FINDING THE SWEET SPOT: EFFECTS OF EXPORTING ON THE RELATIONSHIP BETWEEN R&D INVESTMENT AND NPD PERFORMANCE

ABSTRACT*:*

Purpose: The aim of this research is twofold: (1) to investigate when the effect of R&D investment on New Product Development (NPD) performance peaks – the sweet spot; and (2) to analyze the influence of firms' export activities on where that spot is. Drawing on the knowledge-based view (KBV), we argue that export intensity and export experience lead to differential effects on how R&D investments are converted into new products.

Design/methodology/approach: We test our conceptual framework using time lagged data and optimal level analysis. The data set consists of an unbalanced panel of 608,891 observations and 333,516 firms.

Findings: The results support the expected inverted U-shaped relationship between R&D investment and NPD performance. They also show moderating effects of export intensity and experience. Export intensity enhances innovation processes by enabling firms to stretch the points at which R&D investments eventually taper off. In contrast, export experience improves firms' ability to convert R&D investments into NPD performance. Our results demonstrate that, all else equal, firms with relatively higher export experience can spend less on R&D and still achieve higher levels of NPD performance.

Originality: We contribute to the literature by investigating how export activities provide a valuable context for understanding the theoretical mechanisms that help explain the inverted U-shaped relationship between R&D investment and innovation. We show the effects of exporting activities on the precise points where the R&D investment-NPD performance relationship peaks, thereby identifying the optimal point within this non-linear relationship.

Keywords: exporting; NPD performance; knowledge-based view; optimal point; R&D investment

1. INTRODUCTION

Global dynamic competition requires firms to invest in R&D and to develop ways of working with their export markets to continuously develop new products to prevent them from falling behind (Haschka & Herwartz, 2020; Sousa, Li, & He, 2020; Xia & Liu, 2018). Yet, increasingly, there is evidence that new product development performance can decline even when R&D investment increases. This may be due to higher costs, intense competition and path dependencies. Naturally, managers would prefer to be operating as close to the 'sweet spot', i.e., point where the effect of R&D investment is maximized, as possible. Overshooting or undershooting this point, implies inefficiencies or lost opportunities respectively (Haans, Pieters, & He, 2016; Pierce & Aguinis, 2013).

In recent years, the rise of China's car manufacturers, for instance BYD, has taken several traditional automotive markets by storm. BYD has been introducing new products which are appealing, competitive, and high performing. Arguably, the growth in new product development performance it is witnessing is the result of significant R&D investments in emerging technologies (in BYD's case, electric vehicles) and its creative interaction with its export markets. Yet, prominent and well-documented cases, such as that of Nokia (Doz & Wilson, 2017) and Kodak (Larish, 2012), indicate how the 'sweet spot' can be overlooked. Despite substantial increases in R&D investment, years of export experience, and substantial export revenues, the growth in new product development performance plateaued and, in some cases, dramatically declined.

So how can firms know when they are reaching the sweet spot, and what can they do to reach it? This question has largely been overlooked in the literature. Yet, there are strong theoretical and managerial reasons for improving our understanding both of the factors that determine the point at which the effect of R&D investment on NPD performance peaks (i.e., revenues by new or significantly improved products peak), and of the role firms' exporting activities play.

Studies in the innovation literature that have been aiming to explore how NPD performance can be maximized, have highlighted the importance of external knowledge to improve the firm's innovation output (Alam, Rooney, & Taylor, 2022; Ovuakporie, Pillai, Wang, & Wei, 2021; Robertson, Caruana, & Ferreira, 2023; Tsinopoulos, Sousa, & Yan, 2018). Exporting can play an important role in this regard by suggesting that firms' knowledge bases can be expanded by interacting with exporting markets in ways that improve innovation output (D'Angelo, Ganotakis, & Love, 2020; Freixanet & Rialp, 2022; Golovko & Valentini, 2014).

By investing in R&D a firm expands its knowledge resources, increases its flexibility in managing its innovation processes (Lee, Wu, & Pao, 2014; Nohria & Gulati, 1996), and potentially develops more effective relationships with customers and suppliers (Cohen & Levinthal, 1990; Griliches, 1979). Similarly, exporting increases sales revenue and exposes a firm to new contexts, thereby providing additional resources and learning opportunities (Assadinia, Boso, Hultman, & Robson, 2019; Hoque, Ahammad, Tzokas, Tarba, & Nath, 2022; İpek, 2019), which may affect how it accesses and integrates knowledge and manages its processes more broadly. This suggests that a firm that combines the two – R&D investment and exporting – should overall perform better in terms of development of new products (Ding, McDonald, & Wei, 2021)[1].

[1] There is a separate, complementary stream of literature that has examined innovation as a driving force behind exports (see e.g. Greenhalgh, Taylor, & Wilson, 1994; Long, Raff, & Stähler, 2011; McGuinness & Little, 1981; Wu, Wei, & Wang, 2021). The main argument behind these studies is that innovation has a direct and positive impact on exporting through the development of new or improved products. The purpose of this study, however, is to focus on the combined effect of the firm's export activities and R&D investment and how the knowledge generate by those activities can increase NPD performance.

However, after a certain point, increased costs and path dependencies (Gargiulo & Benassi, 2000; Hallen, Katila, & Rosenberger, 2014; Katila & Ahuja, 2002) generate knowledge rigidities that reduce the ability of a firm to convert higher levels of R&D investments to new products (Ahuja & Morris Lampert, 2001). When this occurs, the effect of exporting on the relationship between R&D investment and NPD performance becomes less clear. On the one hand, high levels of exporting could generate new knowledge that help overcome rigidities and thus strengthen the relationship. On the other, it could strengthen network ties whereby the firm accesses similar knowledge for a prolonged period thereby reinforcing rigidities.

Probing into the moderating effect of exporting on the relationship between R&D investment and NPD performance could further advance our understanding of the interplay of the knowledge mechanisms at work when a firm exports. Although previous research has examined some of the direct effects of learning by exporting (Baum, Sui, & Malhotra, 2023; Sousa, Yan, Gomes, & Lengler, 2021; Vendrell-Herrero, Gomes, Darko, & Lehman, 2024), little is known about whether and how exporting moderates the innovation process (i.e., the process of converting R&D investment into NPD performance), and about the possible impact on the non-linearity of these effects (Ding et al., 2021). Specifically, when effects are non-linear, analyzing them empirically to estimate their optimal points would help develop a more accurate and comprehensive view of how exporting and R&D investments affect NPD performance.

We investigate the effects exporting activities have on a firm’s ability to convert their R&D investments into NPD performance. More precisely, we aim at determining the point where the effect of R&D investment on NPD performance peaks. We explain how export intensity and export experience influence a firm’s innovation behavior. Specifically, we make two contributions.

First, we expound theoretical mechanisms that help explain the inverted U-shaped relationship between R&D investment and innovation. While non-linear relationships between R&D and innovation outputs have been explored in innovation management research (e.g. Hottenrott & Lopes-Bento, 2016; Ugur, Trushin, & Solomon, 2016; Zhang, Jiang, Wu, & Li, 2019), what affects such relationships remains relatively poorly explained. As such, we distinguish between two knowledge-sharing mechanisms through which firms' exporting activities influence turning R&D investment into new products. We argue and show that export intensity and export experience have differential effects. Export intensity predominantly increases knowledge access, whereas export experience predominantly increases knowledge integration. Hence, our study's more fine-grained analysis brings new insights about exporting-related knowledge sharing mechanisms. Specifically, the results indicate that depending on the levels of R&D investment, the effect of export experience is different to that of export intensity. We find that for export market exposure to increase NPD performance, there needs to be a sizeable R&D budget. We also find that firms with relatively higher export experience can spend less on R&D and still achieve higher levels of NPD performance than those with less experience.

Second, we explain and empirically validate the effects of exporting activities on the precise points where the R&D investment-NPD performance relationship peaks. Determining the optimal point in this non-linear relationship helps generate a more comprehensive view of the effect of exporting and R&D investments on NPD performance. This is important as it helps firms to locate the optimal point in their strategic choices. The lack of careful analysis of optimal points when examining moderations on curvilinear relationships has hindered research progress (Haans et al., 2016; Pierce & Aguinis, 2013). To our knowledge, this study presents a first attempt at identifying them.

2. THEORY AND HYPOTHESES

2.1 Theoretical Background

2.1.1 The link between R&D and NPD performance

A key objective of a firm's investment in R&D is to generate knowledge that can be integrated into new products and services, which in turn will generate revenue. As such, we define, and subsequently measure, NPD performance as the sales generated by new or significantly improved products (Klingebiel & Rammer, 2014). In this context, R&D investments are input to a process, the outputs of which are new products that generate revenue. Understanding how this process works has received considerable attention in extant literature (e.g. Kleinschmidt & Cooper, 1991). Findings suggest that this is not a simple and straightforward process (Ding et al., 2021). On the one hand, when a firm's R&D expenditure is relatively low, increases in investment will improve a firm's innovation output (Griliches, 1990). Initial R&D investments support the efforts of technical staff to improve their knowledge base and subsequently develop new products. Such efforts increase efficiency in developing and testing new concepts, and their eventual commercialization (Cruz-Cázares, Bayona-Sáez, & García-Marco, 2013).

