effects (BGV) based on including the five-year pre-sample mean of the dependent variable (see Blundell et al., 1999); industry fixed effects based on the Fama and French (1997) 48 industry classification.
Figure 2. The moderating effect of CEO general skills on the relationship between technological innovations and NPD performance: The exploration of new markets

*The number of technological innovations*

![Graph showing the moderating effect of CEO general skills on the number of technological innovations.]

*The quality of technological innovations*

![Graph showing the moderating effect of CEO general skills on the quality of technological innovations.]

The number of technological innovations

The quality of technological innovations
for this finding is that founders usually have most of their wealth invested in the company, which may become an obstacle in accepting potential losses, both material and reputational, stemming from new ventures (Gedajlovic et al., 2004). At the same time, more educated CEOs, CEOs who hold the chairman position, as well as male CEOs have a positive direct effect on NPD performance.

Robustness checks and extensions

To ensure that our results are not sensitive to modelling or measurement errors, we have performed several robustness checks of and extensions to our baseline specifications, with only a brief overview provided here.

First of all, we have verified our modelling approach. We started with testing whether our statistical inference is affected by the choice of the model type to fit the empirical data and found great consistency in the estimated coefficients across different models. To ameliorate the omitted variable bias problem, we then experimented with the inclusion of additional individual and firm-specific controls that can potentially impact NPD performance, but it did not change the results as well. And finally, we also tested for the effect of outliers by trimming patent-based indicators at 99th, 95th, and 75th percentiles. Not only has this action reinforced the validity of our conclusions, but it has also revealed that the exclusion of outliers increases the significance of the obtained estimates.

Another set of questions relates to how general managerial skills and patent quality are captured. To begin with the general ability index, we altered its specification so as to account for a CEO’s military, academic, and civil service experiences, thus responding to prior studies indicating that such experience has an impact on managerial perception and decision-making (see Benmelech and Frydman, 2015; Bertrand et al., 2007; Dietz and Bozeman, 2005). We also experimented with the inclusion of the full index, without converting it into a dummy variable,
as well as calculated the generalist CEO measure based on the original general ability index computed by Custódio et al. (2013). It turns out that the results are largely comparable across different specifications of the general ability variable, with the non-converted index showing a slightly better performance. So far as the patent quality index is concerned, to gain more insights into how its individual components may influence product development, we conducted a by-component analysis. According to the results, the quality of technological innovations is still a significant predictor of NPD performance, even when alternative, more granular patent quality measures are employed.

Finally, we have also addressed the potentially endogenous matching between chief executives and companies. More specifically, it can be assumed that individuals are drawn to, and advance within, the professional environment that provides a better fit to their knowledge, skills, and career aspirations. Alternatively, it can be part of a company's objective to appoint new CEOs with the traits necessary to develop and implement a range of particular strategies. Therefore, a realistic scenario is that chief executives with the abundance of general skills are attracted to or hired by companies that put an emphasis on technology-intensive NPD projects. So, to avoid spurious results, we have checked that the effects identified for generalist CEOs are not driven by either self-selection or the selection by a company.

Two approaches have been focused on to perform this check: we first re-estimated our baseline models using different cut-off dates for CEO tenure, ranging from three to five years. This approach is consistent with the study by Hirshleifer et al. (2012), where the authors note that the strength of the matching effect gradually declines as CEO tenure progresses because, unlike personality traits that are relatively persistent, organizational strategies tend to vary over time in response to internal and external pressures. Another way to address concerns related to the endogeneity of the CEO–company match is with the instrumental variables approach. Here, we invoked two sources of exogenous variation in the generalist status. On the one hand,
the diversity of an individual's skills is often constrained by the tacit knowledge acquired in
the higher education environment, thereby making the breadth of higher education our first
instrumental variable.\(^9\) On the other hand, the legal framework in which CEOs advance their
careers limits the number of job opportunities available to them, too. For example, working in
organizations that enforce noncompetition contracts is likely to influence executive mobility
and, via this, affect the generality of their backgrounds. So, following Custódio et al. (2017),
for each chief executive we have calculated an index reflecting the average stringency of non-
competition regimes across all public companies in which this executive has held a position.
Our index largely draws on the estimates of noncompetition enforcement for U.S. states made
by Garmaise (2011): we linked his results to companies in our sample by using the headquarter
location. In addition, there is also an argument that some executives may stay in their position
not long enough so as to leave a lasting imprint of their personality on organizational strategy.
We have addressed this argument by removing short-tenured CEOs from our analysis, where
the short tenure is determined as being three years or less. Overall, the results from these tests
mostly mirror the original picture, with only few variations across subsamples, thus supporting
the initial expectation that the effect of the endogenous matching on our findings is negligible.

