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Dynamic analysis of the capital structure in technological firms based on their life cycle stages

Análisis dinámico de la estructura de capital en empresas tecnológicas basado en sus fases de ciclo de vida

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This article analyses the effect of a firm's life cycle stages on the capital structure in tech versus non-tech firms using a wide sample of public companies from Europe. An innovative approach based on operating, investing and financing cash flows allows us to analyse differences in leverage and specify the differential role of significant drivers of the capital structure across stages in both sectors. Our results point to the information asymmetry factor posed by the pecking order as the predominant driver behind the differences in the effect of intangible assets and growth opportunities for tech firms in some stages, mainly maturity. Frank and Goyal's (2003) test of the pecking order theory confirms the lower use of debt by tech firms during all life cycle stages. In addition, we find that the results obtained for tech firms are largely attributable to the behaviour of high-tech firms with the highest growth opportunities.

Keywords: life cycle; capital structure; technology firms; growth opportunities; leverage; pecking order theory

JEL classification: D91; D92; G32; L6

Este trabajo analiza el efecto del ciclo de vida sobre la estructura de capital en empresas tecnológicas y no tecnológicas usando una amplia muestra de empresas cotizadas europeas. Una clasificación innovadora basada en flujos operativos, de inversión y financieros nos permite analizar las diferencias de endeudamiento y especificar el papel diferenciador de los inductores significativos de la estructura de capital en las etapas del ciclo de vida en ambos tipos de empresas. Nuestros resultados señalan que el factor diferenciador predominante para las empresas tecnológicas es la información asimétrica (teoría de la jerarquía), que afecta a los activos intangibles y a las oportunidades de crecimiento, especialmente durante la madurez. Aplicando el test de Frank y Goyal (2003) para la teoría de la jerarquía, se confirma el menor uso de la deuda para las empresas tecnológicas en todas las fases del ciclo de vida. Además, encontramos que los resultados obtenidos para empresas tecnológicas se pueden atribuir en gran medida a las empresas de alta tecnología con mayores oportunidades de crecimiento.

Palabras clave: Ciclo de vida; Estructura de capital; Empresas tecnológicas; Oportunidades de crecimiento; Apalancamiento; Teoría de la jerarquía

JEL clasificación: D91; D92; G32; L6

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1. Introduction

The main theories on the capital structure, pecking order and trade-off highlight a few factors that explain the level of equity and debt. In fact, there are some generally accepted factors, such as the negative effect of profitability on leverage. Frank and Goyal (2009) indicated that explanatory factors for different theories of the capital structure might be significant, regardless of whether the sign is positive or negative, in firms under some circumstances but irrelevant in others. Thus, both the environment and the characteristics of firms might affect their capital structure. Recent papers have addressed some aspects of the technology sector related to financing or capital structure (Hogan & Hutson, 2005; Hyytinen & Pajarinen, 2005). Our main contributions to this growing literature are as follows: (1) the introduction of a dynamic framework, by placing the capital structure models in the changing life cycle stages of the firms and (2) the use of growth opportunities as a discriminant factor to distinguish high-tech firms. These analyses allow us to check the prevalence of pecking order and trade-off across stages for non-tech, tech and high-tech firms.

This article attempts to check how the capital structure theories (trade-off and pecking order) change their prevalence along the life cycle stages. Furthermore, this article attempts to demonstrate that remarkable differences in the life cycle of specific sectors are behind part of the by-industry differences in capital structure patterns. Our dynamic standpoint in examining the capital structure is inspired by Fischer, Heinkel, and Zechner's (1989) model. Berger and Udell (1998) and La Rocca, La Rocca, and Cariola (2011) can be considered the main reference points, as they identify life cycle stages as determinants of firms' financial requirements, the availability of financial resources and the related cost of capital.

Certain factors, such as growth, profitability, size and age, are considered to be key factors in distinguishing between the life cycle stages of a firm. More precisely, Graham and Leary (2011) argued that the trade-off and the pecking order theory define the following as strategic elements for the capital structure: profitability, research and development (R&D), age, risk, growth, size and tangible assets. That is, certain characteristics are important for distinguishing between the life cycle stages of the company, on the one hand, and defining the capital structure, on the other. Therefore, we hypothesise that there is a core connection between the capital structure and the life cycle through these factors. As previous authors do not agree on an accurate measure of the life cycle variable, we find Dickinson's (2011) proposal advantageous as a proxy for the life cycle stages, as it focuses on several relevant aspects of the business by using accounting information on operating, investing and financing cash flows.

Concerning the technology sector, the empirical evidence indicates that the rapid development, the complexity of the technology, the relevant intangible component of the business and the presence of network effects might have implications for its financing patterns (Hogan & Hutson, 2005; Hyytinen & Pajarinen, 2005). Studies on small high-tech firms have reported less leverage than in other small businesses. Hyytinen and Pajarinen (2005) linked this result to R&D, whereas Hogan and Hutson (2005) attributed this result to information asymmetries between the founders and banks, which require fixed assets as collateral. The greater degree of asymmetric information in tech firms makes the sector particularly sensitive to financing because of the vested interest of the shareholders and managers of the firm.

Furthermore, authors such as Gul (1999) related growth opportunities with debt issuance, whereas others, such as Rajan and Zingales (1995), suggested high growth opportunities as a source of the costs of financial distress, inclining firms towards equity financing when the stocks are overvalued, which is consistent with the trade-off theory. Considering that growth opportunities in tech firms can rapidly improve high performance, we test growth opportunities as key factors in distinguishing high-tech firms to observe the capital structure along their lives.

Using a panel data approach, we find that the pecking order theory offers the prevalent reasoning behind the lower leverage used by tech firms along their life cycle. Information asymmetry turns growth opportunities and intangibles into the most differential drivers. In addition, differences in tech firms' strategic behaviour induce changes in the capital structure by stage, mainly during maturity and also during introduction and decline. These differences are closely related to the differential effect of the age variable, a sign of success, considering not only the rapid development but also the rapid decline of tech firms, both of which are linked to changes in growth rates. In fact, we find that growth opportunities are key factors for discriminating between groups of high-tech firms when studying their capital structure. Our results have relevant implications for researchers both in the selection of the sample to be analysed and the interpretation of results depending on the distribution of the sample over the life cycle stages. Due to the evolution of the capital structure patterns along the life cycle, a sample consisting of firms in different stages of their life cycles would produce some non-significant or spurious results, whereas different samples could produce opposite results, depending on the life cycle stage in which most firms are included.

This article is different from the existing literature in several ways. First, we explain the capital structure through the firms' life cycle stages and observe the differences by stage, contributing to both research streams, i.e., capital structure and business life cycle, as this is the first time that Dickinson's (2011) approach is used in a capital structure article. Second, our work contributes to a very small group of works comparing tech firms to non-tech firms concerning the capital structure. Unlike the two most comparable studies (Hogan & Hutson, 2005; Hyytinen & Pajarinen, 2005), using a one-country small and medium-sized enterprise (SME) sample, we study an international sample of listed companies. Moreover, the two works referenced adopt a static standpoint without considering life cycle stages. Third, we use the differences in growth opportunities to discriminate between high-tech firms to further analyse their capital structures.

The remainder of this article proceeds as follows. Section 2 reviews the theory of the capital structure and the life cycle model, in relation to the technological sector, to develop our hypotheses. Section 3 describes the research design, explaining the measure of the life cycle and the classification of tech firms, as well as the methodology. Section 4 contains a discussion of the sample and descriptive statistics. Section 5 presents the results and, finally, the study's conclusions.

2. Theoretical background and hypotheses

The trade-off theory postulates that firms choose leverage by balancing the benefits and costs of using debt (Rajan & Zingales, 1995; Titman & Wessels, 1988), and its key features are taxation (Fama & French, 1998) and bankruptcy costs (Opler & Titman, 1994). On the other hand, Myers and Majluf (1984) developed the pecking order theory, indicating that due to the existence of asymmetric information between corporate insiders and outside investors, the firm upholds a financing hierarchy of retained earnings, debt and then equity to minimise the adverse selection costs of security issuance. Less profitable companies issue debt because they lack adequate internal funds to finance investment and because debt financing is first in the order of choices of external financing. We argue that the trade-off and the pecking order play different roles across life cycle stages in tech firms compared to non-tech firms, considering the evolution of the distinctive elements of firms in the tech sector. Furthermore, we argue that growth opportunities are key drivers of capital structure patterns for tech firms.

2.1. Life cycle stages in tech firms

Many authors have studied firm life cycles, and more specifically, the evolution of some features of the business along the life cycle. As the theory of firms' life cycles was originally developed as an extension of the product life cycle theory, firms are considered to progress through four main life cycle stages, namely, start-up, growth, maturity and decline, as described by Frielinghaus, Mostert, and Firer (2005). Corporate life cycle models have been applied in organisation studies since the 1960s. According to a few authors, such as Chandler (1962), the stages change, as do firms' strategies and structures. Organisational life cycle models differ extensively in a number of features, ranging from 2 (Bulan & Yan, 2010) or 3 stages to as many as 10 (Adizes, 1999).

A relevant study in the examination of common stages in the early literature is that by Miller and Friesen (1984). They found convergence in five life stages: birth, growth, maturity, revival and decline. The proxies used for the life cycle stages have changed quite a bit over time: investment (Wernerfelt, 1985), production behaviour (Wernerfelt, 1985), learning and experience (Spence, 1981). In the context of financing decisions, Hirsch and Walz (2011) analysed SME's cycle considering two stages: start-up (defined as the period of product development) and expansion (defined as the period of market entry for the firm's product). Additionally, Pfaffermayr, Stöckl, and Winner (2013) used age to analyse the evolution of taxation and the capital structure. Our reference in the distinction of life stages, Dickinson (2011), uses the signs of operating, investing and financing cash flows. By considering these three aspects of the business jointly, this method of classifying the life cycle stages overcomes the partiality of using just one discriminant variable, which is commonplace in the literature. This criterion allows us to place each firm into a life cycle stage to test our first set of hypotheses.

