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Financing patterns of working capital and physical investment: their effects on innovation and productivity

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ABSTRACT

Firms must access financial markets to surpass financial barriers limiting innovation activities. However, an overreliance on debt might moderate creativity and innovativeness. From a sample of European manufacturing firms, and applying a system of equations using GSEM, we derive a function to determine the thresholds of the optimal acquisition of working capital and physical investment. Contrasting this information with the descriptive data, firms tend to under-finance working capital, as future short-term needs are more challenging to identify when designing investment plans. Additionally, we find evidence for the heterogeneous financial needs of firms operating in high-tech as compared to low-tech sectors, as well as other differences related to firm age. Overall, this paper demonstrates the existence of an optimal proportion of working capital and physical investment that maximizes innovation activities and firm performance, deriving diminishing returns from debt financing and the complementarities between short-term and long-term financial needs.

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1. Introduction

As a strategic resource allocation method, debt financing has long been recognized as a vital determinant of innovation. It serves as a tool to surpass financial constraints and barriers (Canepa and Stoneman 2008; Hall 2002). Debt financing, as a strategy to generate additional short-term and long-term resources, addresses key financial barriers that impede the correct development of innovation activities and hamper firm performance (García-Quevedo, Segarra-Blasco, and Teruel 2018; Gilmore, Galbraith, and Mulvenna 2013; Khan, Shah, and Rizwan 2021). Yet, relying excessively on debt financing generates intricate ties with external agents that moderate creativity and innovative behaviour, as firms must adhere to stricter disclosure requirements (Christensen, Kaufman, and Shih 2008; Shi, Gong, and Chen 2019).

Ang, Daher, and Ismail (2019) demonstrate the existence of an optimal acquisition of debt financing which maximizes firm value. However, these ideal proportions have not yet been uncovered or approximated in the field of innovation economics. Furthermore, they can be addressed with an increased degree of empirical precision. A better understanding of the non-linear returns from debt financing for different capital resource needs would provide valuable managerial and policy insights. Our paper addresses this gap by examining the debt profile of innovative companies and determining the optimal debt boundaries of working capital and physical investment.

Therefore, our research objectives are three-fold: (i) to determine the nature of the effects of debt financing on innovation and productivity, searching for the critical point at which the marginal gains

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from debt financing reach their maximum; (ii) to explore the complementarities between short-term and long-term financial assets, building on a relatively underexplored literature strand based on Fazzari and Petersen's (1993) foundational notions; (iii) to examine potential heterogeneous effects related to the particular characteristics and needs of high-tech sectors and young firms (Pellegrino 2018; Cowling, Liu, and Zhang 2021).

To achieve these purposes, this research employs a robust sample of 7,019 European manufacturing firms. The dataset is derived from a combination of several World Bank Enterprise Surveys (WBES) for European economies. The WBES questionnaires address firm behaviour in many dimensions: resources, performance, capital composition, etc. In this case, we focus specifically on the dimensions that cover finance, innovation, and performance.

Designing a multi-equation framework based on Generalized Structural Equation Models (GSEM),[1] we capture the complex associations between the financial dimension of a firm and its effects on R&D, innovation, and productivity, providing comprehensive insights into the nature of capital composition, innovation, and firm performance. The methods employed are built on a reformulation of the CDM model (Crépon, Duguet, and Mairesse 1998) proposed by Baum et al. (2017).

The results obtained confirm the intuition of Christensen, Kaufman, and Shih (2008) by demonstrating that the returns from debt financing on innovation activities and productivity are diminishing by nature. From our estimations, we derive a numerical expression that proves the existence, and thresholds, of an optimal combination of working capital and physical investment that allows a firm to maximize its innovative behaviour and performance. This optimal investment strategy envisages significant complementary effects between working capital and physical investment, as firms leverage long-term assets more effectively if they simultaneously expand their short-term capital. This conclusion has implications for the interpretation of short-term and long-term needs, as the analysis of one dimension would be incomplete if the other is ignored.

Contrasting our findings with the WBES data, we find that European manufacturing firms tend to under-finance their working capital. Despite this result being sample-specific, it provides a valuable intuition on the inefficiencies when designing investment plans, aligning with previous evidence (Deloof 2003). When planning the development of their innovation activities, firms tend to over-value the role of long-term assets. This leads to a sub-optimal acquisition of working capital, relevant for short-term operations overlooked during the planning process. In terms of sector and firm age heterogeneities, we do observe different working capital and physical investment patterns across subsamples.

In this context of inefficiency in investment design, driven by misalignments during investment design, the principal role of policymakers should be improving information availability and the quality of public agencies regarding efficient financial strategies to boost innovation. Furthermore, additional credit lines targeting short-term capital needs should be designed for firms with investment structures that under-finance working capital. Given the different needs of firms operating in different industries, it is important to increase the heterogeneity and flexibility of credit lines to address each sector properly. The differences between young firms and incumbents also need to be considered.

The paper is structured as follows. Section 2 presents a literature review addressing the interconnections between working capital, physical investment, and firm behaviour. Section 3 describes the database and the variables used in the analysis, differentiating innovative firms, high-tech sectors, and young firms. Section 4 addresses the modelling structure. Section 5 shows the baseline results and the heterogeneous effects across different subsamples and, finally, Section 6 discusses the results and concludes the research.

2. Literature review

This section presents a review of the literature addressing the role of finance in three subsections. Firstly, it provides an overview of the interlinkages between financial strategies, in specific debt financing, and the development of innovation activities. Secondly, it narrows the scope of capital resources to working capital and physical investment, explaining differential characteristics and potential complementarities. Thirdly, it explains potential sources of heterogenous effects related to the sector of activity and firm age.

2.1. Corporate finance, debt financing, and innovation

The uncertain nature of innovation generates a trade-off between expectations, innovation outcomes, and firm value which shapes market entry and exit patterns, becoming a key mechanism of business selection in an evolutionary context (Nelson and Winter 1982). In this framework, Joseph Schumpeter (1911) was the first author to analyse the influence of financial markets on business cycles, innovation and, therefore, productivity and economic growth. He demonstrated that, despite the risks inherent in innovation, firms need to address financial markets to develop their innovation activities effectively and boost their performance. Undoubtedly, the complementarities between the development of the financial sector and innovation generate the optimal ground for sustained growth (Prah 2022).

To conduct their operations, firms rely on various options to finance their activities. In an ideal world with abundant resources, firms would rely only on their internal assets to develop their operations, as acquiring them externally results in obligations which might hinder firm performance (Hall and Lerner 2010). However, the reality is far from this idealized conception, as a firm's resources are inherently limited. Then, access to financial markets serves as a determinant of a firm's success, and it is a relevant generator of a competitive business environment (Beck and Demirguc-Kunt 2006; Lv and Xiong 2023).