On the other hand, the positive effect of further increases of R&D investment on sales of new or significantly improved products is not indefinite (Wales, Parida, & Patel, 2013). Beyond a certain point, the costs incurred in conducting activities associated with managing the process of innovation start to increase disproportionally. When this happens, increased levels of R&D expenditure no longer leads to proportional increases in the number of new products, and as a result the revenue generated from NPD levels out. Subsequently, fund allocation decisions are likely to be aimed at projects that strengthen existing competences (Helfat, 1994), and address current perceived customer needs (Han, Kang, Oh, Kehoe, & Lepak, 2019). "Playing it safe" by searching in the neighborhood of existing knowledge bases and trajectories (Surdu, Greve, & Benito, 2021; Zhou & Wu, 2010) results in optimizing current products and in further elaborating familiar technologies (Covin, Garrett, Kuratko, & Shepherd, 2015; Zhou & Chen, 2011; Li et al., 2022).

However, it also makes firms reluctant to replace them with entirely new ones (Michael & Palandjian, 2004), thus generating knowledge rigidities and biases. Such "bounded" search for new knowledge (Han et al., 2019) is likely to be more prevalent when firms have already spent significantly on R&D and try to navigate changing customer needs (Danneels & Sethi, 2011). Firms then find it ever more difficult to respond quickly to environmental and market changes (Hannan & Freeman, 1984). As a result, when their customers' needs have manifestly changed – for example because a competitor has disrupted the existing technology trajectory – revenues from new products decline despite increasing R&D expenditure. As a case in point, Nokia's revenues from new phones were significantly reduced after 2010 even though the company increased its R&D spending (Doz & Wilson, 2017). Taken together, the above arguments suggest that there will be diminishing returns between R&D investment and NPD performance, which leads us to our baseline hypothesis:

Baseline hypothesis: *There is an inverted U-shaped relationship between R&D investment and NPD performance.*

2.1.2 The effect of exporting on knowledge sharing mechanisms

Knowledge between an organization and its external environment is shared through two main mechanisms: knowledge access and knowledge integration (Grant & Baden-Fuller, 2004; Hagedoorn, Lokshin, & Zobel, 2018). Knowledge access refers to situations where a firm attains skills and knowledge that may help improve its market understanding and competitive advantage. Knowledge integration refers to situations where a firm absorbs and internalizes external knowledge. The effect of these mechanisms on firm innovation performance is not linear because of the increased costs and relational inertia associated with increased levels of knowledge sharing (Hagedoorn et al., 2018).

By exporting a firm expands the environmental domain within which it operates, and thereby increases the pool of knowledge sources potentially available to it (Assadinia et al., 2019; Wilson, Uddin, & Wright, 2022). Exporting activities can affect how a firm accesses tacit and codified knowledge as well as how it integrates it from a foreign market to its innovation activities for two connected reasons.

First, opportunities and ideas about new products may originate from interaction with the export market. For example, foreign market customers may use an existing product differently by finding new applications, which may be appealing in the home market (Golovko & Valentini, 2011). This enables access to new ideas that helps expand both a firm's codified and tacit knowledge bases (Johanson & Vahlne, 1990; Kotabe, Jiang, & Murray, 2011). In addition, export activities often involve collaborations with external partners, including suppliers, distributors, and research institutions. These partnerships provide access to specialized knowledge, expertise, and resources that can influence the firms' innovation activities.

Second, while information about how a country works, e.g. its legislation, infrastructure and so on (Kafouros, Buckley, Sharp, & Wang, 2008), is generally useful, it becomes particularly valuable when it is combined with knowledge that already exists within the firm, and which has been developed internally (Surdu et al., 2021). This encourages learning by doing, which increases the tacit component of product knowledge and supports knowledge integration (Pisano, 1994; Tzabbar, Aharonson, & Amburgey, 2013). For instance, testing the adherence of a new product to a foreign country's legislation and product standards leads to additional knowledge about its performance, which can then be used in future product development. Engaging in export activities often requires firms to adapt their products (Abdi, Aulakh, & Ma, 2024; Pierre, Descotes, & Pla-Barber, 2024). By integrating knowledge obtained from these export activities, firms can iteratively refine their products, services, or processes to better meet customer needs. Thus, by exposing firms to export markets, it broadens their perspectives and stimulates cross-fertilization of ideas, leading to the integration of diverse knowledge sources.

2.2 Research Hypotheses

An underlying premise of our theoretical model is that export intensity and export experience are conceptually distinct, that they trigger different knowledge sharing mechanisms, and thus, affect differently a firm's ability to convert its R&D investments into new products. Export intensity, defined as the ratio of export sales to total sales, measures the firm's present exposure to and involvement in export activities. Export experience, defined as the length of time a firm has been engaged with exporting activities, captures the accumulation of internationalization knowledge. These two dimensions (i.e., export intensity and export experience) capture distinct aspects of the firm's export activities (Chen, Sousa, & He, 2016; Sousa, Martinez-Lopez, & Coelho, 2008) and, as a result, can have crucial and distinct effects in determining its learning paths (Minguzzi & Passaro, 2001).

We argue that each dimension will trigger distinctively different knowledge sharing mechanisms, which will affect a firm's ability to convert its R&D investments into new products. Export intensity will predominantly increase knowledge access whereas export experience will predominantly increase integration. Export intensity enhances a firm's access to diverse and extensive knowledge bases across different export markets. This access allows the firm to tap into a variety of new ideas and technologies that will enhance their R&D capabilities leading to the development of new and improved products. Export experience, on the other hand, facilitates the integration of this knowledge. As a firm gains export experience, it should be able to understand and contextualize the codified knowledge better. This is consistent with the argument that international experience accelerates assimilation and facilitates the utilization of this new knowledge (Oviatt & McDougall, 2005; Park & Harris, 2014). This deepened integration capability ensures that the external knowledge is not only absorbed but also applied in a manner that enhances the firm's R&D efforts, leading to more efficient and effective new product development. Consequently, while export intensity provides access to new knowledge, export experience strengthens the firm's ability to internalize and leverage this knowledge, thereby contributing to the innovation process.

Next, we develop hypotheses by considering at what level of R&D investment, NPD performance achieves its optimal point for different levels of export intensity and export experience.

2.2.1 Export intensity

A low level of export intensity suggests that a firm focuses on its domestic market. Conversely, higher levels of export intensity indicates that a firm is actively involved in foreign markets and that it has been relatively successful at it (Ganotakis & Love, 2012). When export intensity is high, the firm has typically been able to respond successfully to the foreign market’s characteristics and customer needs (Chen et al., 2016; Sousa et al., 2008), often by introducing products that are entirely new to the firm and valued by the foreign customers.

Performing well in exporting points to a firm that has been able to amass knowledge about how customers perceive its products and services, and has developed a good understanding of what drives their desirability (Chung, Ding, & Ma, 2019). This kind of foreign market knowledge is used by managers to strengthen those attributes and actions that are thought to have led to the improved performance (Lages, Jap, & Griffith, 2008). Higher level of export intensity increases access to such knowledge, which enhances a firm's ability to convert R&D investment into NPD performance. For example, a Chinese firm that successfully exports bicycle parts to Europe – thereby increasing its export intensity – gathers substantial amounts of valuable market information, for example about customer preferences, volume seasonality of product demand and so on, either directly from customers or through its dealings with local distributors. It can use this information to advance its understanding of how its products are perceived by European customers and develop crucial knowledge about which product characteristics are key to improving performance. This understanding will inform managers in the decisions they make during the innovation process, thereby improving the ability to convert R&D investment into new products.

To summarize, a higher level of export intensity is associated with greater exposure to export markets, which enhances knowledge access and thus increases market knowledge. Since the boost in knowledge access due to export intensity positively affects the relationship between a firm's investment in R&D and its NPD performance, the point where the effect of R&D investment on NPD performance peaks should consequently also be higher. Hence, we hypothesize:

Hypothesis 1a: *Export intensity moderates the inverted U-shaped relationship between R&D investment and NPD performance in such a way that when export intensity is higher, the optimal point in the inverted U-shaped curve (i.e., where the effect of R&D investment on NPD performance peaks) is also higher.*

As a firm's export intensity increases, its exposure to international markets intensifies. As a result, it will be facing increasing competition from both local and international firms that are seeking to gain market shares in the various markets where it chooses to operate (Liu, Hodgkinson, & Chuang, 2014). This will motivate the firm to become more efficient in converting R&D investment into new marketable products. Moreover, increased levels of exposure to international markets require the firm to be more responsive to satisfy customers' needs. This may intensify the willingness to learn from others and to explore how new products can be developed and introduced. Hence, as a firm's export intensity increases, additional expenditure is required, thereby increasing R&D investment levels, to be able to develop new products.