5 \hspace{1em} **DISCUSSION AND CONCLUSION**

In this work, we have studied the impact of technological innovations on product development,
putting a particular emphasis on the role of CEO general skills in moderating this relationship.
The results of our analysis suggest that companies generating more technological innovations
have better NPD performance, but the effect tends to be non-linear: in other words, as soon as
a certain level of technology generation is achieved, increasing the number of new technologies
in a company's invention portfolio does not correspond to a pro rata increase in the diversity

\(^9\) We coded all higher education degrees into seven categories: arts and humanities; engineering and technology;
life sciences and medicine; natural sciences; business studies; legal studies; and other social sciences. This
coding is based on the classification designed by Quacquarelli Symonds Limited for their university ranking.
of product portfolio. At the same time, companies whose inventions are of higher quality are
much more active with respect to developing new products than those organizations that create
lower-quality inventions. What is perhaps even more important here is that CEO general skills
moderate this relationship, with generalist chief executives inducing greater NPD performance
in companies where the quality of new technologies is higher; moreover, the managerial effect
is more pronounced when product development in new markets is considered.

Overall, the results demonstrated in this study have reinforced the contention that the
technological input is crucial for succeeding in product development. Nonetheless, there is also
the reverse side of intensifying technological generation which consists in higher coordination
and integration costs associated with extensive technological portfolios. Once a new technology
is created, it is likely to face a variety of obstacles before reaching the commercialization stage,
including the aversion to risks stemming from its use, the scarcity or resources for competing
technologies, and a lack of communication among functional groups interacting to bring this
technology to the marketplace. One of the solutions to the technology conversion problem is
to ensure top management involvement in this process, given that this involvement usually
improves the overall NPD efficacy as well. However, the attention should be paid not only to
what corporate leaders have to do in order to achieve NPD success, but also to what personality
characteristics they require to make this participation meaningful, thus turning top managers'
human capital into yet another source of a company's competitiveness in the product market.

Limitations and future research

This work has some limitations that provide opportunities for future research. First, to profit
from technological innovations, companies may prefer a contractual model, which consists in
licensing a technology to another company (see Teece, 1986). This model is attractive because,
if adopted, the innovator does not have to incur the upfront capital expenditures associated
with bringing the technology in the form of a product to the marketplace. Further studies are
thus needed to evaluate the role of CEOs and their characteristics in choosing the contractual business model and the extent to which the product market performance is contingent on this choice.

Second, we use patent applications to understand how well the company performs in terms of developing new technologies. However, products are likely to incorporate a variety of technologies created both within and outside the company (see Tatikonda and Stock, 2003). So, another potentially fruitful research direction is to examine the effect of generalist CEOs on the decision to engage in technology transfer and how it impacts the company's NPD effort. Relatedly, we only capture here the overall level of technology generation in one period and compare it to the overall level of product development performance in another period, without actually attempting to establish the precise technology–product link. A plausible alternative is to conduct research at a granular level of analysis, à la Chandy et al. (2006), so as to answer the question of whether the effect of generalist executives still holds when the commercialization of concrete technologies is considered.

And fourth, the focus of our study is on large publicly-traded companies. Given that incentives and mechanisms related to product development are likely to function differently in those companies than in small and medium-sized enterprises (see Block et al., 2015), our findings may not be fully generalisable to the entire size distribution. Nevertheless, we still expect that the flatter organizational structure of small firms and their market orientation may actually result in an even stronger influence from the CEO's side, if not equal.
References