Besides internal funds or retained earnings, there are two additional mechanisms to expand a firm's resources: (i) capital expansions due to owner contributions or newly issued equity shares; (ii) acquiring funds by accessing external agents, most commonly through debt financing. Durand (1952) provides valuable insights for understanding the implications of these two strategies, which allows us to identify the trade-offs associated with each strategy. On the one hand, if firms decide to finance their capital internally, they have incentives to take more risks at higher prices, as shareholders will demand higher returns in exchange. On the other hand, debt-financed capital is comparatively cheaper but involves long-term obligations that restrict firm behaviour.

Examining the implications of equity markets, they have long been considered relevant to finance innovation (Müller and Zimmermann 2009; Santarelli 1991), since firms acquire capital according to their value. However, a relevant literature strand has emphasized the negative effects of equity market imperfections on R&D investment and innovation decisions (Bloch 2005). More concretely, if equity markets operate under asymmetric information, the allocation of resources is suboptimal, resulting in an undervaluation of firms with more valuable, but yet unidentified, opportunities (Yulianto, Witiastuti, and Widiyanto 2021). Consequently, these firms, which have larger growth potential, tend to issue more debt than equity, as this strategy limits the agency problem arising from ex-ante information asymmetry (Leland and Pyle 1977; Ross 1977). This sends, at the same time, a positive signal to equity markets.

Therefore, debt financing has raised a significant amount of attention as a driver of a firm's innovative behaviour (Canepa and Stoneman 2008; Hall 2002). Perfect credit markets would generate long-run productivity-enhancing investments, as they directly address key barriers to innovation, such as a lack of own resources, insufficient (or too expensive) credits and funding shortages due to inefficient equity markets (Savignac 2008; Silva and Carreira 2012; Ughetto 2009). There is a point of agreement that, if financial barriers are not efficiently surpassed, they can lead to slower development, abandonment, or non-pursuit of innovation projects (García-Quevedo, Segarra-Blasco, and Teruel 2018; Gilmore, Galbraith, and Mulvenna 2013).

However, excessive reliance on debt can moderate creativity and innovation outcomes, as firms need to adhere to stricter objectives and requirements, and must be more transparent regarding their activity (Christensen, Kaufman, and Shih 2008; Shi, Gong, and Chen 2019). This dichotomy between the need for debt financing and its potential negative effects if there is an over-reliance on debt, provides the intuition that an optimal level of debt financing should maximize innovation and productivity.

Some recent studies demonstrate the existence of this optimal proportion, maximizing firm value (Ang, Daher, and Ismail 2019). Additionally, Li, Li, and Albitar (2021) provide thresholds for an optimal volume of aggregate financial resources on R&D and innovation for a sample of Chinese companies. Based on this, we propose the following.

H1. There exists an optimal level of debt financing that maximizes innovation activities and firm performance.

2.2. The role of working capital and physical investment

To provide a more comprehensive and coherent analysis, one needs to differentiate between long-term and short-term investments. Physical investment has long and extensively been considered a significant determinant of innovation activities. It provides firms with the necessary infrastructure, equipment, and other long-term liabilities to develop R&D and innovation in a consistent and sustained manner (Carboni and Medda 2020; Hall et al. 2016).

In contrast, a firm's working capital has crucial implications in the short-term (Fazzari and Petersen 1993). It provides firms with sufficient resources to cover operational expenses before revenue is obtained. Therefore, it serves as a good measure of a firm's liquidity and ability to meet its most immediate financial obligations.

Working capital alleviates financial constraints when the financial system is not efficient (Ding et al. 2013) and allows firms to provide more effective responses to market demands (Kahl, Shivdasani, and Wang 2015). Limited availability of working capital forces firms to ration all their resources at a suboptimal level, which significantly hampers firm performance (Chan 2014). For these reasons, the most innovative firms accumulate an extensive volume of short-term resources to alleviate the risk to innovation activities (Baldi and Bodmer 2017). In sum, working capital becomes essential for the proper development of R&D investment and innovation (Brown, Fazzari, and Petersen 2009; Mulkay, Hall, and Mairesse 2001).

Despite the effects of physical investment and working capital on innovation having been extensively analysed separately, the complementarities between both have received limited attention in the literature. Fazzari and Petersen (1993) provide coherent reasoning for the strategies combining working capital and physical investment, highlighting that it is relatively costlier to adjust physical investment levels as compared to adjusting the volume of working capital. Consequently, firms tend to rely more on short-term resources to address financial constraints and alleviate the effects of negative shocks on fixed capital investment (Ding et al. 2013). Building on this overlooked dimension in the literature, we propose the following hypothesis:

H2. An extensive acquisition of physical investment through debt cannot be sustained without expanding the base of working capital.

2.3. The heterogeneous effects of debt financing

It is reasonable to assume that firms will not uniformly benefit from debt financing, as some firms will depend more systematically on external sources of capital. Therefore, it becomes necessary to identify the sources of potential heterogeneity in the effects of debt financing on innovation activities.

Focusing first on the differences related to firm age, young firms are more likely to face stronger financial constraints (Pihkala, Ylinenpaa, and Vesalainen 2002; Pellegrino 2018). Additionally, their access to financial markets is more limited (Fazzari, Ferri, and Greenberg 2015), and they have more incentive to differentiate themselves from their established competition in a market, leading to a stronger reliance on debt financing to develop market innovations (Robinson and Stubberud 2014). Overall, the implications of debt financing on the growth of new firms are positive and well-backed by recent evidence (Fryges, Kohn, and Ullrich 2015).

Conversely, successful mature firms are more long-term oriented and tend to focus on the sustainability of their financial structure, while maintaining a lower dependence on external sources of capital (DeAngelo and DeAngelo 2007).

Consequently, we propose a third hypothesis:

H3. Young firms leverage resources more extensively, while mature firms build more complex structures to guarantee long-term financial stability.

Finally, a firm's capital structure varies significantly depending on the industry in which it operates. The literature, however, has mixed results in this regard. While some authors find that firms operating in high-tech sectors are more sensitive to debt financing (Causholli and Knechel 2012), others explain that these differences are more directly linked to the innovative capabilities of the firm rather than to the technological intensity of its sector (Cowling, Liu, and Zhang 2021).

Inherently, firms operating in high-tech sectors are subject to higher risks (Hutton and Nightingale 2011). Consequently, the relations between the firm and external financier are affected (Cole and Sokolyk 2016; Han, Fraser, and Storey 2009), encouraging innovative high-tech firms to design more sustainable and robust financial structures which minimize risk and guarantee stability. Consequently, our final hypothesis is the following:

H4. The debt structure of firms operating in high-tech sectors is more complex than in low-tech sectors.