Firms also need to consider the changing demands of their foreign customers. Frequent changes in preferences and expectations indicate that consumers are constantly looking out for new products (Sheng, Zhou, & Lessassy, 2013), which entails that firms have to invest more in R&D. This is especially so in conditions of uncertainty and rapidly changing market environments, which firms are increasingly likely to encounter as they expand their exporting activities (Azar & Ciabuschi, 2017; Tan & Sousa, 2019). To succeed, export firms respond by developing products that satisfy more diverse customer needs and preferences. Accordingly, firms increase their R&D investments, with the aim of strengthening the processes through which they access external knowledge, and, consequently, their ability to convert resources into outputs (Love & Mansury, 2009). As a result, we should expect that the upward shift of the optimal point of R&D investment and NPD performance (as hypothesized in H1a) will be achieved at a relatively higher level of R&D investment. Hence:

Hypothesis 1b: *Higher level of export intensity is associated with a higher optimal point in the inverted U-shaped curve at a higher level of R&D investment.*

2.2.2 Export experience

As export experience develops, so does the understanding of richer knowledge. A firm with experience from an export market should be able to understand and contextualize the codified knowledge better. Furthermore, by engaging with local networks (Ganotakis & Love, 2012), it may access technical know-how that is not available in the home country (Salomon & Jin, 2010; Un, 2016). Experienced exporters are also in a better position to identify and manage collaborative opportunities, to build trustworthy relationships (Howells, 2006), and, by engaging with a country's innovation system more effectively (De Silva, Howells, & Meyer, 2018), to identify and interact with local expertise (Almeida, 1996).

Moreover, KBV arguments suggest that experience broadly improves a firm's ability to integrate knowledge acquired from external sources. More specifically, Wezel, Cattani, and Pennings (2006) studied the experience of individual employees from working in other firms than their current employer. They argue that increased levels of experience allow them to better understand both their own routines and those of other firms, making them better able to improve by replicating processes and then by integrating knowledge and ideas from external sources. Applied to the context of export experience, the longer a firm sells to a market other than its domestic, the more insight its managers will have gained about how their own routines perform in different contexts. They are therefore better positioned to understand how skills and knowledge learned from the export market can be used to overcome deficiencies in their own firm's knowledge base (Zahra, Ireland, & Hitt, 2000). Managers will also be better able to evaluate which ideas and knowledge gained from the export market are more likely to be successfully integrated into their firms. For instance, the integration of a radical idea from an export market into the development of a new product may require going beyond merely triggering an evaluation process. A tacit understanding of the innovation managers' thinking, and which aspects of the new idea they are likely to be most interested in is essential. Consequently, it is likely easier for experienced exporters to improve their competence base by learning from their interactions with foreign markets and thereby advancing their ability to convert R&D investment into new products (Filipescu, Prashantham, Rialp, & Rialp, 2013).

Bringing things together, higher levels of export experience are likely to lead to increased levels of interaction with export markets, which should facilitate knowledge integration. We, therefore, conjecture that export experience will affect the relationship between a firm's investment in R&D and its NPD performance. Given the curvilinear relationship, firms with a higher level of export experience should achieve a higher optimal point than firms with lower levels of export experience.

Hypothesis 2a: *Export experience moderates the inverted U-shaped relationship between R&D investment and NPD performance in such a way that when export experience is higher the optimal point in the inverted U-shaped curve (i.e., where the effect of R&D investment on NPD performance peaks) is also higher.*

Finally, we expect the optimal point to be reached with relatively less R&D investment when a firm has more experience with exporting because of two connected reasons. First, when investment is low, experienced exporters facilitate "learning by exporting" processes by enabling access to new codified and tacit knowledge which can be combined with internal knowledge to support a firm's core innovation activities (Filipescu et al., 2013). Export experience may also provide access to important sources of technology and learning that would not have been available otherwise (Love & Ganotakis, 2013). The new knowledge obtained by experienced exporters allows the firm to develop new products with less investment in R&D.

Second, a firm that has been exporting for an extended period will have engaged with several and often different types of external stakeholders, due to changes in the external environment such as legislation and regulations, as well as the need to take part and develop a role in local networks. Export experience fosters the relational mechanisms that help firms improve how to deal with cross national differences (Lavie & Miller, 2008). According to KBV, that provides greater opportunities to learn (Lavie & Rosenkopf, 2006), and thus to increase firms' knowledge bases with relatively fewer resources (such as R&D investments).

Based on the above discussion, we expect an inward shift of the optimal point when a firm has longer export experience. In particular, we conjecture that firms with longer experience will reach the optimal point of NPD performance at a lower level of R&D investment than firms with shorter export experience.

Hypothesis 2b: *Higher level of export experience is associated with a higher optimal point in the inverted U-shaped curve at a lower level of R&D investment.*

The two diagrams in Figure 1 provide a graphical summary of the hypotheses. Both demonstrate the inverted U shape relationship between R&D investment and NPD performance (thin lines). Diagrams A and B show how we expect the optimal point to change when export intensity and export experience are at play, respectively.

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3. METHOD

3.1 Data and Sample

We use the context of Chinese manufacturing firms' exporting behavior from 2001 to 2007 to examine our theoretical argument and to test the hypotheses. This is a highly appropriate setting for our study as manufacturing in China increased substantially in the last few decades, as a result of exploring opportunities to develop new products for both the domestic and the international markets. We focus on the period from 2001 to 2007 for the following reasons. China joined the World Trade Organization in 2001. The consequent removal of many barriers to trade greatly enhanced access to export markets. Interaction with foreign operations led to important development in knowledge and exchange thereof (Xia and Liu, 2017). In 2008, two events significantly affected the decisions of Chinese firms to invest in R&D as well as to export. The first was the global financial crisis and the second was the tax policy changes (Haveman, Jia, Shi, & Wang, 2017). The former decreased the survival rates and profit margins of manufacturing firms and reduced China's inward FDI. The latter made the tax regime relatively more unfavorable to foreign firms (Xia and Liu, 2017).[2] By focusing on the 2001-2007 period, we ensure our analysis is not affected by these economy-wide events.

Our data comes from two large proprietary panel datasets – specifically, the Annual Industrial Survey (AIS) and the Chinese Customs Trade Statistics (CCTS) – both of which

[2] According to Xia and Liu (2017), the introduction of 'integrated income tax' removed the tax incentive for foreign firms, leading several of them to exit.

have frequently been used for empirical analysis (Chang & Xu, 2008; Xia & Liu, 2017). The AIS is administrated by the National Bureau of Statistics (NBS)[3], whereas the CCTS by the General Administration of Customs (GAC). Firms are legally required to complete both surveys, and the quality of the information provided is strictly monitored by the Government. Beyond the benefit of very high response rates, these databases generally present low risk of common method variance, as all key variables are based on objective measurements (Antonakis, Bendahan, Jacquart, & Lalive, 2010; Podsakoff, MacKenzie, & Podsakoff, 2012). Therefore, they are suitable for empirically testing our hypotheses.

The AIS dataset includes all listed and non-listed manufacturing firms with sales revenues greater than 5 million Chinese Yuan (approximately US$676,000). It lists a broad set of firm level operational and financial information. It includes data on the industrial sector, ownership, employment, R&D expenditures, export revenues, and new product output value, all of which are of special interest to this study. We included 29 manufacturing sectors of varying technology levels including low (e.g., textiles, food and beverage manufacturing), medium-low (e.g., rubber and plastic manufacturing), and high (e.g., pharmaceutical and communications equipment manufacturing).

The CCTS dataset provides transaction-level trade data that covers all Chinese exporters and contains disaggregated product information of firms' exporting destination markets, and export quantities and value at the 8-digit product level. This information allows us to identify the number of markets to which a firm exports.

To facilitate inference, we test our hypotheses by lagging the measures of independent, moderating and control variables (*t*-1) to the dependent variable (*t*) by one year[4]. The time

[3] http://www.stats.gov.cn/tjsj/tjgb/gypcgb/qggypcgb/200203/t20020331_30467.html

[4] Because we use unbalanced panel data, we use STATA's command *tsfill* to process observations for firms that have intermittent presence in the survey to obtain an accurate time lag measurement for each lagged variable.

predictor is also included in models 1-5 (see Table 1). In total, the data set consists of an unbalanced panel of 608,891 observations and 333,516 firms.

3.2 Measures

3.2.1 Dependent variable: NPD performance

We define NPD performance as the amount of revenue generated by new or significantly improved products (e.g. Klingebiel & Rammer, 2014). Specifically, it is measured by the natural logarithm of the annual sales generated by products that a firm reports as 'new' to the market[5]; hence,

$$NPD\ performance = \ln(1 + new\ product\ output\ value)$$

"New products" are defined by NBS as those products that that have demonstrated substantial improvements in terms of quality and/or functionality through the adaptation of the integration of innovative technology, implementation of new design/structure, or manufacturing technique (China, 2005).

3.2.2 Independent variable: R&D investment

We define R&D investment as the amount of money spent on R&D activities. It is measured as the natural logarithm of the ratio of R&D expenditure to number of employees (Barge-Gil

[5] We use the raw value measurement rather than ratios (new product sales by total sales) because the raw value directly reflects a firm's innovation activities, and an increase in ratio may result from a decrease in total sales instead of an increase in new product sales (Klingebiel & Rammer, 2014).

& López, 2014) for each firm-year observation[6]. R&D expenditure includes all costs associated with R&D activities including costs for staff and materials, and fees for construction of fixed assets and management (National Bureau of Statistics of China, 2013).

3.2.3 Moderating variables

Our two moderating variables are export intensity and export experience. In line with prior studies, we measure export intensity as the ratio of export sales to total sales (Leung & Sharma, 2021; Wu, Wei, Wang, McDonald, & Han, 2022). Export experience is measured as the length of time firms have been involved in exporting activities (Bodlaj, Kadic-Maglajlic, & Vida, 2020; Kim & Cavusgil, 2020).