Several authors (Audretsch & Feldman, 1996; Klepper, 1996) pointed to innovation as a proxy for the life cycle of tech firms. The amount of innovation is high during the early stages of the industry life cycle, decreases during the maturity stage, although established large enterprises tend to maintain the innovative activity, and plays a much less important role in the latter stages. In addition, new products and services may work as barriers to entry or market demand factors that improve firms' performance and future growth opportunities. This close relationship between innovation and growth opportunities as a differential explanatory factor of the strategic positioning of the firm supports our second hypothesis.

2.2. Capital structure in tech firms

Concerning the evolution of leverage across the firm's life cycle, there is no evidence for tech firms and only very little empirical evidence for non-tech firms. Factors such as size, age, tangible assets, retained earnings, profitability (all used by Bulan & Yan, 2010) or dividends (DeAngelo, DeAngelo, & Stulz, 2006) follow different leverage patterns when firms are mature, as the maturity effect is related to debt capacity. Bulan and Yan (2010) found that the pecking order theory better describes the financing behaviour of mature rather than growing firms. Both Frielinghaus et al. (2005) and Teixeira and Coutinho Dos Santos (2014) observed that the pecking order theory explains how firms tend to adopt specific financing strategies as they progress along their lives. The changes in the adverse selection costs and information asymmetry in the pecking order offer signs of a high–low–high general pattern in firms' leverage. On the contrary, the benefits and costs of using debt, considered by the trade-off, give signs of a low–high–low general pattern.

Tech firms are often built upon new and proprietary products or applications to be sold into untested markets, which create information asymmetries and adverse selection: the insiders of

Table 1. Predicted sign of variables by pecking order theory versus trade-off theory.

Variable	Proxy	Pecking order theory	Trade-off theory	Tech firms
PROF	Profitability	−	+	±
GROWTH	Growth opportunities	+/−	−	−
LIQ	Liquidity	+/−	+/−	+/−
SIZE	Size	−	+	+/−
NDTS	Non-debt tax shield	+	−	+/−
TANG	Tangible assets	−	+	+
AGE	Age	−	+	+
AMINTAN	Intangible assets	+	−	−

Notes: The definitions of the variables are provided in Table A1.

an ICT[1] firm might know more about the possibility of the firm's success than outside investors (Hyytinen & Pajarinen, 2005). Information asymmetry can be interpreted by the pecking order theory as a cause to obtain less external debt or less equity. However, Halov and Heider (2011) and Frank and Goyal (2008) argued that with greater asymmetric information concerning risk (instead of value), debt has a more severe selection problem, and firms would only issue equity. In addition, as information asymmetry is linked to growth opportunities for this type of firm, in which high growth rates are reached for a relevant part of the life cycle, a positive relation with debt is expected when internally generated funds are insufficient to finance all needs (Michaelas, Chittenden, & Poutziouris, 1999). In Table 1, the expected signs of some variables of interest are included, considering the reasoning posed by the pecking order and trade-off theories. Note that the signs expected for tech firms in both theories are the result of the exacerbation of some aspects of the reasoning.

Furthermore, tech firms face particular difficulties associated with their higher dependence on intangible assets (products or applications that have little or no track records) that cannot be used as collateral (Brierley, 2001). According to the trade-off theory, firms with more intangible assets tend to borrow less (Rajan & Zingales, 1995). Intangible assets are more likely to lose value in financial distress, thus increasing the expected cost of bankruptcy (Myers, 1984). The pecking order theory makes predictions in the opposite direction: higher financing needs are required, and high information asymmetry linked to intangible assets makes equity issuances more costly (Frank & Goyal, 2009), inducing higher leverage. However, considering the higher proportion of asymmetric information about risk as well as less information about value attributable to small, young and high-growth firms (Halov & Heider, 2011), a higher reliance on equity can be expected for tech firms. As the ICT business needs technical people for developing knowledge, the intangible technological component of the ICT business is remarkable. Consequently, during the first stages, tech firms rely more on equity financing, as indicated by lower debt to assets ratios and a higher equity base (for example, Hogan and Hutson (2005) found evidence of it in Irish software companies). It sounds that the tangible component of assets is used as collateral to obtain debt, especially in this type of firm. Whereas the trade-off theory predicts higher leverage for tech firms with more tangibles, like in any other type of firm, the pecking order theory would not affect tech firms to the same extent as non-tech firms. In tech firms, higher tangibles are not expected to reduce leverage due to the less costly equity issuances because equity is already used as the primary source of funds, and therefore, the assets are expected to be used to obtain an additional source of financing.

Moreover, tech firms are under pressure to develop rapidly along their life cycle. Tech knowledge is accumulated throughout the life cycle,[2] but the ageing of technologies makes them increasingly vulnerable to obsolescence. Kazanjian (1988) indicated that if a product is technically feasible and achieves market acceptance, a period of high growth will typically result for the product and hence for the firm. Otherwise, as the growth rate slows down to a level consistent with market growth, the venture enters a new stage, that is, maturity. Introduction and decline are less important stages, as they are frequently shorter. For the trade-off theory, age is a positive inductor of debt, considering it as a proxy for reputation (Frank & Goyal, 2009). By contrast, the pecking order theory predicts a negative relation, based on the greater opportunities of older firms to retain earnings (Frank & Goyal, 2009). However, in line with the previous reasoning, during the most important stages for tech firms, growth is high enough to require more funds than those generated. Therefore, we expect age to work as a positive inductor of leverage.

Freear and Wetzel (1990) found that sources of equity capital shift when tech firms mature. Thus, while private investors are in control in the earliest stages of firm development, venture capitalists play a more prominent role in later rounds of financing. Bozkaya and Van Pottelsberghe De La Potterie (2008) demonstrated that as Belgian firms mature and move through different life cycle stages, their sources of financing change. Therefore, we argue that the life cycle of a firm affects the financing strategies of both tech firms and non-tech firms, resulting in different capital structure patterns. The different business characteristics highlighted allow us to pose the following hypotheses, in line with the sign predictions posited for tech firms in Table 1:

H1a: Higher levels of information asymmetry will induce less debt in tech firms than in non-tech firms along the firms' life cycle.

H1b: Growth opportunities and intangible assets will induce less debt in tech firms than in non-tech firms.

H1c: Older age and higher tangible assets induce more debt in tech firms than in non-tech firms.

Although common technology reflects similar opportunities (Castellacci, 2007), firms in the same industry can follow different strategies, depending on their growth opportunities, which are different along the business life (Caves & Porter, 1977). In tech firms, growth is favoured or conditioned by at least three features (Hyytinen & Pajarinen, 2005). First, network effects lead particularly to demand-side economies of scale. Second, in good intermediate ICT industries, such as software and ICT equipment, where the main form of innovation is the development of higher quality products, the appropriability of innovations can be high (Martin & Scott, 2000). Third, in some ICT industries, the costs of entry are fixed, whereas marginal and transportation costs are low because of the nature of the products.

In tech firms, future growth opportunities are proxied by the market-to-book ratio because of the effect of the R&D item, which indicates innovation. According to the pecking order theory, growth opportunities foster problems of information asymmetry between investors and firm managers. In addition, firms with more growth opportunities should need more debt. Michaelas et al. (1999) found support for both short-term and long-term debt, indicating that rapidly growing firms are likely to have insufficient earnings to finance all of their growth internally. In non-tech firms, financing needs tend to increase as the firms grow and evolve, but nothing has been reported for the tech sector yet.

The trade-off theory of the capital structure postulates that firms with high growth opportunities will tend to be less leveraged, as Rajan and Zingales (1995) and González and González (2008) demonstrated for the seven major industrialised countries.

Bruinshoofd and De Haan (2011) indicated that this choice is to prevent the cost of future underinvestment associated with high leverage. Myers (1977) argued that as growth opportunities push firms to take more risks, and they have higher financial distress costs, additional financing in the form of equity instead of debt contributes to mitigate the moral hazard problem. Furthermore, Halov and Heider (2011) demonstrated that the adverse selection costs are stronger when the outside market knows little about firms' risk. In addition, growth causes variability of the firm's value, which is interpreted as higher risk, preventing the firm from raising debt capital under favourable terms. Therefore, firms use internal capital to finance new projects until these funds run out, and only then do firms finance growth opportunities with debt.

Therefore, taking into account that characteristic factors of high-tech firms such as innovation and technology affect the growth opportunities of those firms, we can form homogeneous groups within our sample by taking growth opportunities as a second-level separation criterion. Consistent with the sign prediction posed in Table 1, we argue that the growth opportunities variable is a strategic factor for distinguishing between capital structures of high-tech firms and observing leverage behaviour over the life cycle of the firms.

H2: Higher levels of information asymmetry induce lower leverage in high-tech firms with high levels of growth opportunities than in high-tech firms with low levels of growth opportunities.

3. Research design

3.1. Measure of life cycle stages

We follow the approach of Dickinson (2011) to distinguish among the different life cycle stages of firms using information extracted from the cash flow statement. The three net cash flow activities (operating, investing and financing) can take a positive or negative sign, resulting in eight possible combinations, which are reorganised by the author into the five stages selected in line with the literature, as presented in Table 2.

The combination of those cash flow patterns characterises the interaction between the firm's resource allocation and operational capabilities and the firm's choice in strategy. Cash flows from operating activities are produced by the (core) business of the firm. Cash flows from investing activities come from the purchase or sale of long-term assets. Finally, cash flows from financial activities refer to the flow of cash between the firm and its shareholders and creditors.

3.2. Classification of tech firms

We distinguish between tech (including low and high) and non-tech firms following Francis and Schipper (1999), based on the three-digit Standard Industrial Classification (SIC) code and taking into account the classification by Kwon, Yin, and Han (2006).[3] The high-tech group includes, among others, computer-related services, electronic components and accessories, drugs, business services, computer and office equipment, telephone

Table 2. Life cycle stage model.