3. Data and descriptive statistics

3.1. The database

This study utilizes establishment-level information from the World Bank Enterprise Survey (WBES), encompassing 22 European economies. The WBES presents representative information of registered firms, ensures comparability across countries and is collected via face-to-face interviews with business owners or top managers. To ensure representation, the sample is stratified by industry, size, and location within each country. The WBES employs standardized sampling instruments and a uniform methodology to minimize measurement error.

It is important to remark that each observation pertains to the most relevant establishment within each firm. With a research scope set on manufacturing firms, as they compose the main body of the WBES, these are represented by production plants in the sample. However, to enhance readability and coherence, we consistently refer to these establishments as firms throughout the paper.

Our final dataset comprises 7,019 European manufacturing firms. Although the data is cross-sectional, and limits the adaptation of panel data models, firms appear in different fiscal years. This temporal variation allows us to control for year fixed-effects, enabling the identification of homogenous shocks across the period 2017–2021, such as the COVID-19 crisis. To increase the robustness of the analysis, all monetary variables are converted to Euros (in case the local currency is different) and inflation-adjusted, providing real values to adjust observations appearing during different fiscal years. The WBES offers distinct advantages for the objectives of this article. Firstly, it provides granular information on a firm's working capital composition and fixed investment over a specific fiscal year, enabling a clear identification of the proportion of these resources financed through debt. Secondly, it includes the necessary information to establish connections between this financial dimension and R&D investment, innovation, and productivity. Additionally, the data's availability and quality are remarkable, as the information is obtained rapidly, and most of the sample exhibits comprehensive and consistent data.

3.2. Descriptive statistics

This research examines the effect of debt financing on all stages of the innovation process. For this purpose, we address innovation from three different perspectives. Following the guidelines of the fourth version of the Oslo Manual, jointly revised by the OECD and Eurostat in 2018 (OECD and Eurostat 2018), we consider three main innovation activities. Firstly, the variable *R&D* is a dichotomous indicator that takes value one if the firm has consistently invested in R&D during the last three years, as a proxy of innovation inputs. Secondly, the variable denoted as *Product* indicates if the firm has introduced at least one product innovation during the last three years, serving as the first proxy of innovation outcomes. Thirdly, *Process* identifies firms introducing at least one process innovation during the last three years, being the second proxy of innovation outcomes.

Finally, productivity is introduced to capture the monetary gains resulting from the development of innovation activities, it is calculated as the total sales during a fiscal year over firm size. It is denoted by Productivity. The financial dimension of the firm is approached from two perspectives: short-term and long-term. On the one hand, the weight of debt financing for working capital is derived by summing the working capital borrowed from banks, both private or state-owed, along with working capital borrowed from non-bank financial institutions, such as microfinance institutions, credit cooperatives, credit unions or finance firms. This variable is relativized as a proportion of a firm's total working capital. On the other hand, the share of debt financing for physical investment is proxied as the weight of investment borrowed from the same bank and non-bank financial institutions over the firm's total investment in physical assets during a specific fiscal year. Additionally, the analysis incorporates traditional explanatory variables such as firm age, size, trade status (exports, imports and market scope), the perceived number of direct competitors, as well as geographic and sector dummies. Table 1 presents the definitions of all variables.

Regarding the geographical dummies, Eastern European countries refer to those that joined the European Union (EU) in the 2000s and, during the Cold War, were socialist economies. These countries include Bulgaria, Croatia, Czech Republic, Hungary, Lithuania, Poland, Romania, and Slovenia. Mediterranean countries are EU members located in southern Europe, namely Greece, Italy, Spain, and Portugal. The Nordic countries consist of EU members situated in the Scandinavian peninsula, more specifically Denmark, Finland, and Sweden, with the inclusion of Estonia, which we consider having stronger technological ties with Nordic rather than Eastern countries. Finally, the Centre-European countries encompass Austria, Belgium, France, Germany, Ireland, and the Netherlands. The sector clusters in our analysis are based on Pavitt's taxonomy (Pavitt 1984) which is linked to the NACE classification system by Bogliacino and Pianta (2016). High-tech firms are identified as those operating in science-based and specialized-suppliers sectors. Alternatively, low-tech firms operate in scale-intensive and supplier-dominated sectors.

Table 2 provides a summary of all the variables used in the analysis. Approximately one-third of our data comprises firms engaging in R&D investment (34%), product innovation (33.9%), or process innovation (33%). On average, firms finance 15.8% of their working capital from financial institutions. Although excluding those firms which do not borrow working capital, this value rises to 41.1%. The distribution for the proportion of physical investment is relatively similar; on average the proportion of debt is 13.1% but considering only firms borrowing to invest in physical assets this value increases to 64.6%.

Firms engaging in innovation activities exhibit larger productivity than non-innovators, both in terms of innovation inputs and outputs. In average terms, innovators also borrow more short-term and long-term resources. Additionally, they engage more directly with international markets and face a relatively moderate number of competitors. Finally, firms conducting innovation activities are more likely to be in high-tech industries.

4. Methodology

4.1. Empirical strategy

To capture the nature of the interrelations between R&D, innovation, and productivity, Crépon, Duguet, and Mairesse (1998) proposed a multi-equation framework connecting past productivity

Table 1. Definition of the variables.

Dependent variables	
	Dummy indicating if the firm …
R&D	… has invested in R&D during the last three years.
Product	… has introduced at least one product innovation during the last three years.
Process	… has introduced at least one process innovation during the last three years.
Productivity	Labour productivity as sales per employee.
Firm characteristics	
Size	Plant size measured as the number of full-time employees.
Age	Difference between the fiscal year and the year in which the firm started operations.
WC	Working capital borrowed from financial or non-financial institutions as a proportion of the total working capital.
FI	Last year's investment in physical assets borrowed from financial or non-financial institutions as a proportion of the total investment in physical assets.
Trade status	
	Dummy indicating if the firm …
Non-exporter	… does not sell directly or indirectly to foreign markets.
Direct exporter	… sells directly to foreign markets.
Indirect exporter	… sells indirectly to foreign markets.
Importer	… acquires supplies or intermediate products from foreign markets.
	Dummy indicating if the market scope of the establishment is …
Local scope	… local.
National	… national.
International	… international.
Perceived competition	
	Dummy indicating if the firm …
No competition	… does not perceive any direct competitor.
One competitor	… perceives only one direct competitor.
Between 2 and 3 competitors	… perceives two or three direct competitors.
Between 4 and 10 competitors	… perceives between four and ten direct competitors.
Between 10 and 30 competitors	… perceives between ten and thirty direct competitors.
More than 30 competitors	… perceives more than thirty direct competitors.
Sector	
Supplier-dominated, Scale-intensive, Science-based, Specialized suppliers	Dummy indicating if the firm belongs to a supplier-dominated sector, a scale-intensive sector, a science-based sector, or a sector dominated by specialized suppliers.
Country	
Eastern, Mediterranean, Nordic, Centre	Dummy indicating if the firm is located in Eastern Europe, the Mediterranean, Nordic countries, or Central Europe.

to R&D as a first step, innovation outcomes as a second, and present productivity as the final step. This methodology is known as the CDM model and is widely used in the innovation literature. However, the original CDM model is limited in many ways, as it lacks dynamic interlinkages between dependent variables (Aw, Roberts, and Xu 2011), suffers from endogeneity issues, and omitted-variables bias (Baum et al. 2017).