3.2.4 Control variables

We control for several firm and industry level variables. At the firm level, we control for characteristics such as firm age, labor intensity, firm employment, type of ownership, and the type of trade processed by a firm. We measure labor intensity by the sales per employee of each firm. We measured firm size by four size bands of number of employees[7]. We measure firm ownership using a categorical variable, distinguishing between state owned firm, private firm, joint venture, foreign firm, and other types as the baseline category (coded as zero). We also distinguish between firms processing trade and those that do not.

[6] Prior studies have typically used the R&D investment/sales ratio as a measure (Laursen & Salter, 2006). We compared the results of using R&D by sales and R&D by employee and found that results are consistent with each other (see Table 5 Model 11). We use R&D by employees, because its distribution has smaller skewness and kurtosis in our dataset than the alternative measurement.

[7] Four size bands: band 1 (≤50); band 2 (51-100); band 3 (101-250); band 4 (>250)

We also control for the number and similarity of the markets to which a firm export – and potentially learns from – as well as the different forms of exporting. Specifically, we include: (1) number of export markets, (2) cultural distance, and (3) export form. Number of markets is the simple count of markets to which a firm exports in a given year. Cultural distance is an index of the cultural distance between China and a given export country. This was calculated by measuring the cultural distance (CD) between China and the export destination country j using the well-known Kogut and Singh (1988) index, which was then weighted by the ratio of the export value of firm *i* in country *j* (v_{ij}) to the total export value of firm *i* in a given year (V_i): $Cultural\ distance\ = CD_j \times \omega_j$, and $\omega_j = v_{ij}/V_i$. Finally, we differentiated between direct and indirect exporting.

We also control for industry level variables. The firm-level data are nested in industries and regions. To identify the industry sector, we use the two-digit Standardized Industry Code (SIC) as dummy variables[8], and use 31 provincial-level dummies to identify different regions. We use OECD's (2011) classification for technology intensity. Since we are using data from eight survey years, we also include year dummies. Table 1 summarizes the empirical models and variables used in the study.

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3.3 Model Selection

We use a firm-year unit of analysis to form our estimator and compute the regressions using STATA, and the Likelihood Ratio Test and the Information Criteria (i.e., AIC and BIC) to

[8] We replaced one-digit and four-digit SIC codes with two-digit SIC codes as industry dummy variables in models 1-5. The results were consistent with those using two-digit SIC codes.

select models. For some industries (e.g., chemical materials, chemical products, and chemical fibers), NPD performance shows a large variance. NPD performance also varies a lot across firms in some provinces (for example Guangdong and Jiangsu). We, therefore, employ a multi-level mixed effects model to associate the differences in the conditional variance of NPD performance with those of industry and province information of the firm[9]. This modeling approach nests our firm-level data at two levels: industry and province. We report the results of the multi-level mixed effects models 1-5 in Table 3.

Testing for multicollinearity among the independent variables by calculating the variance inflation factors (VIF), shows that the VIF values are all within acceptable limits ranging from 1.07 to 3.6 (Hair, Black, Babin, & Anderson, 2009). Also, following Aiken and West (1991) we mean-centered the independent variable and the moderators to minimize the potential for multicollinearity. Table 2 shows the VIF values, the mean, maximum, minimum, the standard deviation, and correlation matrix for all variables.

--- INSERT TABLE 2 ABOUT HERE ---

4. RESULTS

Table 3 shows the results of the model estimations and hypotheses testing. The Wald-Chi-square statistics indicate that models 1-5 are significant at the 0.001 level. One way to identify the moderating effects on the curvilinear lines is to observe the slope change (i.e. the steepening and flattening) and another is to observe the optimal point shift (i.e. up/down,

[9] However, Tobit model is suitable to the left censored nature of the dependent variable, because not all firms do new product output each year. We use them in the robustness check to observe the consistency across different estimates.

left/right) (Haans et al. 2016)[10]. As our research hypotheses focus on the shift of optimal points, we calculate the coefficient values of the regression results (following Equation A3.3, Haans et al. 2016, p. 1195).

--- INSERT TABLE 3 ABOUT HERE ---

Model 1 presents the baseline model that includes the linear term of R&D investment and the control variables. Model 2 adds the quadratic terms of R&D investment. Model 3 adds the moderators – export intensity and export experience. Model 4 includes the linear interaction terms between R&D investment and export intensity and experience. Finally, Model 5 adds the quadratic interaction terms between R&D investment and export intensity and experience. Model 5 provides a better fit according to the Likelihood Ratio Test and has the lowest values of AIC and BIC (see Table 3). Therefore, we used Model 5 for the hypothesis testing.

NPD performance is positively related to the linear term of R&D investment ($\beta_{R\&D\ investment} = 2.189,\ p\ = 0.000$), but negatively related to its squared term ($\beta_{R\&D\ investment^2} = -0.360, p\ = 0.000$). The linear and squared terms of R&D investment are both statistically significant, which suggests support to our baseline hypothesis. The negative and significant quadratic term indicates that there is an inverted U-shape relationship between R&D investment and NPD performance. To further test the presence of an inverted U-shaped relationship, we followed Lind and Mehlum (2010) and estimated the extreme point

[10] There are two types of optimal point shifts; one is the additive turning point shift, and the other is the multiplicative turning point shift (see Table II, p.1185, Haans et al. 2016). The latter fits our context.

of R&D investment[11]. The results show that the inverted U-shape is highly significant ($t = 32.67,\ p\ = 0.000$) and that the optimal point is at 3.0, which is within the upper and lower bounds of R&D investment. We visualize the inverted U-shape in Figure 2.

--- INSERT FIGURE 2 ABOUT HERE ---

Hypothesis 1a predicted that export intensity strengthens the positive effects of R&D investment on NPD performance. In Model 5, the results show that the main effect of export intensity is negative and significant at the 0.01 level ($\beta_{Export\ Intensity} = -1.176,\ p = 0.000$). The interaction term between R&D investment and export intensity is negative and significant at the 0.001 level ($\beta_{R\&D\ Investment \times Export\ Intensity} = -1.437,\ p\ = 0.000$). In addition, the interaction term between the quadratic R&D investment and export intensity is positive and significant ($\beta_{R\&D\ Investment^2 \times Export\ Intensity} = 0.466,\ p\ = 0.000$). Figure 3 displays the relationship between R&D investment and NPD performance for two values of export intensity: $'\mathrm{low}' = \mu - \sigma$, and $'\mathrm{high}' = \mu + \sigma$, where μ and σ are the mean and standard deviation of the export intensity, respectively. We visualize the inverted U-shapes at low (high) levels of export intensity in Figure 3. The solid line shows the relationship for high export intensity firms, and the dashed line shows the relationship for the ones with low export intensity. At low (high) levels of export intensity, NPD performance peaks at 3.6 (3.8) when R&D investment is 2.8 (6.1). Therefore, the optimal level of R&D investment for NPD performance is moderate when export intensity is low. When export intensity is high, the optimal level shifts to a higher point. These results suggest that export intensity strengthens

[11] Lind and Mehlum (2010) have adopted and developed Sasabuchi (1980) general framework for U and inverted U shape tests.

the positive effects of R&D investment on NPD performance. Hence, Hypothesis 1a is supported.

--- INSERT FIGURE 3 ABOUT HERE ---

Hypothesis 2a predicted that export experience strengthens the positive effects of R&D investment on NPD performance. In Model 5, the main effect of export experience is positive and significant at the 0.001 level ($\beta_{Export\ Experience} = 0.071,\ p\ = 0.000$). The interaction term between R&D investment and export experience is positive and significant at the 0.001 level ($\beta_{R\&D\ Investment \times Export\ Experience} = 0.630,\ p\ = 0.000$). In addition, the interaction term between the quadratic R&D investment and export experience is negative and highly significant ($\beta_{R\&D\ Investment^2 \times Export\ Experience} = -0.202,\ p\ = 0.000$). Figure 4 displays the relationship between R&D investment and NPD performance for two values of export experience: $'\mathrm{low}' = \mu - \sigma$, and $'\mathrm{high}' = \mu + \sigma$, where μ and σ are the mean and standard deviation of the export experience, respectively. We visualize the inverted U-shapes at low (high) levels of export experience in Figure 4. The solid line shows the relationship for high export experience firms; and the dashed line shows the relationship for low export experience firms. At low (high) levels of export experience, NPD performance peaks at 3.4 (4.3) when the level of R&D investment is 4.0 (2.2). Therefore, the optimal level of innovation performance shifts from a lower point when a firm has lower level of exporting experience to a higher point when it has higher level of such experience. These results indicate that when export experience is high, R&D investment has a stronger positive effect on NPD performance. Hence, Hypothesis 2a is supported.

--- INSERT FIGURE 4 ABOUT HERE ---

Hypotheses 1b and 2b investigate at what level of R&D investment NPD performance achieves the optimal point, and consequently under what circumstances firms obtain better NPD performance. Following Haans et al., (2016, p. 1195 – see eq. A3.3), we compare and contrast the curved lines in Figures 3 and 4. Figure 3 shows that NPD performance peaks at a lower level of R&D investment (2.8) for a firm with less export intensity, while it peaks at a higher level of R&D investment (6.3) for a firm with higher export intensity. This suggests that firms with higher export intensity will reach the optimal point of NPD performance at a higher level of R&D investment than those firms with lower export intensity. Therefore, Hypothesis 1b is supported.