Cash flow type	Introduction	Growth	Mature	Shake-out	Decline
Operating	−	+	+	+/−	−
Investing	−	−	−	+/−	+
Financing	+	+	−	+/−	+/−

communications and communication equipment, which are the industries that contain a higher number of firms in our sample of the high-tech sector. The industries in the low-tech sector with a higher number of firms in our sample are motor vehicles and equipment, general industrial machinery and equipment, air transportation and miscellaneous plastic products.

To test our second hypothesis, we calculate the median of the growth opportunity variable by year and life cycle. Then, we create a variable as the difference between the growth opportunities and the median of this variable by year and life stage. If the result is higher (lower) than zero, those companies are considered to have more (fewer) growth opportunities. Thus, we only select high-tech firms with the highest growth opportunities (HGOs) and the high-tech firms with the lowest growth opportunities (LGOs).

3.3. Methodology

This study controls the endogeneity problem and avoids significant bias in estimates by employing a more advanced method of generalised method of moments (GMM) (Arellano, 2003; Baltagi, 2005; Wooldridge, 2007). We apply the system GMM in panel data, outlined by Arellano and Bover (1995) and fully developed by Blundell and Bond (1998). Specifically, we apply the two-step GMM estimator, included in the *xtabond2* Stata routine written by Roodman (2009), which uses one-step residuals to construct the asymptotically optimal weighting matrix and addresses the heterogeneity and endogeneity problems. This estimator could be more efficient because it may control the correlation of errors overtime as well as the heteroscedasticity across firms and the measurement errors, due to the utilisation of the orthogonality conditions on the variance-covariance matrix. In addition, panel data increase the degrees of freedom due to the availability of a large number of observations and reduce collinearity among explanatory factors, which leads to a more efficient estimation. Moreover, according to Hsiao (2003), the efficiency of GMM improves by adding new non-linear functions of the exogenous variables to the instruments (even in the homoscedasticity hypothesis). Arellano and Bover (1995) proposed the use of instruments in first differences for equations in levels and instruments in levels for equations in first differences. Blundell and Bond (1998) supported the efficiency of the Arellano and Bover (1995) estimator, especially for short sample periods and persistent data. The specification tests for the GMM estimator are the Hansen test, the test of lack of residual serial correlation and the Wald test.

Considering the main factors that the traditional capital structure theories have proposed to explain leverage and the factors that determine the firms' stages according to the life cycle theory, we selected a group of variables to be included in our model. For hypotheses H1b and H1c, leverage (*LDEBT*) is the dependent variable and the selected independent factors are: profitability (*PROF*); growth opportunities (*GROWTH*); liquidity (*LIQ*); size (*SIZE*); non-debt tax shields (*NDTS*); tangible assets (*TANG*); age (*AGE*) and intangibility (*AMINTAN*). We study leverage considering a dynamic factor not previously analysed in this line of research: the evolution along the life cycle stages.

$$\begin{aligned} LDEBT_{it} = {} & \alpha + \beta_1 LDEBT_{it-1} + \beta_2 PROF_{it} + \beta_3 GROWTH_{it} + \beta_4 LIQ_{it} \\ & + \beta_5 SIZE_{it} + \beta_6 NDTS_{it} + \beta_7 TANG_{it} + \beta_8 AGE_{it} \\ & + \beta_9 AMINTAN_{it} + \sum_{k=1}^{m} C_k + \sum_{t=2000}^{2012} Y_t + \mu_{it} + \gamma_i . \end{aligned} \tag{1}$$

We used a dummy variable that equals one if the firm is in one stage and zero otherwise. Thus, the model was applied five times, obtaining different coefficients for the groups of firms in introduction, growth, maturity, shake-out and decline. In all models, we control the potential endogeneity of the independent variables in the GMM estimations by using the same variables as for instruments in all regressions. C_k is the set of country dummy variables controlling other aspects beyond those explicitly included in the equation; Y_t is a set of time dummy variables for each year, capturing any unobserved firm time effect not included in the regression. μ_{it} is the error term and γ_i is the firm effect, which is assumed to be constant for firm i over t.

To test the pecking order hypothesis (required for H1a and H2 in this study) we use the model developed by Shyam-Sunder and Myers (1999) and partly modified by Frank and Goyal (2003). The variation of debt (ΔD) is a function of the funds flow deficit (DEF) and an error term (ε_{it}).

$$\Delta D_{it} = a + b_{PO} DEF_{it} + \varepsilon_{it}. \tag{2}$$

With all stock variables measured at the end of period t, the funds flow deficit is given as:

$$DEF_t = DIV_t + I_t + \Delta W_t - C_t. \tag{3}$$

We defined the notation as follows:

DIV_t: cash dividends in year t
I_t: net investment in year t
ΔW_t: change in working capital in year t
C_t: cash flow after interest and taxes

According to the simplest version of the pecking order theory, a is expected to be 0 and b should be 1 because, after the use of self-generated funds, the firm is expected to use debt to cover its fund needs and use equity only as a last resort.

The pecking order theory is based on how information asymmetry addresses capital structure decisions. For non-tech firms, the safest security may mean deciding without revealing managers' inside information (Shyam-Sunder & Myers, 1999), that is, what makes them prefer debt rather than equity. On the contrary, with higher perceived distress risk from external funders and sufficiently favourable manager information (Fama & French, 2002), the issue price of equity will be lower for tech firms. A broader pecking order hypothesis considers that a preference for equity may occur.

4. Sample and descriptive analysis

We used data from the Worldscope database of all listed[4] firms from Austria, Belgium, France, Germany, Italy, Netherlands, Spain and the UK from 2000 to 2012. To avoid the effects of outliers, we winsorised all continuous variables at the bottom and the top 3% of their distributions. All firm-year observations with SIC codes 6000–6999 (financial firms) and 4900–4999 (regulated firms) are excluded. To be included in the final sample, all variables used in this article must be available. Initially, we separated the sample into tech firms (6,945 firm-year observations) and non-tech firms (10,861 firm-year observations), then we distinguished between HGOs (3,139 firm-year observations) and LGOs (2,647 firm-year observations).

Table 3 reports the descriptive statistics by country (panel A and panel B), showing average values for long-term debt ratios[5] between 10% and 20%, that turn into a 48–60% range when the total liabilities to the total assets ratio is considered. Panel C shows the mean, standard deviation, median and the mean difference for tech and non-tech firms by variable. We find significant differences between tech and non-tech firms. Non-tech firms have higher mean values for leverage, profitability, size, tangible assets and age. In contrast, according to the literature, tech firms have the highest values in market to book value, liquidity and amortisation of intangible assets. Remarkable differences indicated that tech firms are less leveraged, less profitable, smaller and younger, have more intangible and fewer tangible assets and have more growth opportunities and liquidity.

Looking at the growth opportunities across life stages in high- and low-tech firms (Table 4), we noticed significant differences in median and mean values. They are higher for high-tech firms, remarkably so during the introduction, growth and decline stages. The mean difference test shows significant differences in all of the stages except shake-out. In both types of tech firms, the introduction stage shows the most significant growth opportunities. These results confirm the potential role of the growth opportunity variable in classifying firms.

In Table 5, panel A reports correlations of tech firms (above the diagonal) versus non-tech firms (below the diagonal), and panel B reports correlations of LGOs (above the diagonal) versus HGOs (below the diagonal). All variance inflation factors (VIFs) are below the benchmark of 10, which is indicative of the absence of multicollinearity between the independent variables. The table with VIF is not reported in the article for brevity. In all cases, size and tangibility are the most influential factors, with a positive relation, followed by liquidity with a negative relation. The main differences between tech and non-tech firms concern intangibles, non-debt tax shields, tangible assets, age and growth opportunities. Tech differential behaviour reduces debt when firms are more intangible and younger and have more growth opportunities and less tangible assets, in line with the signs predicted by both the pecking and the trade-off theories for tech firms (Table 1). Stronger positive correlations with leverage are also found for non-debt tax shields, although the previous literature has not offered support for differential behaviour in tech firms. In panel B, we appreciate that HGO firms address the differential effect of most factors, with LGO firms being more similar to that observed with non-tech firms. Intangibles appear as negative differential factors in both HGOs and LGOs with respect to non-tech firms.

5. Results

5.1. Estimation of the capital structure along the life cycle

Table 6 shows that all of the variables considered play a role in explaining leverage, both for tech and non-tech firms, consistent with the previous empirical literature. Our results indicate that profitability has a negative influence, and tangibility has a positive influence on leverage across the five stages of the life cycle in both tech and non-tech firms. The negative effect of profitability is the most prevalent result across different models and specifications in the literature, supporting the pecking order theory (Myers, 1993), whereas the positive effect of tangible assets is a more general finding when the dependent factor is measured as the book value of debt (Shyam-Sunder & Myers, 1999), but it is not so stable when other specifications of leverage are used (Welch, 2011). The positive sign is consistent with the trade-off theory and with hypothesis H1c, related to lower costs of

Table 3. Descriptive statistics.