Employing an estimation approach based on Generalized Structural Equation Modelling (GSEM) (Rabe-Hesketh, Skrondal, and Pickles 2004), we construct a system of recursive equations that handles sample selection and captures bidirectional effects between innovation and productivity. The econometric structure presented in this section follows most of the suggestions made by Baum et al. (2017), with some modifications to better adapt to the characteristics of our data and improve the coherence of the estimator.

In the first step, we design a preliminary equation determining the likelihood of investing in R&D. This expression allows us to approximate the effects of a latent variable obtained through the variance-covariance distribution between all observed endogenous and exogenous variables. This latent variable captures the unobserved factors that differentiate R&D investors from other firms (which we cannot approximate through our observed variables), mitigating the omitted-variables

Table 2. Summary statistics. All values show Mean (Std. Dev.).

Dependent variables	All firms	R&D	Product	Process
R&D	0.340(0.474)	1.0(0.0)	0.520(0.500)	0.501(0.500)
Product	0.339(0.473)	0.588(0.492)	1.0(0.0)	0.506(0.500)
Process	0.330(0.470)	0.551(0.498)	0.492(0.500)	1.0(0.0)
Prod (thou. EUR)	200.002(858.538)	248.984(614.077)	232.062(737.528)	240.838(754.586)
Firm characteristics				
Size	86.509(551.462)	136.311(983.165)	113.242(894.138)	116.558(938.043)
Age	31.918(26.733)	38.237(30.521)	36.310(30.777)	36.234(30.503)
WC (Including Zeros)	0.158(0.264)	0.197(0.287)	0.183(0.281)	0.188(0.285)
WC (Without Zeros)	0.411(0.279)	0.418(0.286)	0.421(0.284)	0.411(0.281)
FI (Including Zeros)	0.131(0.293)	0.182(0.328)	0.163(0.316)	0.197(0.340)
FI (Without Zeros)	0.646(0.302)	0.631(0.300)	0.639(0.304)	0.646(0.302)
Trade status				
Non-exporter	0.343(0.475)	0.134(0.341)	0.234(0.424)	0.217(0.412)
Direct exporter	0.567(0.496)	0.788(0.409)	0.686(0.464)	0.697(0.460)
Indirect exporter	0.090(0.286)	0.077(0.267)	0.079(0.270)	0.085(0.280)
Importer	0.521(0.500)	0.740(0.439)	0.671(0.470)	0.654(0.476)
Local scope	0.197(0.398)	0.075(0.264)	0.140(0.347)	0.132(0.338)
National	0.515(0.500)	0.476(0.500)	0.499(0.500)	0.530(0.499)
International	0.287(0.453)	0.449(0.497)	0.361(0.480)	0.338(0.473)
Perceived competition				
No competition	0.035(0.184)	0.024(0.152)	0.034(0.181)	0.028(0.166)
One competitor	0.027(0.162)	0.029(0.168)	0.029(0.167)	0.025(0.158)
Between 2 and 3 competitors	0.165(0.371)	0.187(0.390)	0.188(0.391)	0.176(0.381)
Between 4 and 10 competitors	0.395(0.489)	0.478(0.500)	0.462(0.499)	0.462(0.499)
Between 10 and 30 competitors	0.086(0.280)	0.107(0.310)	0.094(0.291)	0.097(0.296)
More than 30 competitors	0.292(0.455)	0.175(0.380)	0.194(0.395)	0.211(0.408)
Sector				
Supplier-dominated	0.583(0.493)	0.439(0.496)	0.492(0.500)	0.533(0.499)
Scale-intensive	0.087(0.282)	0.089(0.284)	0.094(0.291)	0.098(0.297)
Science-based	0.139(0.346)	0.216(0.412)	0.189(0.391)	0.176(0.381)
Specialized suppliers	0.191(0.393)	0.255(0.436)	0.226(0.418)	0.193(0.395)
Country				
Eastern	0.261(0.439)	0.148(0.355)	0.176(0.381)	0.193(0.395)
Mediterranean	0.315(0.464)	0.186(0.389)	0.227(0.419)	0.150(0.357)
Nordic	0.172(0.377)	0.308(0.462)	0.277(0.448)	0.327(0.469)
Centre	0.252(0.434)	0.359(0.480)	0.320(0.466)	0.329(0.470)
Observations	7,019	2,107	2,381	2,316

bias. The first equation is specified as follows:

$$R\&D_i = \beta_0 + \beta_1 X_i + L_i + \beta_{i,s} + \beta_{i,c} + \beta_{i,t} + \varepsilon_i \quad (1)$$

where $R\&D_i$ indicates the likelihood of being an R&D investor, assumed to follow a probit distribution function; β_0 is the intercept; β_1 are the coefficients multiplying the set of variables X_i; L_i is the latent variable, restricted with a mean of 0 and a standard error of 1, as its scale cannot be determined initially; $\beta_{i,s}$, $\beta_{i,c}$ and $\beta_{i,t}$ are sector, country and time-specific fixed-effects; ε_i are error terms.

In the second step, we implement three simultaneous equations imputing the effects of the unobserved characteristics of R&D investors on innovation outputs (product and process) and productivity:

$$\text{Product}_i = \gamma_{1,0} + \gamma_{1,1} Z_i + \gamma_{1,2} L_i + \gamma_{1,i,s} + \gamma_{1,i,c} + \gamma_{1,i,t} + e_i \quad (2)$$

$$\text{Process}_i = \gamma_{2,0} + \gamma_{2,1} Z_i + \gamma_{2,2} L_i + \gamma_{2,i,s} + \gamma_{2,i,c} + \gamma_{2,i,t} + u_i \quad (3)$$

$$\ln(\text{Productivity}_i) = \lambda_0 + \lambda_1 K_i + \lambda_2 L_i + \lambda_{i,s} + \lambda_{i,c} + \lambda_{i,t} + v_i \quad (4)$$

In equations (2) and (3) product_i and process_i indicate the likelihood of introducing product or process innovations respectively; $\gamma_{k,0}$ is the intercept; $\gamma_{k,1}$ is a vector of coefficients multiplying the set of variables Z_i; $\gamma_{k,2}$ allows the latent variable L_i to be unrestricted; $\gamma_{k,i,s}$, $\gamma_{k,i,c}$ and $\gamma_{k,i,t}$ are sector, country and time-specific fixed-effects; e_i and u_i are error terms. Note that the subindex k indicates if the parameter refers to the product or process equations.