Conversely, Figure 4 shows that innovation performance peaks at a lower level of R&D investment (2.2) for a firm more experienced in exporting, while it peaks at a higher level of R&D investment (4.3) for a firm less experienced in exporting. This pattern is confirmed by the calculation of Haans (2016, p.1195 – see eq. A3.3) and indicates that the optimal point shifts to the left, and thus suggests that the higher optimal point of NPD performance with longer export experience is reached with a lower level of R&D investment. Therefore, Hypothesis 2b is supported.

We conducted robustness checks by using different estimate strategies and alternative measurement and samples. Table 4 shows models 6-10, which are based on OLS, random effects, fixed effects, Tobit model, panel-effect generalized estimating equation (GEE) (xtgee in *Stata*). Table 5 shows models 11-14 which are based on a mixed effects model using R&D investment by sales, and a mixed effect model on a sample with firms having positive total R&D investment during the observation periods, a logit and a random logit model, respectively. The results of models 6-14 are consistent with those of Model 5.

--- INSERT TABLE 4 AND TABLE 5 ABOUT HERE ---

5. DISCUSSION AND IMPLICATIONS

5.1 Theoretical Implications

We contribute to the literature by analyzing how knowledge sharing affects the all-important innovation processes in firms. By emphasizing the distinction between export experience and export intensity, our study offers nuanced insights into how different aspects of a firm's exporting activities influence the innovation process. Specifically, we clarify that although both export intensity and experience have an overall positive effect, they trigger different knowledge sharing mechanisms. Intensity predominantly increases knowledge access whereas experience predominantly increases integration. As a result, the effectiveness of converting R&D investment to new product development is different under conditions of high export intensity to those of high export experience. In our findings, this difference is manifested by the different levels of R&D investment needed to reach the peak of the inverted U-shape relationship. We explain each in turn.

A higher level of export intensity suggests that the firm has been successful in developing products that appeal to foreign markets. In doing so, it has been accessing knowledge possessed by the foreign market. Although this will include information and ideas which is directly relevant to the development of products for that market, it will also include unrelated knowledge and spillovers from other firms (Salomon & Shaver, 2005). Therefore, the higher the export intensity, the higher the knowledge it has been accessing. Such “knowledge spanning” (De Silva et al., 2018) increases a firm’s innovative ability in two connected ways. First, access generates ideas about new products and improvements to existing ones. This process helps more confidently direct R&D investments to innovation projects with higher chances of success. Second, it allows the firm to accumulate a broad range of knowledge increasing its absorptive capacity needed to identify new opportunities (İpek, 2019). Export intensity, therefore, strengthens an organization’s codified and tacit knowledge bases by providing access to important sources of technology, learning, and markets.

Our results support the above argument and show that export intensity strengthens the positive effect of R&D investments on NPD performance. Specifically, when the revenue from the export market is high, the point where the relationship of R&D investment on NPD performance peaks shift upwardly. Access to knowledge from export markets enhances the overall innovation process, and this peak is achieved at higher levels of R&D investment. Put differently, for export market exposure to increase NPD performance, there needs to be a sizeable R&D budget. This finding extends current exporting literature, as it demonstrates that foreign market knowledge access alone is not sufficient for improving NPD performance; it should be combined with higher levels of R&D investment.

Our results also indicate that firms that spend little on R&D may still improve their NPD performance, provided their export intensity is also low. This points to the efficacy with which tacit knowledge is used to develop new products for the local market. When a firm’s export intensity is low, its level of exposure to the domestic market is correspondingly high. As a result, it is more integrated into local information networks, making it better able to quickly interpret subtle changes in customer preferences and introduce products and services to meet the needs of that market (Un, 2016). When R&D budgets are generous, firms proactively introduce systems that incentivize and organize the processes used to search, integrate and transform tacit into explicit knowledge (Gupta & Govindarajan, 2000; Richtnér, Åhlström, & Goffin, 2014). Conversely, when R&D funds are scarce, knowledge remains tacit and most probably unevenly shared across the firm (Tsoukas, 1996). Hence, a plausible explanation for this finding is that when export intensity is low (local exposure is high) firms with low R&D budgets become more efficient in using their tacit knowledge to develop new products that suit a local market.

Our study shows that export experience plays a positive role in improving an organization's ability to convert R&D investment into NPD performance. More specifically, the findings indicate that when export experience is higher the optimal point is also higher. This supports the argument that experience in exporting helps managers contextualize the knowledge from the export market better and as such supports its integration. Experience can also help managers develop skills for evaluating situations more accurately, and to make decisions that better reflect the conditions and challenges they face (Sousa et al., 2008; Tan & Sousa, 2019). Such skills strengthen a firm's ability to convert its R&D efforts into NPD performance.

A key take-away of this study is that depending on the levels of R&D investment, the effect of export experience is different to that of export intensity. Our results show that, all things being equal, firms with relatively higher export experience can spend less on R&D and still achieve higher levels of NPD performance than those with less experience. This finding is consistent with our theoretical argument that export experience increases knowledge integration. Unlike knowledge access, knowledge integration requires managers to have a good understanding of both the knowledge that is being integrated and the firm's internal systems. Firms' ability to identify, incorporate and integrate knowledge from external sources such as clients, suppliers, and competitors creates a self-reinforcing mechanism that strengthens their internal resource development (Zahra & George, 2002), and may also increase their absorptive capacity thereby potentially compensating for lower levels of investment in R&D. Thus, such efforts support the internalization and subsequently the advancement of knowledge (De Silva et al., 2018) thereby improving NPD performance.

In summary, we have explored the effects of knowledge, a vital strategic resource (Grant 1996), obtained through firms' export activities on their ability to convert R&D investment into new products. By focusing on two mechanisms (access and integration), we explain how different types of external knowledge obtained through export activities interact differently with firms' internal knowledge. Our study, therefore, provides insights for substantial and promising theoretical developments on the intersection of innovation and international business/marketing field that aims to explore how firms can maximize their NPD performance.

5.2 Implications for Managers and Policy Makers

Our results provide guidance for managers by reinforcing the view that exporting generally strengthens the positive effects of R&D investment on NPD performance. Exporting is usually seen merely as a way to increase revenues for a firm. However, we encourage managers to consider exporting also as learning opportunities. Foreign market activities offer learning contexts, which managers may explore to improve their companies' ability to develop new products as well.

The pressing question then is to find the sweet spot. While both export intensity and export experience allow the positive effect of R&D investment to shift to higher points of

NPD performance, their influence is different. Firms with high levels of export intensity must invest significantly in their R&D activities to be able to take advantage of the knowledge accessed in foreign markets. On the export experience front, however, things are different. Here, firms with low levels of export experience need to spend considerably on R&D to boost their NPD performance, whereas those with higher levels can afford to spend less. Since export experience increases NPD performance despite modest investment in R&D, such experience has become a particularly valuable resource for firms that find themselves strapped for funds. Still, caution is advised as our results also suggest that the effect of R&D spending on NPD tapers off rapidly for experienced exporters. Hence, managers need to prudently identify and understand how these relationships manifest themselves in their own firm's context.

Our results are also useful for policy makers. We recommend policy makers – and those in charge of designing and implementing export enhancing strategies more generally – to emphasize the knowledge development aspects of exporting. Specifically, our results demonstrate that export intensity helps improve NPD performance even when investment in R&D remains unchanged. For instance, our results show that, all else being equal, firms that export 34 percent more than the sample average (+1S.D. in export intensity) can expect to achieve a higher level of NPD performance despite their R&D investment being the same. Similarly, in terms of export experience, firms that have been exporting 1.57 more years than the sample average (+1S.D. in export experience) can also expect to exceed at improving their NPD performance. The implication for policy makers seems straightforward. First, exporting brings benefits beyond the obvious extra revenues from export sales. Second, as our findings convincingly demonstrate, exporting also efficiently improves the R&D-innovation conversion; to a degree, it can compensate for limitations associated with investment in R&D.

The policy toolbox should ensure that incentives, such as tax breaks, financial support, and simplification of rules, prioritize activities that boost exporting.

5.3 Limitations and Directions for Future Research

Our study has some limitations, which present opportunities for future research. First, our study is based on a sample of Chinese firms. While the dataset has highly appealing features, especially in terms of reliability and completeness, our findings could be country-specific. We think the theoretical arguments are general, yet caution needs to be exercised in generalizing our findings too broadly. Future studies could test our conceptual model in other countries and contexts to move towards a more generalizable base for understanding the role of exporting in the R&D-innovation relationship.

Second, R&D investments are key fund allocation decisions that for most firms invoke several considerations and attendant tradeoffs. Future studies should take into account and explore additional factors that drive R&D investment decisions. Such factors include internal issues such as firm ownership, board composition, and the characteristics of key decision makers, as well as external turbulence (e.g., environmental, socio-political, and technological uncertainty), which could shape firms' investment decisions. We encourage future research on how organizational and environmental characteristics influence R&D investment decisions.

Third, a limitation is the age of the secondary data, which spans from 2001 to 2007. It is essential to acknowledge and highlight the potential differences between the economic and business environment of that period and the present context. Notable differences may include the rapid advancements in technology, substantial shifts in market dynamics, changes in regulatory frameworks, and the evolving nature of global economic factors. These differences are crucial to consider when interpreting the findings and their applicability to the current environment.