Leverage (LDEBT = Long-term debt/total assets)							
Country	Obs.	Firms	Mean	Standard deviation	Median	Min.	Max.
Panel A. Leverage by country I							
AUT	422	53	0.1397	0.1192	0.1148	0	0.5387
BEL	483	70	0.1700	0.1408	0.1472	0	0.5387
DEU	3,409	452	0.1253	0.1327	0.0870	0	0.5387
ESP	125	48	0.2017	0.1433	0.1776	0	0.5387
FRA	2,360	380	0.1340	0.1206	0.1094	0	0.5387
GBR	10,749	1,289	0.1044	0.1389	0.0343	0	0.5387
ITA	86	9	0.1087	0.0677	0.1005	0	0.2871
NLD	172	25	0.1948	0.1493	0.1883	0	0.5387
TOTAL	17,806	2,326	0.1165	0.1362	0.0666	0	0.5387
Leverage (LEV = Total liabilities/total assets)							
Panel B. Leverage by country II							
AUT	422	53	0.5571	0.1933	0.5457	0.0424	1
BEL	483	70	0.5863	0.1838	0.5921	0.0468	1
DEU	3,409	452	0.5521	0.2147	0.5768	0.0424	1
ESP	125	48	0.5787	0.1776	0.5810	0.1068	0.9093
FRA	2,360	380	0.5931	0.1881	0.6056	0.0424	1
GBR	10,749	1,289	0.4796	0.2513	0.4823	0.0424	1
ITA	86	9	0.6237	0.2107	0.7105	0.2097	0.9165
NLD	172	25	0.4959	0.1937	0.5064	0.1226	1
TOTAL	17,806	2,326	0.5148	0.2373	0.5288	0.0424	1

Variable	Obs.	Mean	Standard deviation	Median	Min.	Max.	Mean (tech)	Mean (non-tech)	Mean diff.
Panel C. Summary statistics									
LDEBT	17,806	0.12	0.14	0.07	0.00	0.54	0.10	0.13	−0.02***
PROF	17,806	0.05	0.19	0.10	−0.6	0.33	0.03	0.07	−0.04***
GROWTH	17,806	1.36	1.17	0.95	0.22	5.42	1.56	1.23	0.33***
LIQ	17,806	2.12	2.05	1.46	0.38	10.27	2.21	2.06	0.15***
SIZE	17,806	11.90	2.29	11.73	7.35	17.38	11.66	12.05	−0.38***
NDTS	17,806	0.03	0.03	0.03	0.00	0.11	0.03	0.03	−0.0008*
TANG	17,806	0.23	0.21	0.16	0.00	0.87	0.16	0.27	−0.10***
AGE	17,806	2.62	1.19	2.56	0.00	4.68	2.47	2.72	−0.26***
AMINTAN	17,806	0.26	0.27	0.16	0.00	0.91	0.34	0.20	0.14***

Notes: The definitions of the variables are provided in Table A1. Mean diff. indicates the mean difference test (*t*-test) between tech and non-tech firms. * and *** indicate significance at the 5% and 0.1% level, respectively.

Table 4. Growth opportunities and life cycle in tech firms.

	High-tech firms				Low-tech firms				
Life cycle	Obs.	Mean	Standard deviation	Med.	Obs.	Mean	Standard deviation	Med.	Mean diff.
Introduction	1,310	2.46	1.77	1.84	95	1.77	1.57	1.09	0.69***
Growth	1,339	1.55	1.16	1.20	333	0.92	0.61	0.75	0.63***
Maturity	2,271	1.40	1.06	1.05	634	0.90	0.57	0.76	0.49***
Shake-out	510	1.25	1.09	0.86	78	1.08	1.00	0.79	0.17
Decline	356	1.69	1.49	1.10	19	0.74	0.94	0.56	0.95**
Total	5,786	1.68	1.38	1.17	1,159	0.99	0.79	0.76	0.69***

Notes: Mean diff. indicates the mean difference test (*t*-test) between high tech and low tech firms. ** and *** indicate significance at the 1% and 0.1% level, respectively.

Table 5. Correlation analysis.

	LDEBT	PROF	GROWTH	LIQ	SIZE	NDTS	TANG	AGE	AMINTAN
Panel A. Correlations in tech (above diagonal) and non-tech (below diagonal) firms									
LDEBT	1	0.1140*	−0.1007*	−0.2818*	0.3745*	0.2189*	0.3644*	0.0963*	−0.1258*
PROF	0.1242*	1	−0.2739*	−0.2562*	0.4569*	−0.0027	0.2037*	0.2512*	−0.0310*
GROWTH	−0.0788*	−0.1293*	1	0.2902*	−0.3415*	−0.0349*	−0.1791*	−0.1934*	−0.0125
LIQ	−0.2652*	−0.2163*	0.2361*	1	−0.2730*	−0.1983*	−0.2340*	−0.1847*	−0.0525*
SIZE	0.3627*	0.4002*	−0.2403*	−0.2679*	1	0.1109*	0.3748*	0.2702*	−0.1296*
NDTS	0.1409*	0.1948*	−0.0594*	−0.2386*	0.0502*	1	0.6077*	0.0724*	−0.4387*
TANG	0.3279*	0.1842*	−0.1103*	−0.2470*	0.1708*	0.5049*	1	0.1925*	−0.4681*
AGE	0.0552*	0.2469*	−0.2281*	−0.1866*	0.2301*	0.1425*	0.1336*	1	−0.1625*
AMINTAN	0.0076	−0.0918*	0.0499*	−0.0729*	−0.0623*	−0.3643*	−0.3975*	−0.1467*	1
Panel B. Correlations in high-tech firms by growth opportunities (HGO, above; LGO, below)									
LDEBT	1	0.0713*	−0.1174*	−0.2833*	0.3061*	0.2229*	0.3522*	0.0799*	−0.0646*
PROF	0.1248*	1	−0.3865*	−0.2597*	0.5390*	−0.0526*	0.1873*	0.2453*	0.0846*
GROWTH	0.1287*	−0.0163	1	0.2594*	−0.3939*	0.0184	−0.1373*	−0.1781*	−0.1372*
LIQ	−0.2219*	−0.2107*	0.1344*	1	−0.2327*	−0.2555*	−0.2443*	−0.1923*	−0.0935*
SIZE	0.3283*	0.3336*	−0.0217	−0.1949*	1	0.0212	0.2863*	0.2424*	0.0420*
NDTS	0.1767*	−0.0692*	−0.0275	−0.0759*	0.0801*	1	0.6313*	0.0069	−0.4127*
TANG	0.3158*	0.1154*	−0.0348	−0.1271*	0.2278*	0.6061*	1	0.0799*	−0.3695*
AGE	0.0691*	0.2299*	−0.1737*	−0.1369*	0.1758*	0.0500*	0.1458*	1	0.0036
AMINTAN	−0.1125*	−0.0614*	0.0085	−0.1061*	−0.0840*	−0.4222*	−0.4343*	−0.2075*	1

Notes: The definitions of the variables are provided in Table A1. In panel A, tech firms are above and non-tech firms are below the diagonal. In panel B, LGOs are above and HGOs are below the diagonal. * indicates significance at the 5% level.

Table 6. By-stage determinants of leverage.

VARIABLES	All samples	Intro.	Growth	Maturity	Shake-out	Decline
Panel A. Determinants in non-tech firms. GMM						
$LDEBT_{t-1}$	0.580***	0.381***	0.398***	0.868***	0.498***	0.630***
	[0.000485]	[0.000407]	[0.000639]	[0.0218]	[0.00364]	[0.00307]
$PROF_t$	−0.0437***	−0.048***	−0.116***	−0.0490**	−0.0405***	−0.0571***
	[0.000307]	[0.000135]	[0.000277]	[0.0209]	[0.00207]	[0.00222]
$GROWTH_t$	0.00115***	0.0020***	0.0004***	0.00230	0.0055***	0.00175***
	[5.49e-05]	[1.57e-05]	[5.52e-05]	[0.00297]	[0.000495]	[0.000350]
LIQ_t	−0.0006***	−0.002***	0.0045***	−0.00202	0.0023***	−0.0009***
	[3.92e-05]	[1.32e-05]	[2.59e-05]	[0.00229]	[0.000143]	[0.000144]
$SIZE_t$	0.0159***	0.0116***	0.0273***	0.00494***	0.00951***	0.00682***
	[0.000108]	[6.58e-05]	[9.03e-05]	[0.00119]	[0.000410]	[0.000268]
$NDTS_t$	−0.310***	0.00256*	−0.534***	0.193	0.134***	−0.263***
	[0.00272]	[0.00155]	[0.00328]	[0.122]	[0.0186]	[0.0165]
$TANG_t$	0.108***	0.0749***	0.126***	0.0529***	0.148***	0.0780***
	[0.000725]	[0.000315]	[0.000372]	[0.0149]	[0.00318]	[0.00275]
AGE_t	−0.0031***	0.0050***	0.00254***	−0.000307	−0.0025***	0.000571
	[9.92e-05]	[6.83e-05]	[0.000122]	[0.00206]	[0.000498]	[0.000505]
$AMINTAN_t$	0.0332***	0.0354***	0.0593***	0.0624***	0.00441***	0.0564***
	[0.000356]	[0.000130]	[0.000243]	[0.0145]	[0.00165]	[0.00146]
Constant	−0.189***	0.0427***	−0.246***	−0.0709***	−0.121***	−0.0410***
	[0.00162]	[0.00778]	[0.00386]	[0.0180]	[0.00994]	[0.00652]
Country eff.	YES	YES	YES	YES	YES	YES
Time eff.	YES	YES	YES	YES	YES	YES

(*Continued*)

Table 6. (*Continued*).

VARIABLES	All samples	Intro.	Growth	Maturity	Shake-out	Decline
Obs.	10,731	1,769	2,607	4,895	1,032	428
# Firms	1,427	658	987	1,047	592	288
F-Test	149545	2.140e+07	483360	144	3328	3.025e+06
Sig. *F*-test	0	0	0	0	0	0
Hansen test	1297	559.7	927.7	251.7	462.9	216.4
Sig. Hansen	0.348	0.679	0.487	0.107	0.441	0.647
m2	2.113	0.0454	1.372	1.482	1.167	0.837
Sig. m2	0.0346	0.964	0.170	0.138	0.243	0.403
Panel B. Determinants in tech firms. GMM						
$LDEBT_{t-1}$	0.596***	0.549***	0.495***	0.569***	0.500***	0.902***
	[0.000889]	[0.00318]	[0.0113]	[0.00495]	[0.00185]	[0.0127]
$PROF_t$	−0.0494***	−0.0349***	−0.0767***	−0.0501***	−0.0314***	−0.028***
	[0.000458]	[0.00215]	[0.00697]	[0.00495]	[0.00108]	[0.00994]
$GROWTH_t$	−0.00022***	0.00277***	0.000345	−0.00127**	0.00701***	0.00219
	[6.62e-05]	[0.000335]	[0.000931]	[0.000531]	[0.000186]	[0.00197]
LIQ_t	−0.00221***	−0.0039***	0.00177***	−0.0028***	−0.0086***	−0.000856
	[5.50e-05]	[0.000216]	[0.000602]	[0.000543]	[0.000140]	[0.000914]
$SIZE_t$	0.00457***	−0.0047***	0.0157***	0.0131***	0.00935***	−0.0046**
	[0.000136]	[0.000770]	[0.00110]	[0.000609]	[0.000216]	[0.00222]
$NDTS_t$	−0.0314***	0.359***	−0.453***	−0.192***	0.269***	−0.519***
	[0.00492]	[0.0268]	[0.0690]	[0.0397]	[0.0136]	[0.163]
$TANG_t$	0.185***	0.0968***	0.104***	0.0547***	0.149***	0.0574***
	[0.00182]	[0.00713]	[0.0138]	[0.00716]	[0.00330]	[0.0192]

(*Continued*)

Table 6. (*Continued*).