In equation (4) Productivity$_i$ is the productivity of firm i; λ_0 is the intercept; λ_1 are the coefficients determining the effects of variables K_i; λ_2 allows L_i to be unrestricted; $\lambda_{i,s}$, $\lambda_{i,c}$ and $\lambda_{i,t}$. are sector, country and time-specific fixed-effects; v_i are error terms.

As a relevant remark to the econometric strategy, the dataset does not allow us to identify individual heterogeneities, due to the cross-sectional nature of the data. However, part of this heterogeneous behaviour is addressed by the country fixed-effects, thacapture common regulations, culture, similar conduct, etc.

4.2. Treatment of the financial dimension and identification

The disaggregated information provided by the World Bank's Enterprise Survey allows us to examine the structure of working capital and physical investment during a specific fiscal year. We can thus identify the weight of debt financing within these short-term and long-term investment indicators.

To test our hypotheses, we need to incorporate into the modelling an expression that captures non-linear effects and complementarities between the two types of investment. To achieve this, we introduce the following expression in all equations identified in Section 4.1:

$$\tau_i = \delta_1 WC_i^2 + \delta_2 WC_i + \delta_3 PI_i^2 + \delta_4 PI_i + \delta_5 WC_i \times PI_i \tag{5}$$

where τ_i represents the impact of the expression on the regression outcomes, and δ_k are the marginal impacts.

Note that if δ_1 and δ_3 are smaller than 0, they indicate that the marginal gains from debt financing are negative. Additionally, if δ_5 is statistically different from 0, it implies that the marginal impacts of both working capital and physical investment cannot be interpreted separately, as their effects are interdependent.

Another critical aspect to consider is the identification of which variables need to be introduced in each step of the system to ensure coherent and robust results while minimizing endogeneity issues and capturing maximum information. In addition to the financial dimension of the firm, which is introduced in all the equations of the system, firm age and size are also present in all steps, as well as sector, country, and time dummies. These are suggested by prior studies (Morris 2018). Export and import dummies are included to capture potential learning-by-exporting effects (De Loecker 2007). In equations (1), (2) and (3) these dummies indicate whether a firm engages in import or export activities, either directly or indirectly. In Equation (4) we substitute these dummies with the market scope of the company, which can be classified as local, national, or international.

Finally, the amount of perceived competition provides essential information, as it captures the incentives (or disincentives) that a specific market position provides for the development of market activities (Marshall and Parra 2019). This dimension is introduced to determine the likelihood of being a selected firm and its productivity. It is relevant to remark that we do not assume direct effects on the intensity of R&D investment, but rather indirect effects through determining whether it is an innovative firm.

5. Regression outcomes

5.1. Baseline outcomes

Table 3 presents the coefficients that determine the various steps of the multi-equation framework.[2] In columns (1), (2), and (3) we can only interpret the sign of a specific parameter, but not its exact value. In the preliminary equation (column 1), we observe that all the financial variables have a significant influence on the likelihood of being an R&D investor.

Table 3. GSEM outcomes for the R&D-Innovation-Productivity relationship.

Variables	(1) R&D	(2) Product	(3) Process	(4) Productivity
Financial aspects				
WC(External/Total)	0.885***(0.286)	0.118*(0.062)	0.051(0.060)	−0.134(0.129)
WC x WC	−0.829**(0.340)	−0.129*(0.075)	−0.031(0.072)	−0.003(0.155)
PI (External/Total)	1.710***(0.357)	0.314***(0.082)	0.566***(0.078)	0.349**(0.168)
PI x PI	−1.762***(0.393)	−0.353***(0.090)	−0.469***(0.086)	−0.345*(0.185)
WC x PI	0.438*(0.249)	0.119**(0.057)	0.001(0.054)	0.100(0.117)
Firm characteristics				
Age (logs)	−0.022(0.032)	−0.002(0.007)	−0.012*(0.007)	0.136***(0.014)
Size (logs)	0.263***(0.022)	0.019***(0.005)	0.026***(0.005)	0.109***(0.010)
Trade status				
Exporting directly	0.684***(0.066)	0.041***(0.014)	0.073***(0.013)	
Exporting indirectly	0.461***(0.097)	0.011(0.020)	0.052***(0.019)	
Importing	0.463***(0.055)	0.108***(0.012)	0.057***(0.012)	
National market scope				0.376***(0.030)
International market scope				0.489***(0.036)
Perceived competition				
No competition	−0.237(0.146)			0.037(0.062)
One competitor	0.230(0.151)			0.264***(0.070)
2–3 competitors	0.156**(0.078)			0.240***(0.035)
3–10 competitors	0.210***(0.064)			0.235***(0.028)
10–30 competitors	0.333***(0.095)			0.261***(0.043)
Sector dummies	Yes	Yes	Yes	Yes
Country dummies	Yes	Yes	Yes	Yes
Time dummies	Yes	Yes	Yes	Yes
L	Constrained	0.171***(0.009)	0.122***(0.008)	0.080***(0.019)
Observations	7,019	7,019	7,019	7,019

*$p < 0.10$,**$p < 0.05$,***$p < 0.01$.Coefficients (Std. Err.) Reported. Non-exporters are the base outcomes for trade dummies. Having a local market scope is the base outcome for scope dummies. Firms identifying more than 30 direct competitors are the base outcome for perceived competence dummies. Supplier-dominated sectors are the base outcomes for sector dummies. Centre-European countries are the base outcome for country dummies.

The quadratic form of both working capital and physical investment exhibits a clear non-linear effect. Its negative sign indicates diminishing marginal, providing evidence for a convex relationship between R&D investment and debt acquisition. Furthermore, the product of working capital and physical investment presents a positive impact at $\alpha = 0.1$ confidence level, suggesting complementarities between short-term and long-term resources.

For the determination of product innovations, the results are similar. The quadratic expressions of both working capital and physical investment provide significant information for the diminishing returns from debt acquisition, also the complementarities between working capital and physical investment increase the likelihood of introducing product innovations. Alternatively, to develop process innovations, only physical investment seems to provide significant positive returns, suggesting a more long-term orientation of these specific innovations. Also, for process innovations the physical investment provides non-linear returns, a pattern similarly observed in the determination of firm productivity.

Considering the rest of the explanatory variables, we observe how bigger firms are more likely to conduct all innovation activities, also presenting a larger productivity. Younger firms are more likely to introduce process innovations, as they are immersed in learning processes to consolidate their market position. Alternatively, mature firms present larger productivity. In all equations, the effect of the number of competitors presents a complex distribution.

Not identifying any competitor does not provide sufficient incentives to boost creativity and performance, in line with the replacement effect (Arrow 1962/1972; Tirole 1997). Having a larger number of competitors also discourages the development of innovation activities, confirming the U-shaped pattern between innovation and market concentration demonstrated by Aghion et al. (2005).