Fourth, the lack of attention in identifying the optimal points when exploring moderations on curvilinear relationships has, in the past, impeded research progress. This study represents a pioneering effort to identify these optimal points, specifically considering the firm's exporting activities as a moderator. Future research is encouraged to build on these findings by exploring other potential moderators and conducting more detailed investigations into the optimal levels of R&D investment for enhancing NPD performance.

The international business/marketing and innovation bodies of literature acknowledged the importance of innovation and export on firms' performance. Yet often studies have examined the impact of export activity and innovation in isolation. As uncovered in this study, export activities provide a valuable context for understanding how R&D investment contributes to innovation within firms. Thus, we urge researchers to delve into this area and further explore the relationship between firm's innovation activities and export behavior/activities.

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Table 1: Regression Models 1-5 for R&D Investment and NPD performance

Model 1: $NPD\ performance_{ijt} = \beta_{10} + \beta_{11} R\&D\ Investment_{ijt-1} + Control\ Variables_{ijt-1} + \mu_i + \varepsilon_{ijt}$

Model 2: $NPD\ performance_{ijt} = \beta_{20} + \beta_{21} R\&D\ Investment_{ijt-1} + \beta_{22} R\&D\ Investment^2_{ijt-1} + Control\ Variables_{ijt-1} + \mu_i + \varepsilon_{ijt}$

Model 3: $NPD\ performance_{ijt} = \beta_{30} + \beta_{31} R\&D\ Investment_{ijt-1} + \beta_{32} R\&D\ Investment^2_{ijt-1} + \beta_{33} Export\ Intensity_{ijt-1} + \beta_{34} Export\ Experience_{ij} + Control\ Variables_{ijt-1} + \mu_i + \varepsilon_{ijt}$

Model 4: $NPD\ performance_{ijt} = \beta_{40} + \beta_{41} R\&D\ Investment_{ijt-1} + \beta_{42} R\&D\ Investment^2_{ijt-1} + \beta_{43} Export\ Intensity_{ijt-1} + \beta_{44} Export\ Experience_{ijt-1} + \beta_{45} R\&D\ Investment_{ijt-1} \times Export\ Intensity_{ijt-1} + \beta_{46} R\&D\ Investment_{ijt-1} \times Export\ Experience_{ijt-1} + Control\ Variables_{ijt-1} + \mu_i + \varepsilon_{ijt}$

Model 5: $NPD\ performance_{ijt} = \beta_{50} + \beta_{51} R\&D\ Investment_{ijt-1} + \beta_{52} R\&D\ Investment^2_{ijt-1} + \beta_{53} Export\ Intensity_{ijt-1} + \beta_{54} Export\ Experience_{ijt-1} + \beta_{55} R\&D\ Investment_{ijt-1} \times Export\ Intensity_{ijt-1} + \beta_{56} R\&D\ Investment_{ijt-1} \times Export\ Experience_{ijt-1} + \beta_{57} R\&D\ Investment^2_{ijt-1} \times Export\ Intensity_{ijt-1} + \beta_{58} R\&D\ Investment^2_{ijt-1} \times Export\ Experience_{ijt-1} + Control\ Variables_{ijt-1} + \mu_i + \varepsilon_{ijt}$

Note: Dependent variable is at time *t*. Predicting variables are at t_{-1}.

Table 2: Descriptive Statistics for All Variables and Correlations for Ratio Variables

		Mean	S.D.	Min	Max	VIF	1	2	3	4	5	6	7	8	9	10	11	12
1	NPD performance $_t$	0.88	2.78	0	11.60													
2	R&D investment $_{t\text{-}1}$	0.11	0.45	0	7.47	1.07	0.30											
3	Export intensity $_{t\text{-}1}$	0.18	0.34	0	1	2.35	0.01	-0.03										
4	Export experience $_{t\text{-}1}$	0.89	1.57	0	6	2.41	0.13	0.07	0.65									
5	Firm age $_{t\text{-}1}$	9.23	10.49	1	64	1.18	0.07	0.04	-0.08	0.00								
6	Labor intensity $_{t\text{-}1}$	378.65	1344	0	354678	1.07	0.02	0.05	-0.04	0.00	-0.04							
7	Number of markets exported $_{t\text{-}1}$	1.59	5.54	0	159	3.26	0.10	0.07	0.33	0.39	-0.03	0.01						
8	Cultural distance $_{t\text{-}1}$	5.03	14.85	0	96.48	1.71	0.02	0.01	0.32	0.31	-0.05	0.00	0.13					
9	Export form	0.45	0.76	0	2	3.6	0.15	0.06	0.66	0.65	-0.02	-0.01	0.48	0.47				
10	Ownership type	2.06	1.04	0	4	1.43	-0.04	-0.02	0.38	0.34	-0.24	0.03	0.24	0.30	0.37			
11	Trade type	0.35	0.79	0	3	3.24	0.06	0.04	0.47	0.47	-0.06	0.00	0.55	0.55	0.69	0.43		
12	Technology intensity	2.04	1.05	0	4	1.84	0.12	0.18	-0.15	-0.05	-0.01	0.03	0.00	-0.05	-0.10	0.02	-0.03	
13	Size band	2.53	1.08	1	4	1.52	0.15	0.07	0.20	0.25	0.13	-0.07	0.19	0.11	0.29	0.03	0.23	-0.1

Notes: Time $t_{\text{-}1}$ refers to the baseline of time, which is 1-year prior to the dependent variable at time *t*.
Number of observations=608,891.

Table 3: Multi Level Mixed Effect Model for NPD performance

DV: **NPD performance**	**Model 1**		**Model 2**		**Model 3**		**Model 4**		**Model 5**	
Control variables										
Firm age	0.012	(0.000)	0.011	(0.000)	0.010	(0.000)	0.009	(0.000)	0.009	(0.000)
Labor intensity	0.000	(0.044)	0.000	(0.003)	0.000	(0.004)	0.000	(0.004)	0.000	(0.004)
Firm size band 1 (as base)										
Firm size band 2	0.084	(0.000)	0.073	(0.000)	0.070	(0.000)	0.073	(0.000)	0.079	(0.000)
Firm size band 3	0.208	(0.000)	0.188	(0.000)	0.186	(0.000)	0.191	(0.000)	0.201	(0.000)
Firm size band 4	0.918	(0.000)	0.853	(0.000)	0.819	(0.000)	0.817	(0.000)	0.814	(0.000)
Number of markets exported	0.021	(0.000)	0.020	(0.000)	0.024	(0.000)	0.023	(0.000)	0.022	(0.000)
Cultural distance	-0.001	(0.243)	-0.001	(0.322)	0.001	(0.065)	0.001	(0.045)	0.001	(0.053)
Non export firm (as base)										
Indirect export	1.189	(0.000)	1.165	(0.000)	1.606	(0.000)	1.580	(0.000)	1.564	(0.000)
Direct export	0.802	(0.000)	0.790	(0.000)	1.162	(0.000)	1.137	(0.000)	1.127	(0.000)
Other ownership (as base)										
State owned firm	0.001	(0.994)	-0.006	(0.940)	-0.016	(0.851)	-0.012	(0.886)	-0.014	(0.868)
Private firm	-0.174	(0.010)	-0.174	(0.011)	-0.174	(0.013)	-0.170	(0.014)	-0.169	(0.014)
Joint venture	-0.216	(0.018)	-0.218	(0.014)	-0.195	(0.026)	-0.191	(0.027)	-0.181	(0.037)
Foreign firm	-0.507	(0.000)	-0.493	(0.000)	-0.434	(0.000)	-0.418	(0.000)	-0.406	(0.000)
No Trade (as base)										
Processing trade	0.090	(0.008)	0.082	(0.013)	0.030	(0.392)	0.041	(0.230)	0.054	(0.104)
Non-processing trade	-0.406	(0.000)	-0.388	(0.000)	-0.212	(0.000)	-0.200	(0.000)	-0.190	(0.000)
Hybrid trade	-0.064	(0.062)	-0.065	(0.058)	-0.013	(0.723)	-0.005	(0.893)	0.003	(0.932)
Technology intensity not identified (as base)										
Technology intensity low	-0.006	(0.969)	-0.014	(0.926)	-0.097	(0.505)	-0.105	(0.495)	-0.108	(0.488)
Technology intensity medium-low	0.097	(0.535)	0.086	(0.570)	-0.026	(0.857)	-0.037	(0.806)	-0.045	(0.772)
Technology intensity medium-high	0.525	(0.003)	0.493	(0.004)	0.371	(0.025)	0.365	(0.034)	0.358	(0.040)
Technology intensity high	0.871	(0.000)	0.820	(0.000)	0.706	(0.000)	0.723	(0.000)	0.723	(0.000)
Direct effects										
R&D investment	1.454	(0.000)	2.515	(0.000)	2.405	(0.000)	2.274	(0.000)	2.189	(0.000)
R&D Investment^2			-0.442	(0.000)	-0.415	(0.000)	-0.389	(0.000)	-0.360	(0.000)
Export Intensity					-1.178	(0.000)	-1.121	(0.000)	-1.176	(0.000)
Export Experience					0.056	(0.000)	0.040	(0.000)	0.071	(0.000)
Interaction effects										