VARIABLES	All samples	Intro.	Growth	Maturity	Shake-out	Decline
AGE_t	0.000435***	0.0123***	0.00213*	−0.0075***	−0.0028***	0.0108*
	[0.000139]	[0.000587]	[0.00117]	[0.000745]	[0.000339]	[0.00565]
$AMINTAN_t$	0.0155***	0.0238***	−0.00272	−0.0109***	−0.0083***	−0.0275**
	[0.000430]	[0.00227]	[0.00612]	[0.00264]	[0.000798]	[0.0133]
Constant	−0.00826	0.181***	−0.176***	−0.0926***	0.234***	0.0837
	[0.0204]	[0.0214]	[0.0180]	[0.0133]	[0.00435]	[0.0725]
Country eff.	YES	YES	YES	YES	YES	YES
Time eff.	YES	YES	YES	YES	YES	YES
Obs.	6,876	1,372	1,656	2,899	585	364
# Firms	892	454	602	647	339	212
F-Test	62113	1819	191.1	1265	273100	76368
Sig. *F*-test	0	0	0	0	0	0
Hansen test	819.2	350.3	358.2	489.7	303.4	64.89
Sig. Hansen	0.404	0.366	0.262	0.155	0.912	1
m2	−0.307	−0.565	−0.650	1.467	1.206	1.635
Sig. m2	0.759	0.572	0.516	0.142	0.228	0.102

Notes: Regressions are estimated using the Arellano and Bover (1995) and Blundell and Bond (1998) two-step GMM difference estimator for panel data with lagged dependent variable. The definitions of the variables are provided in Table A1. We include country dummies and year dummies in all specifications. m2 is a serial correlation test of the second order using residuals in first differences, asymptotically distributed as N(0, 1) under the null of no serial correlation. The Hansen test is a test of the overidentifying restrictions, asymptotically distributed as χ^2 under the null of no correlation between the instruments and the error term. ***, ** and * indicate significance at the 1%, 5% and 10% level, respectively. Standard errors in brackets.

distress, as tangible assets are a form of secured collateral. As for the coefficient of the lagged leverage variable, it shows similar results to those obtained by González and González (2008) and Rubio and Sogorb (2011, 2012)), but is lower than those obtained by Flannery and Rangan (2006), Lemmon, Roberts, and Zender (2008) and Öztekin and Flannery (2012).[6] By stage, all of the coefficients for tech firms are higher, except during maturity.

When examining firms by stage, the highest number of opposite patterns is observed during maturity, consistent with the different perspectives that tech firms have during this stage. Tech firms show significant changes in negative signs for growth opportunities, age and intangibles. In addition, the maintenance of a negative sign for non-debt tax shields contrasts with the coefficient found for non-tech firms (positive though non-significant). During maturity, the shorter duration of the stage for tech firms joined with the strong reduction of growth opportunities implies remarkable lower investment needs in tangible, intangible and other operating assets. Considering the generation of positive operating cash flows that characterises maturity, the specific features of tech firms exacerbate the effect of these factors to avoid/reduce debt. As a source of information asymmetry, intangibles and growth opportunities cause tech firms to rely more on equity financing (H1b). Furthermore, the higher dependence on intangible assets of tech firms prevents them from using assets as collateral to obtain banking debt (Brierley, 2001). Non-debt tax shield can proxy for the current business activity of tech firms, becoming an indicator of the capacity of the firm to generate cash flows, making debt less necessary. Finally, our differential results regarding the age factor confirm the effect of the rapid development of tech firms (Kazanjian, 1988) (H1c).

The other two stages in which differences are exacerbated are introduction and decline. In both stages, size shows opposite behaviour, as it is a significant positive driver for non-tech firms, but a significant negative one for tech firms. In addition, non-debt tax shields, tangibility, age and intangibles are significant differential drivers of debt (whether positive or negative) for tech firms.

The variable that better characterises tech firms in our study is amortisation of intangible assets. Unlike non-tech firms, during maturity, shake-out and decline, more intangibles induce less debt in tech firms (H1b), providing support for the trade-off theory, consistent with its poor worth as collateral (Titman & Wessels, 1988), as well as for the pecking order theory with respect to the higher reliance on equity by high-growth firms with asymmetric information about risk (Halov & Heider, 2011). During introduction, intangibles induce more debt, in line with their role as a source of information asymmetry as posited by the pecking order theory. During growth, the negative relation is non-significant, pointing to the joint effect of the opposite forces in place.

The growth opportunity factor follows a general trend of inducing more debt in non-tech firms (though not significant during maturity). In tech firms, the positive relation is only significant during introduction and shake-out. The positive effect on debt is consistent with higher fund needs originated by the new investments required to grow, as posited by the pecking order theory. The significant negative relation for mature tech firms points to the prevalence of greater bankruptcy costs and exacerbated debt agency problems (information asymmetry between managers and investors especially concerns the firm's future growth opportunities[7]), according to the trade-off theory (Frank & Goyal, 2009). During growth and decline, the tech firms' non-significant coefficient would result from the offset of both opposite effects. Thus, tech firms would increase debt to finance growth opportunities only when their generation of cash flows is insufficient to cover the higher investment needs. Consistent with both opposite effects showing different prevalence by stage, the scarce previous evidence (in which samples do not distinguish stages) is not conclusive. Bruinshoofd and De Haan (2011) found significant negative coefficients for the US, but weaker ones for the UK. In continental Europe, they found this negative effect for ICT firms, especially during the ICT boom.

Although age follows a similar pattern in both sectors along the life cycle stages, we highlight the stronger positive effect during introduction, the weaker effect during growth, and the negative effect during maturity for tech firms. We appreciate how the results for tech firms' growth and maturity stages are similar to those of the subsequent stages for non-tech firms. The stronger coefficient during introduction suggests that age may be a proxy for notoriety, know-how and reliability in obtaining debt (H1c). Consistent with the required success of tech firms to maintain their position in the market, Bruinshoofd and De Haan (2011) noted that innovation and speed in tech projects are necessary for business growth. The change to a negative effect one stage before, for tech firms than for non-tech firms, confirms the change in strategic perspectives when a tech firm enters maturity, much closer to shake-out or decline than in non-tech firms.

Our results for size indicate a significant positive effect over leverage during all stages for non-tech firms and during growth, maturity and shake-out for tech firms. Consistent with the trade-off theory, with less direct bankruptcy costs, in these stages, the firm has access to a variety of funds, and size acts as a sign of debt capacity, allowing the firm to increase debt (Titman & Wessels, 1988). However, the relation is negative during introduction and decline for tech firms. As detected in our correlation analysis, tech firms' size is linked to profitability, which implies less need for debt financing.

A Chow test was performed, comparing the stages and the sectors (non-tech versus tech firms). The highly significant values obtained indicate that the coefficients of the independent variables are different across the stages as well as for both sectors.

Table 7 shows the results for the pecking order theory tests. The highly significant values obtained using the Chow test (untabulated) indicate that the coefficients of DEF are different across the stages as well as for both sectors. In every stage, tech firms get lower coefficients for DEF than non-tech firms, thus confirming hypothesis H1a. In this line, Hogan and Hutson (2005) indicated that new technology-based firms rely on outside equity more than debt. Maturity and shake-out are the stages in which both sectors cover financing needs with a higher proportion of debt, though the higher values of debt are found during growth (untabulated statistics by stage). These results are consistent with the pecking order reasoning. Along the firms' life cycle, higher information asymmetries during introduction impede or hamper the access to debt; during growth, the positive generation of funds covers a large part of financing needs, though the growth is so high that a part of needs have to be covered with debt (information asymmetry should be lower than in the previous stage); during maturity, information asymmetry is the lowest, as the growth rate is remarkably lower, while the generation of funds is positive and more steady; during shake-out, information asymmetry increases, but the firm is in a good position to obtain debt to finance the new investments and projects and during decline, the financing needs decrease considerably due to the disinvestment process, although the generation of operating cash flows is negative.

In line with the results displayed in Table 6, the tech firms' coefficient for maturity is the highest whereas the coefficient for non-tech firms is that for shake-out, indicating the additional needs of financing when the firm reduces generation of funds but is planning new projects and investments. Our results confirm that this is a strategic behaviour that tech firms already undertake during maturity.

Table 7. Pecking order theory test. Non-tech versus tech.