Conceptually, the R&D and product innovation equations show the need for addressing credit markets to develop innovations effectively. R&D investors and product innovators need to expand their working capital and physical assets in a complementary manner to develop their innovation activities. However, debt acquisition provides decreasing marginal returns to innovation, which grow exponentially for each additional unit of borrowed resources. This provides evidence in regard to a clear limit to the external acquisition of working capital and physical investment. Additionally, the complementarities between working capital and physical investment indicate that the most effective financial strategies combine the acquisition of both resources.

Given all the results obtained in reference to the financial dimension, it is relevant to compute the values where the effect of debt financing reaches its more effective value. Although relatively specific, this will provide valuable insights to the analysis. In column (1), the marginal impact of working capital and physical investment on the probability of being an innovative firm is given by the following equation[3]:

$$\tau_i = -0.158WC_i^2 + 0.169WC_i - 0.337PI_i^2 + 0.327PI_i + 0.084WC_i \times PI_i \tag{6}$$

where the optimal debt financing for working capital and physical investment fulfils the following conditions:

$$\begin{aligned} \frac{\partial \tau_i}{\partial WC_i} &= -0.316WC_i + 0.169 + 0.084PI_i = 0 \\ \frac{\partial \tau_i}{\partial PI_i} &= -0.674PI_i + 0.327 + 0.084WC_i = 0 \end{aligned} \tag{7}$$

which is solved at $WC_i = 0.666$ and $PI_i = 0.494$. Therefore, on average, the critical shares of working capital and physical investment borrowed from financial institutions, at which we observe the maximum influence on the likelihood of being an R&D investor, are approximately two-thirds (66.6%) and one half (49.4%) respectively. Beyond, these thresholds, the marginal gains from debt financing decrease exponentially.

In column (2), the marginal impacts of working capital and physical investment on product innovation are specified as follows:

$$\tau_i = -0.129WC_i^2 + 0.118WC_i - 0.353PI_i^2 + 0.314PI_i + 0.119WC_i \times PI_i \tag{8}$$

where the optimal acquisition of working capital and physical investment fulfils the following conditions:

$$\begin{aligned} \frac{\partial \tau_i}{\partial WC_i} &= -0.258WC_i + 0.118 + 0.119PI_i = 0 \\ \frac{\partial \tau_i}{\partial PI_i} &= -0.706PI_i + 0.314 + 0.119WC_i = 0 \end{aligned} \tag{9}$$

where $WC_i = 0.666$ and $PI_i = 0.453$ define the maximum returns from debt financing. These outcomes resemble greatly the ones obtained for the determination of R&D, highlighting the similarity of financial structures fostering R&D and product innovation. To provide a better interpretation of the returns from the working capital and physical investment structure, Figure 1 shows a hyperplane with the quadratic forms and the complementarities between the two capital resources.

In the graphical representation, we can observe the role of complementarities between the acquisition of short-term and long-term assets, which an additional richness to the interpretation of the results. If firms decide to exclusively increase one of the two variables, the returns they will obtain are considerably lower compared to increasing simultaneously working capital and physical investment. Specifically, firms deciding to solely invest in physical assets during a given period, without expanding their volume of working capital, find moderate returns on R&D intensity when the level of investment is relatively low, and negative returns when the same investment is relatively higher. Consequently, strategies combining the acquisition of short-term and long-term assets appear to provide the best returns for research and development activities.

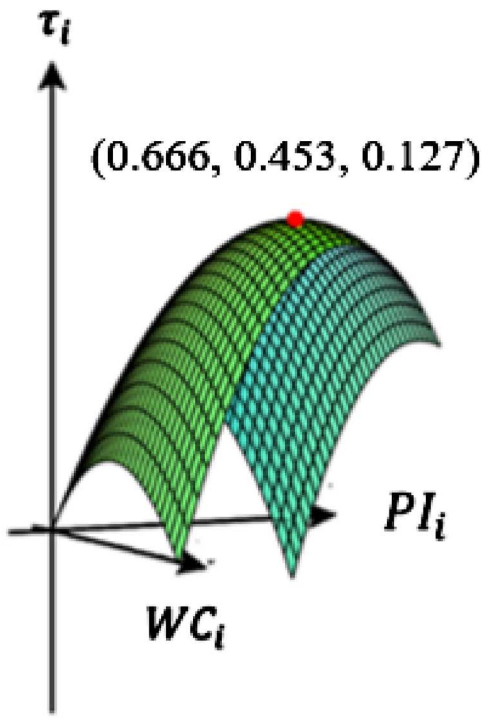

Figure 1. Representation of the marginal returns from debt acquisition in terms of working capital and physical investment. Equation (8). Source: Own elaboration using CalcPlot3D.

As aforementioned, for the determination of process innovations and productivity only physical investment provided non-linear significant returns, emphasizing a more long-term orientation of these dimensions. Applying the same maximization logic, the share of physical investment maximizing process innovation is 60.3% and for productivity this value is 50.6%, providing a higher threshold than the one obtained for R&D and product innovation.

Summarizing all the baseline results, we find consistent evidence supporting the relevance of debt financing in determining the innovative behaviour of a firm and its performance, although this relationship is far from linear. There are clear limits to the acquisition of working capital and physical assets through debt, confirming the first hypothesis *(H1)*, suggesting that exceeding these limits may potentially hamper innovation activities.

Furthermore, we demonstrate the existence of complementarities between the acquisition of working capital and physical assets in the determination of R&D and innovation, supporting the second hypothesis *(H2)*. According to previous evidence, this relationship is not bidirectional. An expansion of the working capital base improves the gains from an increase in physical investment, due to the need for increased flexibility to alleviate unexpected financial constraints (Ding et al. 2013).

These complementarities require us to simultaneously interpret the two dimensions, as changes in one of them affect the returns obtained from the other. Based on our estimates, to maximize their R&D investment and product innovations, firms should finance around two-thirds (66%) of their working capital with debt, while for physical investment this value falls within the 45%-50% threshold. For the case of process innovation and productivity, the effective values for physical investment are comparatively larger, falling within 50%-60%. Considering that, on average, firms rely on debt for 41.1% of their working capital and 64.6% of their physical investment,[4] we observe a clear tendency to under-leverage short-term resources, while the share of physical investment is relatively more adjusted. According to Deloof (2003), approximating the optimal investment of working capital in the long-term is more difficult than for physical investment. This misalignment provides an inefficient distribution of resources, which has its origins in a lack of prevision during the design of investment plans.

5.2. Sources of heterogeneity

This section examines whether the effects obtained in the baseline model differ depending on the technological intensity of the sector (low-tech or high-tech) and firm age (younger than 10 years or older than that). Table 4 presents the effects of the financial dimension across technological clusters. In low-tech sectors, we observe a significant contribution of physical investment across all specifications, while working capital plays a more relevant role in the determination of R&D and product innovation. The complementarities between working capital and physical investment present a significant positive impact on product innovation.