Export Intensity × R&D Investment							-0.504	(0.005)	-1.437	(0.000)
Export Experience × R&D Investment							0.199	(0.000)	0.630	(0.000)
Export Intensity × R&D Investment^2									0.466	(0.000)
Export Experience × R&D Investment^2									-0.202	(0.000)
Random effect parameters (variance)										
Industry	-1.987	(0.000)	-2.039	(0.000)	-2.112	(0.000)	-2.102	(0.000)	-2.113	(0.000)
Province	-0.459	(0.000)	-0.453	(0.000)	-0.475	(0.000)	-0.472	(0.000)	-0.475	(0.000)
Year dummies	Included		Included		Included		Included		Included	
Log likelihood	-1420725.705		-1418324.126		-1415311.606		-1414369.687		-1413372.298	
Number of industry groups	30		30		30		30		30	
Number of province groups	31		31		31		31		31	
Chi-square	4301.638		3441.870		32097.562		72065.465		108455.090	
p-value for Chi2	0.000		0.000		0.000		0.000		0.000	
Likelihood Ratio Test	Model 5 vs. Model 1 LR Chi^2=14706.81 Prob>chi2=0.000		Model 5 vs. Model 2 LR Chi^2=9903.65 Prob>chi2=0.000		Model 5 vs. Model 3 LR Chi^2=3878.62 Prob>chi2=0.000		Model 5 vs. Model 4 LR Chi^2=1994.78 Prob>chi2=0.000			
AIC	2841505		2836704		2830683		2828799		2826805	
BIC	2841811		2837021		2831023		2829139		2827144	

N=608,891

p values are reported in parentheses; All two-tail tests.

Coefficients of industry and regional dummies are omitted and available upon request.

Table 4: Robustness Check with Alternative Estimates

	Model 6		Model 7		Model 8		Model 9		Model 10	
DV: NPD performance	OLS		Random effects		Fixed effects		Tobit		GEE	
Control variables										
Firm age	0.010	(0.000)	0.008	(0.000)	0.001	(0.293)	0.073	(0.000)	0.008	(0.000)
Labor intensity	0.000	(0.000)	0.000	(0.000)	0.000	(0.408)	0.000	(0.000)	0.000	(0.000)
Firm size band 1 (as base)										
Firm size band 2	0.070	(0.000)	0.074	(0.000)	0.065	(0.000)	1.109	(0.000)	0.260	(0.000)
Firm size band 3	0.181	(0.000)	0.203	(0.000)	0.167	(0.000)	2.319	(0.000)	0.484	(0.000)
Firm size band 4	0.788	(0.000)	0.755	(0.000)	0.362	(0.000)	6.362	(0.000)	1.115	(0.000)
Number of markets exported	0.021	(0.000)	0.022	(0.000)	0.020	(0.000)	0.092	(0.000)	0.011	(0.000)
Cultural distance	0.001	(0.014)	0.001	(0.059)	0.001	(0.000)	0.003	(0.220)	0.000	(0.537)
Non export firm (as base)										
Indirect export	1.566	(0.000)	1.599	(0.000)	1.974	(0.000)	10.890	(0.000)	1.313	(0.000)
Direct export	1.137	(0.000)	1.044	(0.000)	0.993	(0.000)	8.695	(0.000)	1.152	(0.000)
Other ownership (as base)										
State owned firm	-0.039	(0.534)	-0.047	(0.462)	-0.269	(0.013)	-0.460	(0.457)	0.128	(0.312)
Private firm	-0.208	(0.001)	-0.209	(0.001)	-0.306	(0.005)	-2.038	(0.001)	-0.121	(0.340)
Joint venture	-0.216	(0.001)	-0.218	(0.001)	-0.237	(0.044)	-1.469	(0.020)	0.142	(0.281)
Foreign firm	-0.442	(0.000)	-0.454	(0.000)	-0.253	(0.028)	-3.116	(0.000)	-0.024	(0.850)
No Trade (as base)										
Processing trade	0.061	(0.001)	0.140	(0.000)	0.339	(0.000)	0.110	(0.570)	-0.017	(0.733)
Non-processing trade	-0.235	(0.000)	-0.128	(0.000)	0.453	(0.000)	-3.502	(0.000)	-0.723	(0.000)
Hybrid trade	0.004	(0.881)	0.083	(0.000)	0.389	(0.000)	-0.137	(0.564)	-0.201	(0.001)
Technology intensity not identified (as base)										
low	0.007	(0.818)	0.073	(0.062)	-0.320	(0.020)	1.226	(0.013)	-0.099	(0.392)
medium-low	0.013	(0.763)	0.149	(0.000)	-0.312	(0.000)	2.555	(0.000)	0.268	(0.018)
medium-high	0.424	(0.000)	0.602	(0.000)	-0.010	(0.895)	6.376	(0.000)	0.827	(0.000)
high	0.825	(0.000)	0.922	(0.000)	0.140	(0.040)	8.487	(0.000)	1.180	(0.000)
Direct effects										
R&D investment	2.194	(0.000)	1.662	(0.000)	0.420	(0.000)	10.221	(0.000)	1.497	(0.000)
R&D Investment^2	-0.341	(0.000)	-0.252	(0.000)	-0.078	(0.000)	-1.778	(0.000)	-0.282	(0.000)
Export Intensity	-1.212	(0.000)	-1.027	(0.000)	-0.116	(0.000)	-6.528	(0.000)	-0.815	(0.000)
Export Experience	0.073	(0.000)	0.057	(0.000)	0.088	(0.000)	0.103	(0.000)	0.015	(0.032)
Interaction effects										
Export Intensity × R&D Investment	-1.469	(0.000)	-0.840	(0.000)	-0.166	(0.058)	0.572	(0.242)	0.398	(0.004)
Export Experience × R&D Investment	0.636	(0.000)	0.411	(0.000)	0.161	(0.000)	0.097	(0.171)	-0.111	(0.000)

Export Intensity × R&D Investment^2	0.478 (0.000)	0.279 (0.000)	0.045 (0.214)	0.024 (0.904)	-0.076 (0.293)
Export Experience × R&D Investment^2	-0.206 (0.000)	-0.134 (0.000)	-0.039 (0.000)	-0.193 (0.000)	0.011 (0.235)
Year dummies	Included	Included	Included	Included	Included
Industry dummies	Included	Included	Included	Included	Included
Province dummies	Included	Included	Included	Included	Included
Log likelihood	-1415756.571		-971878.456	-329127.550	
Chi-square		105912.684		89623.192	41429.866
F-statistic	770.70		232.24		
p-value for Chi2/F	0.000	0.000	0.000	0.000	0.000
AIC	2831685		1943904	658429	
BIC	2832658		1944742	659413	

N=608,891;

p values are reported in parentheses; All two-tail tests.

Coefficients of industry and regional dummies are omitted and available upon request.

Table 5: Robustness Check with Alternative Measurement and Selective Sample

	Model 11		**Model 12**		**Model 13**		**Model 14**	
DV: **NPD performance**	R&D/Sales active firms		R&D active firms		Logit		Random Logit	
Control variables								
Firm age	0.010	(0.000)	0.015	(0.000)	0.012	(0.000)	0.020	(0.000)
Labor intensity	0.000	(0.008)	0.000	(0.178)	0.000	(0.002)	0.000	(0.000)
Firm size band 1 (as base)								
Firm size band 2	0.086	(0.000)	0.154	(0.003)	0.154	(0.000)	0.275	(0.000)
Firm size band 3	0.228	(0.000)	0.418	(0.000)	0.315	(0.000)	0.617	(0.000)
Firm size band 4	0.960	(0.000)	1.456	(0.000)	0.898	(0.000)	1.601	(0.000)
Number of markets exported	0.029	(0.000)	0.025	(0.000)	0.014	(0.000)	0.027	(0.000)
Cultural distance	0.001	(0.142)	0.001	(0.408)	0.001	(0.095)	0.001	(0.159)
Non export firm (as base)								
Indirect export	1.717	(0.000)	2.419	(0.000)	1.759	(0.000)	3.231	(0.000)
Direct export	1.206	(0.000)	1.968	(0.000)	1.392	(0.000)	2.383	(0.000)
Other ownership (as base)								
State owned firm	0.028	(0.759)	0.055	(0.853)	-0.082	(0.377)	-0.131	(0.488)
Private firm	-0.160	(0.025)	-0.345	(0.249)	-0.325	(0.000)	-0.547	(0.004)
Joint venture	-0.113	(0.281)	-0.445	(0.167)	-0.295	(0.002)	-0.465	(0.017)
Foreign firm	-0.442	(0.000)	-1.024	(0.004)	-0.544	(0.000)	-0.923	(0.000)
No Trade (as base)								
Processing trade	0.067	(0.091)	-0.259	(0.000)	-0.004	(0.891)	0.143	(0.017)
Non-processing trade	-0.222	(0.000)	-0.837	(0.000)	-0.501	(0.000)	-0.691	(0.000)
Hybrid trade	0.034	(0.419)	-0.285	(0.003)	-0.012	(0.771)	0.058	(0.432)
Technology intensity not identified (as base)								
low	-0.077	(0.635)	-0.225	(0.091)	0.252	(0.003)	0.201	(0.198)
medium-low	-0.007	(0.967)	-0.156	(0.232)	0.448	(0.000)	0.542	(0.000)
medium-high	0.473	(0.010)	0.658	(0.003)	1.029	(0.000)	1.676	(0.000)
high	0.957	(0.000)	0.844	(0.002)	1.359	(0.000)	2.315	(0.000)
Direct effects								
R&D investment	48.534	(0.000)	1.011	(0.000)	1.518	(0.000)	2.239	(0.000)
R&D Investment^2	-53.089	(0.000)	-0.185	(0.000)	-0.262	(0.000)	-0.376	(0.000)
Export Intensity	-1.368	(0.000)	-2.363	(0.000)	-0.983	(0.000)	-1.724	(0.000)
Export Experience	0.083	(0.000)	0.323	(0.000)	0.004	(0.418)	0.033	(0.000)
Interaction effects								
Export Intensity × R&D Investment	-16.486	(0.046)	-0.567	(0.000)	-0.100	(0.248)	-0.102	(0.524)
Export Experience × R&D Investment	12.215	(0.000)	0.166	(0.000)	0.056	(0.000)	0.058	(0.012)