Variables	All samples	Introduction	Growth	Maturity	Shake-out	Decline
Panel A. All firms. Fixed effects						
DEF	0.188***	0.0166***	0.188***	0.749***	0.580***	0.123***
	[0.00348]	[0.00633]	[0.0110]	[0.00725]	[0.0214]	[0.0197]
Constant	−0.0074***	0.0173***	0.0226***	−0.0056***	−0.015***	−0.016***
	[0.000422]	[0.00169]	[0.00126]	[0.000255]	[0.000845]	[0.00240]
Obs.	17,806	3,247	4,309	7,809	1,630	811
R-sq.	0.158	0.003	0.097	0.636	0.516	0.117
# Firms	2,326	1,123	1,603	1,697	940	513
F-test	2905	6.909	289.3	10693	734.6	39.23
Panel B. Non-tech firms. Fixed effects						
DEF	0.230***	0.0253***	0.225***	0.788***	0.816***	0.167***
	[0.00469]	[0.00875]	[0.0142]	[0.00852]	[0.0231]	[0.0354]
Constant	−0.008***	0.0182***	0.022***	−0.0048***	−0.0098***	−0.015***
	[0.000530]	[0.00223]	[0.00163]	[0.000303]	[0.000895]	[0.00368]
Obs.	10,861	1,842	2,637	4,904	1,042	436
R-sq.	0.203	0.007	0.134	0.689	0.738	0.134
# Firms	1,430	666	996	1,048	598	292
F-test	2400	8.345	252.8	8543	1246	22.22
Panel C. Tech firms. Fixed effects						
DEF	0.139***	0.00730	0.131***	0.684***	0.279***	0.0997***
	[0.00514]	[0.00917]	[0.0175]	[0.0131]	[0.0322]	[0.0227]
Constant	−0.0067***	0.0159***	0.023***	−0.007***	−0.021***	−0.018***
	[0.000689]	[0.00257]	[0.002]	[0.000452]	[0.00132]	[0.00319]
Obs.	6,945	1,405	1,672	2,905	588	375
R-sq.	0.108	0.001	0.05	0.549	0.235	0.112
# Firms	896	457	607	649	342	221
F-test	730.1	0.633	55.81	2745	75.2	19.32

Notes: Regressions are estimated using a fixed-effects model to obtain a better comparison with the pecking order model. The definitions of the variables are provided in Table A1. *** indicates significance at the 1% level. Standard errors in brackets.

5.2. *Growth opportunities as discriminant factors on the capital structure of high-tech firms*

We have separated high-tech firms by their market to book medians into firms with high and low growth opportunities (Table 8). As a general result, we can appreciate how high-tech firms address the coefficients of tech firms along the whole life cycle. Furthermore, high-tech firms with high growth opportunities address the coefficients for DEF of high-tech firms and can be considered to be groups of firms inducing the coefficients of the comprehensive group of tech firms. Consequently, growth opportunities are good discriminant factors for high-tech firms concerning their capital structures.

For HGOs, the lower use of debt by stage is exacerbated with respect to non-tech firms. Moreover, LGOs are very close to non-tech firms in their use of debt across all of the stages, except the slightly higher use of debt during maturity than during shake-out, in contrast to non-tech firms. These differential effects over the capital structure of HGOs versus LGOs confirm our second hypothesis.

Again, we have applied the Chow Test (untabulated) to check that the coefficients obtained are significantly different for each group and across stages.

Table 8. Pecking order theory test. HGOs versus LGOs.

Variables	All samples	Introduction	Growth	Maturity	Shake-out	Decline
Panel A. All high-tech firms. Fixed effects						
DEF	0.120***	0.00645	0.106***	0.628***	0.277***	0.0941***
	[0.00534]	[0.00926]	[0.0189]	[0.0154]	[0.0335]	[0.0225]
Constant	−0.0069***	0.0151***	0.023***	−0.0081***	−0.020***	−0.018***
	[0.000772]	[0.00264]	[0.00223]	[0.000550]	[0.00143]	[0.00330]
Obs.	5,786	1,310	1,339	2,271	510	356
R-sq.	0.091	0.001	0.036	0.489	0.237	0.106
# Firms	753	417	500	530	290	208
F-test	501.8	0.484	31.12	1667	68.07	17.45
Panel B. HGO firms. Fixed effects						
DEF	0.0945***	0.00783	0.0601**	0.539***	0.159***	0.112***
	[0.00692]	[0.0113]	[0.0261]	[0.0225]	[0.0541]	[0.0341]
Constant	−0.00642***	0.0118***	0.0256***	−0.0088***	−0.024***	−0.021***
	[0.00116]	[0.00386]	[0.00346]	[0.000842]	[0.00265]	[0.00709]
Obs.	3,139	734	730	1,246	256	173
R-sq.	0.069	0.001	0.013	0.403	0.107	0.165
# Firms	626	255	335	394	183	118
F-test	186.3	0.479	5.281	574	8.617	10.70
Panel C. LGO firms. Fixed effects						
DEF	0.201***	0.0229	0.248***	0.809***	0.716***	0.121**
	[0.00986]	[0.0209]	[0.0332]	[0.0210]	[0.0380]	[0.0535]
Constant	−0.00794**	0.0163***	0.0150***	−0.0051***	−0.0082***	−0.018***
	[0.000996]	[0.00398]	[0.00301]	[0.000648]	[0.00115]	[0.00325]
Obs.	2,647	576	609	1,025	254	183
R-sq.	0.167	0.004	0.161	0.683	0.805	0.079
# Firms	575	303	317	338	167	122
F-test	414.3	1.202	55.90	1480	355	5.116

Notes: Regressions are estimated using a fixed-effects model to obtain a better comparison with the pecking order model. The definitions of the variables are provided in Table A1. ***, ** and * indicate significance at the 1%, 5% and 10% level, respectively. Standard errors in brackets.

6. Robustness analyses

We have performed several additional regressions to check the robustness of our results.

6.1. Alternative measure of life cycles

We re-estimate Tables 6 and 7 using an alternative classification of firms into the life cycle stages, which discards the use of the signs of the financing cash flows to avoid a possible bias in the capital structure behaviour found by stage. In addition to the signs of the operating and financing cash flows proposed by Dickinson, we have used a variable considering deciles of firms' growth and risk by year and country. The variable takes the value 1 if the average decile (for growth and risk) is equal or higher than 5, and 0 otherwise. We use the yearly growth of sales to proxy for growth and compute the yearly standard deviation of monthly returns as a proxy for risk. In line with the literature on life cycle stages, we assign firms that scored 1 to the introduction and growth stages, firms that scored 0 to maturity and decline and the rest of the firms are assigned to the shake-out stage.

In Table 9, we observe that the general patterns for profitability (negative) and tangibility (positive) are confirmed, as are the high–low–high effects of growth opportunities and age. The negative coefficients of growth opportunities found for tech firms during growth and maturity and the negative (or lower) coefficients of intangibles during the whole life cycle support our findings with respect to the stronger effect of information asymmetry (H1b). The different role of age across stages (especially introduction and maturity) and the remarkable differences for several factors during maturity support the idea of different strategic perspectives for tech firms related to their rapid development linked to high growth rates.

Table 9. By-stage determinants of leverage. Alternative measure of life cycles.

VARIABLES	Introduction	Growth	Maturity	Shake-out	Decline
Panel A. Determinants in non-Tech firms. GMM					
LDEBT$_{t-1}$	0.422***	0.484***	0.493***	0.484***	0.732***
	[0.000747]	[0.00149]	[0.000689]	[0.00685]	[0.0223]
PROF$_t$	−0.00615***	−0.0703***	−0.0843***	−0.0506***	−0.0812***
	[0.000226]	[0.000924]	[0.000529]	[0.00302]	[0.00841]
GROWTH$_t$	0.00123***	−0.000485**	0.00892***	0.00253***	−0.000858
	[4.02e-05]	[0.000188]	[0.000142]	[0.000585]	[0.00162]
LIQ$_t$	−0.000452***	0.000289**	0.00640***	−0.00136***	0.000702
	[5.21e-05]	[0.000128]	[8.34e-05]	[0.000183]	[0.000818]
SIZE$_t$	0.0111***	0.0220***	0.0202***	0.0128***	0.00547***
	[0.000173]	[0.000257]	[0.000166]	[0.000665]	[0.00135]
NDTS$_t$	0.453***	−0.245***	−0.630***	−0.339***	−0.0727
	[0.00760]	[0.00775]	[0.00712]	[0.0254]	[0.0750]
TANG$_t$	0.00969***	0.0944***	0.111***	0.212***	0.0930***
	[0.000836]	[0.00151]	[0.00134]	[0.00572]	[0.0113]
AGE$_t$	0.00231***	−0.00154***	−0.00134***	−0.00175***	0.00304*
	[0.000156]	[0.000288]	[0.000134]	[0.000642]	[0.00168]
AMINTAN$_t$	0.0402***	0.0424***	0.0249***	0.0263***	0.0236***
	[0.000619]	[0.00122]	[0.000559]	[0.00325]	[0.00838]
Constant	−0.138***	−0.224***	−0.225***	−0.141***	−0.0416*
	[0.00415]	[0.00871]	[0.00548]	[0.0135]	[0.0240]
Country eff.	YES	YES	YES	YES	YES
Time eff.	YES	YES	YES	YES	YES
Obs.	1,084	4,174	3,107	1,345	162
# Firms	508	1,097	851	669	130
F–test	1.476e+06	8039	1.721e+06	598.9	6563
Sig. *F*–test	0	0	0	0	0
Hansen test	482.8	934.8	826.4	464	102
Sig. Hansen	0.998	0.422	1	0.426	1
m2	0.902	0.524	1.645	1.210	1.290
Sig. m2	0.367	0.600	0.0999	0.226	0.197
Panel B. Determinants in tech firms. GMM					
LDEBT$_{t-1}$	0.541***	0.561***	0.647***	0.523***	0.781***
	[0.00302]	[0.00957]	[0.00118]	[0.00140]	[0.0731]
PROF$_t$	−0.0169***	−0.0409***	−0.0250***	−0.0308***	0.00259
	[0.00175]	[0.00622]	[0.00157]	[0.000460]	[0.0181]
GROWTH$_t$	0.00102***	−0.00204**	−0.00203***	−0.000262***	0.00582**
	[0.000243]	[0.000862]	[0.000176]	[6.66e-05]	[0.00270]
LIQ$_t$	−0.00314***	0.000539	−0.00353***	−0.00566***	−0.00526**

(*Continued*)

Table 9. (*Continued*).