In high-tech sectors, there are no notable differences in the R&D equation compared to the baseline model. However, product and process innovations largely depend on physical investment rather than on working capital. Furthermore, for firms in high-tech sectors, the effects of the financial dimension on firm productivity are not significant, reflecting the focus towards innovation activities in the design of investment plans.

Comparing the two clusters, we find that innovative firms operating in low-tech sectors rely more on borrowing working capital for developing product innovations, as compared to innovative firms in high-tech sectors. Alternatively, firms in high-tech sectors design more complex financial structures to develop R&D than firms in low-tech sectors. Finally, regarding the effects of physical investment across the two subsamples we do not observe any statistical differences between the two groups.[5]

Table 5 shows the effects of the same variables across age groups, with young firms being less than 10 years old and mature firms being older than that. On the one hand, for young firms, we observe a significant role of working capital investment and the complementarities between working capital and physical investment in the determination of R&D. The role of physical investment is especially relevant for the determination of product and process innovations. Additionally, firms focus their investments towards fostering innovation rather than productivity, as they need to exploit extensively their creative capabilities to consolidate their market position.

On the other hand, mature firms need to design more intricate combinations of working capital and physical investment to achieve optimal R&D and product innovation. In the case of R&D investment, both working capital and physical investment exhibit significant non-linear returns, although the complementarities between the two capital resources are not significantly associated with R&D. For product innovation, physical investment must be complemented with an increase in working capital to generate an effective financial structure.

This implies that as firms mature and grow, their financial strategies become more sophisticated and tailored to their specific needs to effectively drive innovation activities. Additionally, mature firms rely more on external sources of physical investment to boost their productivity, as they must seek additional financing to fund their long-term projects, potentially due to their larger scale and capital requirements.

To summarize, while the effects of physical investment in the determination of all innovation activities are relatively homogenously distributed across all sector and firm age clusters, the effects of working capital do differ greatly depending on which group are we analysing. This outlines the different short-term needs that firms operating in sectors with different technological characteristics, or in a different stage of development, identify. Again, this provides insights referring to the complexity of identifying working capital needs to design effective financial structures to foster innovation activities.

Table 4. GSEM outcomes for the R&D-Innovation-Productivity relationship across technological clusters.

	Low-tech				High-tech			
Variables	(1) R&D	(2) Product	(3) Process	(4) Productivity	(1) R&D	(2) Product	(3) Process	(4) Productivity
Financial dimension								
WC	0.648*(0.358)	0.156**(0.074)	0.098(0.071)	−0.046(0.160)	1.288***(0.486)	0.045(0.114)	−0.057(0.107)	−0.321(0.211)
WC × WC	−0.655(0.420)	−0.142(0.089)	−0.079(0.085)	−0.012(0.192)	−1.180**(0.593)	−0.109(0.140)	0.090(0.132)	0.004(0.259)
PI	1.738***(0.432)	0.274***(0.096)	0.542***(0.092)	0.475***(0.207)	1.587**(0.648)	0.415***(0.154)	0.617***(0.145)	0.030(0.283)
PI × PI	−1.796***(0.476)	−0.297***(0.105)	−0.426***(0.101)	−0.509**(0.227)	−1.597**(0.716)	−0.470***(0.169)	−0.558***(0.159)	0.001(0.312)
WC × PI	0.333(0.304)	0.126*(0.066)	−0.028(0.064)	0.106(0.144)	0.829*(0.454)	0.070(0.107)	0.047(0.101)	0.147(0.197)
Control variables	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Sector dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Time dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
L	Constrained	0.145***(0.011)	0.129***(0.010)	0.090***(0.025)	Constrained	0.222***(0.016)	0.111***(0.014)	0.075***(0.028)
Observations	4,701	4,701	4,701	4,701	2,327	2,327	2,327	2,327

*$p < 0.10$, **$p < 0.05$, ***$p < 0.01$. Coefficients (Std. Err.) Reported. Non-exporters are the base outcomes for trade dummies. Having a local market scope is the base outcome for scope dummies. Firms identifying more than 30 direct competitors are the base outcome for perceived competence dummies. Supplier-dominated sectors are the base outcomes for sector dummies. Centre-European countries are the base outcome for country dummies.

Table 5. GSEM outcomes for the R&D-Innovation-Productivity relationship across technological clusters.

	Young				Mature			
Variables	(1) R&D	(2) Product	(3) Process	(4) Productivity	(1) R&D	(2) Product	(3) Process	(4) Productivity
Financial dimension								
WC	1.417*(0.839)	0.147(0.157)	0.008(0.155)	0.076(0.373)	0.716**(0.307)	0.103(0.068)	0.059(0.064)	−0.170(0.136)
WC × WC	−1.012(0.989)	−0.212(0.192)	0.147(0.190)	−0.423(0.456)	−0.697*(0.366)	−0.105(0.082)	−0.059(0.076)	0.049(0.164)
PI	1.547(1.092)	0.768***(0.213)	0.944***(0.211)	0.178(0.548)	1.685***(0.380)	0.241***(0.088)	0.504***(0.084)	0.409**(0.177)
PI × PI	−1.974(1.231)	−0.748***(0.231)	−0.891***(0.229)	0.178(0.548)	−1.662***(0.418)	−0.288***(0.097)	−0.401***(0.092)	−0.436**(0.195)
WC × PI	1.341*(0.772)	0.038(0.142)	−0.088(0.140)	−0.517(0.336)	0.293(0.267)	0.125**(0.062)	0.014(0.059)	0.196(0.124)
Control variables	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Sector dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Time dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
L	Constrained	0.127***(0.021)	0.174***(0.022)	0.090*(0.053)	Constrained	0.176***(0.010)	0.114***(0.009)	0.085***(0.020)
Observations	1,051	1,051	1,051	1,051	5,968	5,968	5,968	5,968

*$p < 0.10$, **$p < 0.05$, ***$p < 0.01$. Coefficients (Std. Err.) Reported. Non-exporters are the base outcomes for trade dummies. Having a local market scope is the base outcome for scope dummies. Firms identifying more than 30 direct competitors are the base outcome for perceived competence dummies. Supplier-dominated sectors are the base outcomes for sector dummies. Centre-European countries are the base outcome for country dummies.

6. Conclusions

This research paper delves into the financial determinants of innovation activities and firm performance, specifically focusing on the implications of debt financing by differentiating the role of working capital, which provides firms with the resources to cover daily operations (Chan 2014), and physical investment, which provides firms with the long-term resources to develop their activity.