Export Intensity × R&D Investment^2	2.780	(0.879)	0.499	(0.000)	0.042	(0.268)	0.066	(0.308)
Export Experience × R&D Investment^2	-13.317	(0.000)	-0.143	(0.000)	-0.040	(0.000)	-0.048	(0.000)
Year dummies	Included		Included		Included		Included	
Industry dummies	Included		Included		Included		Included	
Province dummies	Included		Included		Included		Included	
Log likelihood	-1426489.829		-259473.772		-147315.531		-132033.375	
Chi-square	78164.22		283846.006		67364.989		20915.172	
p-value for Chi2	0.000		0.000		0.000		0.000	
AIC	2853040		519008		294803		264241	
BIC	2853379		519291		295777		265226	

N=608,891 for Models 11, 13 and 14.
N=93,728 for Model 12 using panel mixed effect model on a sample with firms having positive total R&D investment during the observation periods.
p-value are reported in parentheses; All two-tail tests.
Coefficients of industry and regional dummies are omitted and available upon request.

FIGURES

Figure 1: Summary of hypotheses

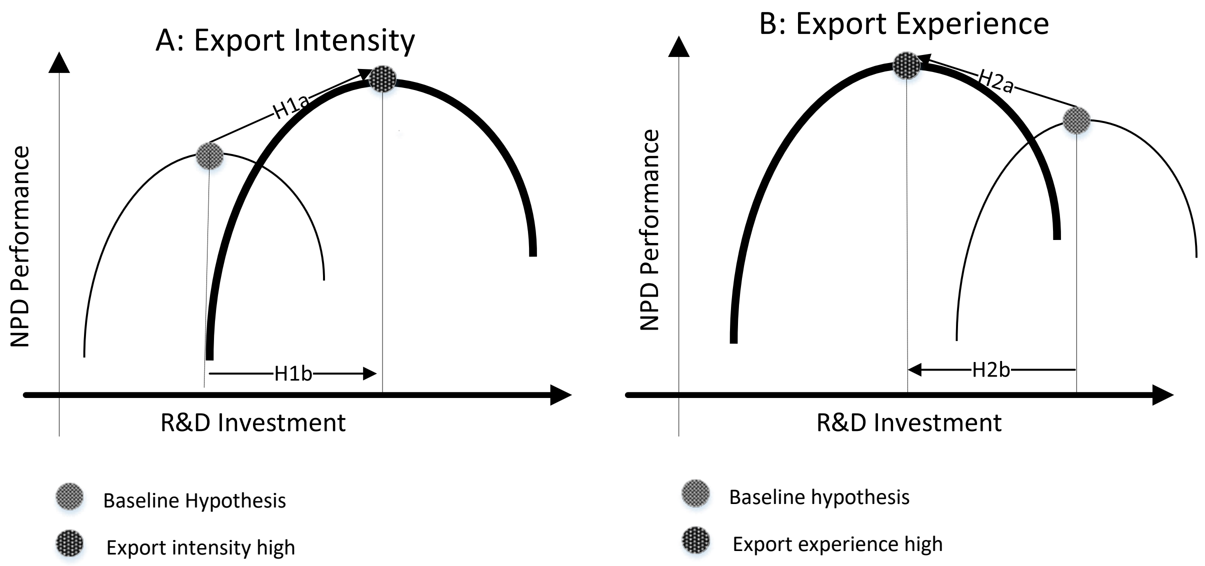

Figure 2: Inverted U-shape relationship between R&D investment and NPD performance

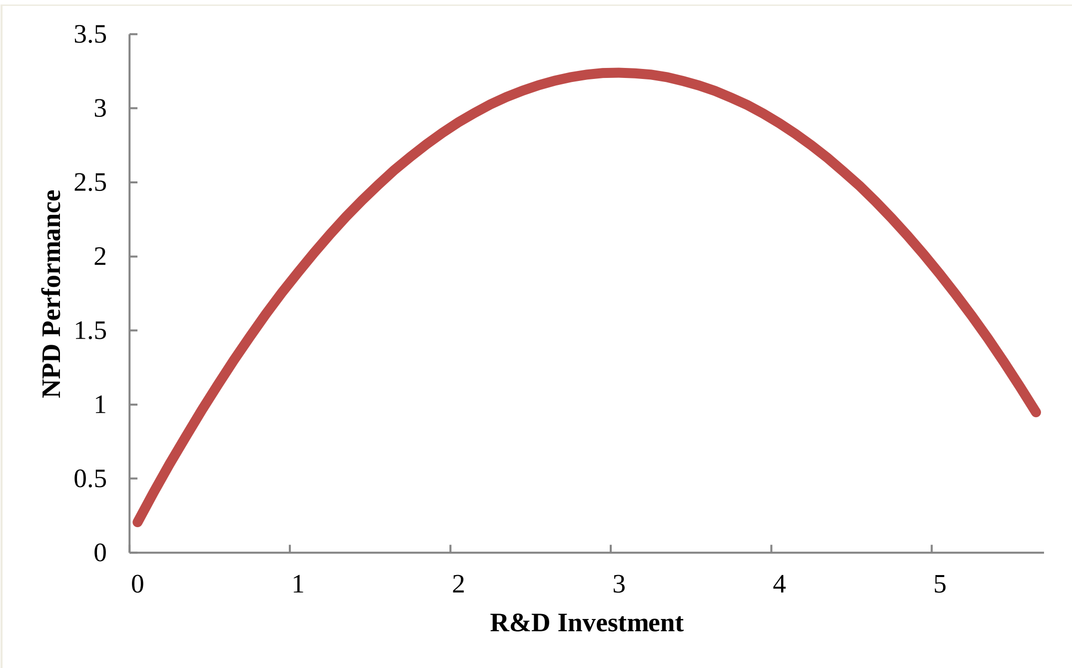

Figure 3: Export intensity moderation on the relationship between R&D investment and NPD performance

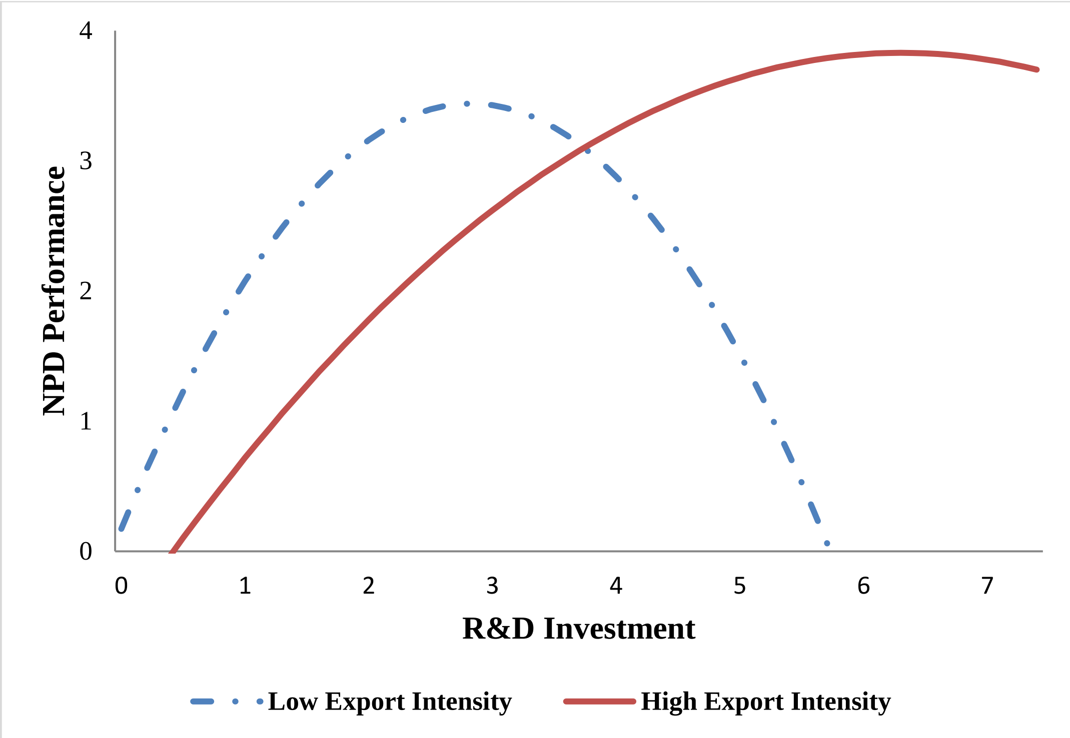

Figure 4: Export experience moderation on the relationship between R&D investment and NPD performance