VARIABLES	Introduction	Growth	Maturity	Shake-out	Decline
	[0.000171]	[0.000690]	[0.000134]	[5.92e-05]	[0.00218]
$SIZE_t$	−0.00166***	0.00698***	0.0129***	0.00402***	0.000562
	[0.000638]	[0.000979]	[9.84e-05]	[0.000134]	[0.00582]
$NDTS_t$	0.431***	−0.614***	0.0967***	0.111***	−0.759**
	[0.0237]	[0.0711]	[0.00706]	[0.00435]	[0.342]
$TANG_t$	0.0445***	0.166***	−0.0178***	0.170***	0.171**
	[0.00600]	[0.0145]	[0.00140]	[0.00133]	[0.0720]
AGE_t	0.0106***	0.000775	−0.00788***	−0.00201***	0.00831
	[0.000597]	[0.00107]	[0.000149]	[0.000105]	[0.00555]
$AMINTAN_t$	0.00364**	−0.00941*	−0.00963***	0.0189***	−0.0216
	[0.00171]	[0.00526]	[0.000718]	[0.000370]	[0.0239]
Constant	0.211***	−0.0274*	−0.144***	0.0211***	0.0520
	[0.0222]	[0.0161]	[0.00188]	[0.00363]	[0.118]
Country eff.	YES	YES	YES	YES	YES
Time eff.	YES	YES	YES	YES	YES
Obs.	1,143	2,823	1,621	881	94
# Firms	451	706	518	457	75
F-test	2752	306.4	73056	7.162e+06	936.1
Sig. *F*–test	0	0	0	0	0
Hansen test	349.3	335.6	470.3	431.8	47.50
Sig. Hansen	0.381	0.587	0.347	0.724	1
m2	−0.104	0.382	−1.261	1.637	−0.294
Sig. m2	0.917	0.702	0.207	0.102	0.769

Notes: Regressions are estimated using the Arellano and Bover (1995) and Blundell and Bond (1998) two-step GMM difference estimator for panel data with lagged dependent variables. The definitions of the variables are provided in Table A1. We include country dummies and year dummies in all specifications. m2 is a serial correlation test of the second order using residuals in first differences, asymptotically distributed as N(0, 1) under the null of no serial correlation. The Hansen test is a test of the overidentifying restrictions, asymptotically distributed as χ^2 under the null of no correlation between the instruments and the error term. ***, ** and * indicate significance at the 1%, 5% and 10% level, respectively. Standard errors in brackets.

Table 10 shows that all coefficients for DEF of tech firms are lower than those of non-tech firms, supporting our results in Table 7 to confirm hypothesis H1a. The pecking order theory is behind the lower leverage of tech firms along the whole life cycle as well as behind the differences of leverage by stage in both tech and non-tech firms.

6.2. Alternative measure of leverage

We have used an alternative measure of leverage as the dependent variable, that is, total liabilities to total assets (Table 11). The inclusion of financial and non-financial liabilities has important implications for the results, as found by Welch (2011). Thus, in both tech and non-tech firms, the negative effect of profitability is stronger, tangibility is a less stable inductor, but, in exchange, liquidity is a stronger and stable negative inductor of leverage. The reasons are that non-financial liabilities can vary quickly in response to higher or lower financing needs, and the role as collateral played by tangibility is unnecessary for non-financial liabilities. In addition, the information asymmetry problem can be mitigated by using short-term rather than long-term liabilities (Myers, 1977). Consequently, and consistent with Welch (2011), most variables are sensible to the leverage specification. Notwithstanding, our results confirm the differential role of

Table 10. Pecking order theory test. Alternative measure of life cycles.

Variables	All samples	Introduction	Growth	Maturity	Shake-out	Decline
Panel A. All firms. Fixed effects						
DEF	0.262***	0.0496***	0.435***	0.743***	0.208***	0.149***
	[0.00395]	[0.00882]	[0.00718]	[0.00830]	[0.0130]	[0.0551]
Constant	−0.0074***	0.0109***	−0.0065***	−0.0032***	−0.019***	−0.02***
	[0.000402]	[0.00185]	[0.000535]	[0.000366]	[0.00113]	[0.00417]
Obs.	16,451	2,230	7,004	4,729	2,232	256
R-sq.	0.237	0.024	0.414	0.704	0.19	0.127
# Firms	2,218	960	1,803	1,369	1,129	205
F-test	4413	31.61	3680	8007	258.1	7.301
Panel B. Non-tech firms. Fixed effects						
DEF	0.348***	0.0786***	0.462***	0.765***	0.309***	0.395***
	[0.00533]	[0.0141]	[0.00910]	[0.00989]	[0.0183]	[0.0875]
Constant	−0.0075***	0.0120***	−0.0063***	−0.0029***	−0.018***	−0.02***
	[0.000484]	[0.00270]	[0.000687]	[0.000433]	[0.00132]	[0.00440]
Obs.	9,880	1,085	4,178	3,108	1,347	162
R-sq.	0.333	0.051	0.456	0.726	0.297	0.396
# Firms	1,334	508	1,097	851	669	130
F-test	4259	31.1	2578	5983	285.4	20.35
Panel C. Tech firms. Fixed effects						
DEF	0.178***	0.0288**	0.393***	0.701***	0.115***	0.0727
	[0.00573]	[0.0112]	[0.0116]	[0.0150]	[0.0174]	[0.0748]
Constant	−0.0069***	0.00950***	−0.007***	−0.0037***	−0.017***	−0.028***
	[0.000673]	[0.00253]	[0.000847]	[0.000673]	[0.00195]	[0.00817]
Obs.	6,571	1,145	2,826	1,621	885	94
R-sq.	0.145	0.009	0.351	0.665	0.094	0.05
# Firms	884	452	706	518	460	75
F-test	964.4	6.621	1148	2184	43.75	0.945

Notes: Regressions are estimated using a fixed-effects model to obtain a better comparison with the pecking order model. The definitions of the variables are provided in Table A1. *** and ** indicate significance at the 1% and 5% level, respectively. Standard errors in brackets.

intangibles along the life cycle, the different function of the drivers during the maturity stage, and the more intense role of age as a positive inductor of leverage.

6.3. Intangible assets measure

Considering the relevance of the intangible assets in the differential behaviour of tech firms, we check that results do not change when a different proxy for intangibles is used. Instead of amortisation of intangibles, we have taken R&D, which is considered to be a good proxy for innovation in tech firms. It is a twofold partial proxy: it alludes only to a specific part of intangibles, and significantly fewer firms have this type of asset in their balance sheets. With these limitations in mind, it is expected that other variables partially change their effects to cover that portion of intangibility not reflected in R&D, such as growth opportunities or non-debt tax shield. In general, most coefficients are similar (untabulated results), supporting the results displayed in Table 6. Like in our main regressions, intangibles show an opposite pattern during most stages of the life cycle, growth opportunities produce lower or more negative influences on leverage, age is a

Table 11. By-stage determinants of leverage. Alternative measure of leverage.

VARIABLES	Introduction	Growth	Maturity	Shake-out	Decline
Panel A. Determinants in non-tech firms. GMM					
LEV_{t-1}	0.378***	0.461***	0.627***	0.522***	0.601***
	[0.000487]	[0.00794]	[0.00342]	[0.00411]	[0.00342]
$PROF_t$	−0.164***	−0.308***	−0.233***	−0.313***	−0.283***
	[0.000275]	[0.00753]	[0.00488]	[0.00339]	[0.00567]
$GROWTH_t$	−0.0107***	−0.0116***	0.00176***	0.00321***	0.00781***
	[2.90e-05]	[0.00134]	[0.000680]	[0.000674]	[0.000617]
LIQ_t	−0.0328***	−0.0285***	−0.0366***	−0.0384***	−0.0413***
	[4.79e-05]	[0.000754]	[0.000668]	[0.000290]	[0.000856]
$SIZE_t$	0.00243***	0.0171***	0.00949***	0.0191***	0.0214***
	[9.03e-05]	[0.00113]	[0.000655]	[0.000845]	[0.000975]
$NDTS_t$	2.171***	−0.316***	−0.0791**	0.821***	0.104**
	[0.00551]	[0.0714]	[0.0328]	[0.0387]	[0.0445]
$TANG_t$	0.0245***	−0.0323***	0.00509	−0.0179**	0.0422***
	[0.000672]	[0.00859]	[0.00552]	[0.00751]	[0.0110]
AGE_t	0.0155***	0.0211***	−0.00262***	0.00284***	0.00869***
	[0.000220]	[0.00158]	[0.000669]	[0.000978]	[0.00140]
$AMINTAN_t$	0.0859***	0.0453***	0.0232***	−0.0270***	−0.0180***
	[0.000353]	[0.00616]	[0.00320]	[0.00367]	[0.00504]
Constant	0.268***	0.101***	0.146***	0.0226	0.135***
	[0.0292]	[0.0219]	[0.0128]	[0.0154]	[0.0197]
Country eff.	YES	YES	YES	YES	YES
Time eff.	YES	YES	YES	YES	YES
Obs.	1,769	2,607	4,895	1,032	428
# Firms	658	987	1,047	592	288
F-test	2.060e+07	632.5	1936	3462	4.872e+06
Sig. *F*-test	0	0	0	0	0
Hansen test	573.8	618.3	832.4	477.6	206.3
Sig. Hansen	0.518	0.108	0.285	0.265	0.809
m2	0.515	1.627	−1.062	−0.420	1.203
Sig. m2	0.607	0.104	0.288	0.674	0.229
Panel B. Determinants in tech firms. GMM					
LEV_{t-1}	0.333***	0.421***	0.691***	0.580***	0.516***
	[0.00448]	[0.00540]	[0.00763]	[0.0138]	[0.00819]
$PROF_t$	−0.185***	−0.241***	−0.218***	−0.160***	−0.226***
	[0.00445]	[0.00497]	[0.0109]	[0.0109]	[0.00700]
$GROWTH_t$	0.0178***	−0.00524***	0.00184*	0.000821	−0.00190
	[0.000783]	[0.000774]	[0.00104]	[0.00145]	[0.00127]
LIQ_t	−0.0473***	−0.0535***	−0.0341***	−0.0363***	−0.0477***
	[0.000398]	[0.000616]	[0.00116]	[0.00111]	[0.000729]
$SIZE_t$	0.00466***	0.00938***	0.00982***	−0.00629***	0.0162***
	[0.00172]	[0.000973]	[0.000870]	[0.00162]	[0.00161]
$NDTS_t$	2.151***	−0.0418	0.709***	0.892***	1.209***
	[0.0509]	[0.0552]	[0.0784]	[0.155]	[0.0757]
$TANG_t$	0.143***	−0.0519***	−0.0541***	0.0728***	0.0723***
	[0.0152]	[0.0106]	[0.0128]	[0.0242]	[0.0167]
AGE_t	0.0320***	0.00765***	0.00283***	0.0149***	0.0129***
	[0.00168]	[0.00117]	[0.000920]	[0.00281]	[0.00184]
$AMINTAN_t$	−0.00739	−0.0836***	−0.0119**	−0.000994	−0.0429***
	[0.00520]	[0.00422]	[0.00465]	[0.0118]	[0.00961]

(*Continued*)

Table 11. (*Continued*).