The aim of the article is threefold. Firstly, to determine the optimal acquisition of working capital and physical investment by approximating the inflexion point at which the marginal gains from debt financing on innovation and firm performance shift from positive to negative. Secondly, it explores the complementarities between short-term and long-term financial resources, expanding a relatively unexplored literature strand that departs from concepts developed by Fazzari and Petersen (1993). Lastly, it identifies potential heterogeneous effects related to the technological intensity of the sector and firm age.

To test these ideas, we apply a multi-equation framework, based on Generalized Structural Equation Models (GSEM), to capture the effects of different combinations of working capital and physical investment on all steps of the innovation process, differentiating R&D, product innovation, process innovation, and productivity. From the outcomes presented in the baseline model, the research confirms the relevance of debt financing in determining innovative behaviour and performance. However, the relationship between debt financing and firm performance is non-linear, as there are limits to the acquisition of working capital and physical assets. Additionally, the study reveals the existence of complementarities between the external acquisition of working capital and physical assets, highlighting the need to interpret these two dimensions simultaneously, and emphasizing the importance of developing strategies combining both to obtain the maximum returns to innovation and performance.

The empirical evidence obtained from the WBES sample highlights that European manufacturers tend to under-leverage working capital, while physical investment is relatively better adjusted. Despite being relatively specific, this suggests the tendency to overestimate the effects of long-run investments, overlooking the crucial role of short-term resources to cover operations effectively. This behaviour is related to the nature of financial constraints. When designing future investment plans is easier to compute long-term needs rather than short-term future necessities.

Distinguishing high-tech and young firms from the rest of the sample, our findings indicate that in low-tech sectors, the complementarities between working capital and physical investment play a more crucial role in the determination of R&D, while in high-tech sectors these complementarities are fundamental for the development of product innovations. Focusing on firm age heterogeneities, the analysis reveals that young and mature firms design different investment structures. Mature firms develop more intricate financial combinations to maximize their innovation activities and performance, as their objectives are more long-term focused.

The principal limitation of the article is the cross-sectional structure of the data, which limits the analysis of dynamics in the R&D-innovation-productivity relationship and the identification of asynchronous effects between short-term and long-term financial resources. Further research in this line should be developed using panel data to include this temporal dimension. Additionally, we can only observe the acquisition of working capital and physical investment during the last fiscal year, with only the relative shares over the absolute values. With more information about the cumulative investments during additional periods and the outstanding debt the analysis could address the topic more in depth and gain additional consistency.

The findings from this study provide valuable insights for both policymakers and firm managers. The insights gathered emphasize the need to adapt financial strategies to maximize innovation activities and firm performance. In a context of transformative change driven by social and environmental challenges, governments must target technological innovation and competitiveness to effectively tackle these problems. In this context, it is necessary to properly understand and identify the key role of financial structures in surpassing resource constraints to develop innovation.

In this line, the main challenge we identify is the ineffective determination of future short-term needs. Therefore, policymakers should provide incentives to increase the volume of working capital investment. These tools include, for instance, improving the advice of public agencies regarding a firm's financial composition, and delving deeper into the relevance of properly identifying future short-term needs. Alternatively, some specific monetary incentives can be developed. Public credit institutions can provide loans targeting short-term needs at relatively lower interest rates or provide public guarantees for these loans to attract investment. Similar practices were introduced during the COVID-19 lockdowns to provide liquidity to firms, in this case, we propose similar practices in relation to working capital, which gathers all the resources necessary for daily operations.

As a concluding remark, we highlight that improving financial strategies in high-tech and oligopolistic markets is crucial to enhance competition and innovation in all European economies. Given that current social and political interests are shifting towards increasing sustainability and private social responsibility, guaranteeing a dynamic and competitive innovation environment will facilitate the transition towards more sustainable environments and increased social welfare.

Notes

1. GSEM are Generalized Linear Models (GLM) applied to Structural Equation Models (SEM).
2. The introduction of equation (4) in the modelling does not seem to cause multicollinearity issues. Providing only a linear expression or omitting the interaction between working capital and physical investment does not provide relevant differences in the coefficients, standard errors, or significance levels.
3. The coefficients of specification (1) cannot be interpreted directly as marginal effects. Equation (5) shows the marginal effects. Non-significant values must also be introduced to avoid biases in the interpretation of the marginal effects.
4. These are the values which do not include zeros.
5. We applied the following test: $(\tau_i^{HT} - \tau_i^{LT})/\sqrt{\sigma_{HT}^2 + \sigma_{LT}^2} \sim N_{0,1}$, under the null hypothesis that the two coefficients are equal.

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Data availability statement

The data supporting the findings of this study are available from the corresponding author upon reasonable request.

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Appendix

Table A1. Correlation matrix.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)
(1) R&D	1.000																	
(2) Product	0.344	1.000																
(3) Process	0.307	0.247	1.000															
(4) Productivity	0.280	0.187	0.210	1.000														
(5) WC	0.099	0.070	0.082	0.060	1.000													
(6) FI	0.116	0.079	0.158	0.098	0.294	1.000												
(7) Size	0.217	0.098	0.107	0.181	0.070	0.068	1.000											
(8) Age	0.135	0.091	0.087	0.266	0.051	0.041	0.261	1.000										
(9) Exporting directly	0.293	0.173	0.185	0.306	0.055	0.084	0.350	0.187	1.000									
(10) Exporting indirectly	−0.028	−0.026	−0.011	−0.050	−0.013	−0.011	−0.022	−0.067	−0.359	1.000								
(11) Importing	0.287	0.215	0.187	0.259	0.052	0.057	0.275	0.116	0.420	−0.054	1.000							
(12) Nat. market scope	−0.052	−0.023	0.021	0.050	0.010	0.037	−0.091	0.014	−0.095	0.074	−0.029	1.000						
(13) Int. market scope	0.234	0.117	0.079	0.159	0.021	0.001	0.345	0.073	0.447	−0.013	0.290	−0.654	1.000					
(14) No competition	−0.040	−0.004	−0.025	−0.034	−0.033	−0.015	−0.032	−0.035	0.010	−0.005	0.004	−0.033	0.022	1.000				
(15) One competitor	0.008	0.007	−0.006	0.027	0.001	−0.022	−0.030	0.018	0.014	−0.021	0.022	−0.020	0.017	−0.032	1.000			
(16) 2–3 competitors	0.039	0.044	0.020	0.060	0.016	0.010	0.006	−0.004	0.044	−0.044	0.059	−0.003	0.003	−0.085	−0.074	1.000		
(17) 3–10 competitors	0.111	0.098	0.097	0.126	0.048	0.051	0.079	0.078	0.075	−0.020	0.084	0.003	0.020	−0.154	−0.134	−0.359	1.000	
(18) 10–30 competitors	0.051	0.021	0.028	0.050	0.004	0.016	−0.004	0.025	0.023	−0.021	0.034	0.012	−0.010	−0.058	−0.051	−0.136	−0.247	1.000