VARIABLES	Introduction	Growth	Maturity	Shake-out	Decline
Constant	0.142***	0.283***	0.0881***	0.309***	0.0932***
	[0.0270]	[0.0209]	[0.0174]	[0.0342]	[0.0260]
Country eff.	YES	YES	YES	YES	YES
Time eff.	YES	YES	YES	YES	YES
Obs.	1,372	1,656	2,899	585	364
# Firms	454	602	647	339	212
F-test	3224	1332	1101	1747	39367
Sig. *F*-test	0	0	0	0	0
Hansen test	341.6	486.3	488.4	237.7	176.2
Sig. Hansen	0.495	0.183	0.166	0.267	0.993
m2	−0.0365	−1.599	−0.907	1.353	1.148
Sig. m2	0.971	0.110	0.364	0.176	0.251

Notes: Regressions are estimated using the Arellano and Bover (1995) and Blundell and Bond (1998) two-step GMM difference estimator for panel data with lagged dependent variables. The definitions of the variables are provided in Table A1. We include country dummies and year dummies in all specifications. m2 is a serial correlation test of the second order using residuals in first differences, asymptotically distributed as N(0, 1) under the null of no serial correlation. The Hansen test is a test of the overidentifying restrictions, asymptotically distributed as χ^2 under the null of no correlation between the instruments and the error term. ***, ** and * indicate significance at the 1%, 5% and 10% level, respectively. Standard errors in brackets.

stronger high–low–high inductor and maturity is the stage in which the change in patterns is more pronounced.

6.4. *Institutional and legal controls*

We have added additional control variables to check that factors such as the crisis period included in the period under study, the legal origin of the countries in the sample, or creditor rights are not addressing a part of our results. The inclusion of these control variables leaves all our results unchanged. As for the control variables included, for non-tech firms, the crisis appears as a positive inductor of debt during introduction and a negative one during the other stages, though it is only significant during shake-out and decline. For tech firms, it is a weaker inductor, only significant during introduction (positive) and shake-out (negative). The creditor rights variable is also a weaker inductor, except during maturity.

6.5. *Complete panels*

To check that our results are robust to the effect of attrition, we replicate all our analyses for the subsample of firms that remain along the whole period under study (untabulated results). The dramatic reduction of the sample produces a lower number of significant coefficients, though most signs and patterns are maintained in our by-stage analysis. As for the pecking order hypothesis test, all coefficients are remarkably higher, consistent with the sample bias (related to longer age and higher stability). However, all our results confirm hypotheses H1a and H2 during all of the stages of the life cycle.

7. Conclusion

This article examined the capital structure of the tech sector in a dynamic framework by exploring the sensitivity of firms' leverage to a set of commonly used factors as well as by applying a pecking order test. To distinguish among the life cycle stages of the firm, we used the innovative model of Dickinson (2011). Our results indicate different capital structures along the firms' life cycle for tech and non-tech sectors over a European sample of quoted firms.

The specific characteristics of the businesses in the tech sector produce pronounced differences in financial behaviour, mainly during maturity, followed by introduction and decline. Consistent with our first set of hypotheses, growth opportunities, amortisation of intangibles and age are the main discriminant factors for these stages, complemented by non-debt tax shields. The negative (or lower) effect of intangible assets during the whole life cycle except introduction, and that of growth opportunities during growth and maturity confirm the link between information asymmetry and risk in inducing tech firms to use more equity instead of debt. Non-tech firms' positive coefficients support the pecking order theory, and the differential tech firms' coefficients (lower or negative) for intangibles and growth opportunities are also addressed by the pecking order theory.

During introduction and decline, age acts as a stronger and positive inductor of debt, pointing to the trade-off reasoning of reputation as prevalent. In these stages, the generation of internal funds is remarkably insufficient to cover the funding needs due to the negative operating cash flows. By contrast, age becomes a negative inductor of debt during maturity, in line with the pecking order reasoning, because unlike non-tech firms, the sharp reduction of growth opportunities in tech firms takes place as firms maintain the positive generation of operating cash flows.

The abovementioned results on the effect of leverage drivers by life cycle stages confirm the role of information asymmetries to differentiate tech firms' capital structure patterns from those of non-tech firms. Furthermore, our results using the Frank and Goyal (2003) test of the pecking order theory confirm the significant lower use of debt by tech firms than by non-tech firms across all of the life cycle stages. In addition, the coefficients obtained for maturity support the previous results on the differential strategic role of this stage for tech firms, closer to that of shake-out for non-tech firms.

Finally, we found that growth opportunities are key features for further distinguishing high-tech firms into smaller homogeneous groups to better explain their capital structure. Consequently, the pecking order is even more prevalent for LGOs across all of the stages, and we found that LGOs are closer to non-tech firms, in line with our second hypothesis.

The study contributes to the empirical literature on the capital structure in two ways. First, it explains the capital structure of tech versus non-tech firms along the life cycle stages. By doing so, our work confirms that Dickinson's (2011) model provides the research community with a new proxy for the life cycle that allows us to apply capital structure models within a new dynamic framework, giving rise to much more detailed analyses either on general or specific sector samples. Our results highlight the relevance of selecting homogenous groups with respect to the life cycle stage to form the sample under analysis to better explain the capital structure theories. Thus, by using by-stage samples, the offsetting effect of some drivers that evolve along the life cycle is avoided, and some mixed effects found in the literature can be disentangled. Second, we show the potential of growth opportunities to identify smaller groups of high-tech firms concerning the capital structure.

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Notes

1. Information and Communication Technology.
2. We distinguish tech firms' life cycles (the time span between a firm's introduction and its decline) and the tech sector's life cycles (the time span between a technology generation's emergence and its decline).
3. Based on the SIC, we have high-technology firms, including 272, 283, 355, 357, 360–367, 369, 381, 382, 386, 481, 484, 489, 573, 596, 621, 679, 733, 737, 738 and 873, and low-technology firms, including 020, 160, 170, 202, 220, 240, 245, 260, 300, 308, 324, 331, 356, 371, 399, 401, 421, 440, 451 and 541.
4. There are two reasons for focusing only on quoted firms: (1) the Dickinson model is generally applicable only to firms issuing the cash flow statement, and this is not mandatory for a significant portion of non-quoted firms; and (2) the definition of the life-cycle stages may vary considerably for quoted versus non-quoted firms, specially concerning introduction and growth.
5. González and González (2008) obtained a similar range (10–20%) for the long-term debt ratio in the European countries of our sample, even though they divide by the market value instead of the book value of assets.
6. Our coefficient without distinguishing stages is 0.58 for non-tech firms and 0.60 for tech firms, whereas the range of coefficients obtained in the comparable works are: 0.16–0.62 by González and González, for the countries included in our sample; 0.69–0.91 by Öztekin and Flannery, for the countries included in our sample; 0.69 by Rubio and Sogorb (2011); 0.31–0.72 by Rubio and Sogorb (2012); 0.62–0.65 by Flannery and Rangan (2006) and 0.75–0.78 by Lemmon et al. (2008). González and González (2008) and Öztekin and Flannery (2012) analysed similar periods (1995–2004 and 1991–2006, respectively). Both samples are international, including the European firms taken in our sample (except The Netherlands in the second work). Rubio and Sogorb (2011, 2012) analysed Spanish firms during a similar period (1995–2003 and 1995–2007, respectively). Flannery and Rangan (2006) and Lemmon et al. (2008) studied US firms in a remarkable longer period (1965–2001 and 1965–2003, respectively), very different from ours. In addition, the leverage variable used by these works is a market debt ratio, except for Öztekin and Flannery and Lemmon et al. that use both market and accounting debt ratios.
7. Maturity is the stage in which debt is used in a higher proportion, as evidenced in Table 7, for both tech and non-tech firms. However, we can appreciate in Table 6 that tech firms' inductors of debt during maturity are only tangible assets and size.

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Appendix

Table A1. Description of variables.

Variable	Definition
Firm characteristics. Data source: Worldscope	
LDEBT	Long-term debt to the book value of assets (Shyam-Sunder & Myers, 1999).
PROF	Earnings before interest and taxes to the total assets (Rajan & Zingales, 1995).
GROWTH	Market value of equity plus debt in current liabilities plus long-term debt plus preferred stocks minus deferred taxes and investment tax credit, all scaled by the total assets (Frank & Goyal, 2009).
LIQ	Current assets to current liabilities (Ozkan, 2001).
SIZE	Logarithm of the total assets (La Rocca et al., 2011).
NDTS	Depreciation, depletion and amortisation to the total assets (Titman & Wessels, 1988).
TANG	Net property, plant and equipment to the total assets (González & González, 2008).
AGE	The logarithm of years after the firm's foundation (La Rocca et al., 2011).
AMINTAN	Amortisation of intangibles to the total depreciation.
HGO	Equals one if a firm has high technology with higher growth opportunities and zero otherwise.
LGO	Equals one if a firm has high technology with lower growth opportunities and zero otherwise.
DEF	Cash dividends plus net investment plus the change in working capital plus cash flow after interest and taxes plus the current portion of the long-term debt plus net debt issued plus net equity issued (Frank & Goyal, 2003).
LEV	The total liabilities to the total assets (Welch, 2011).
CRISIS	Equals one if a firm is in systemic banking crisis period and zero otherwise (Laeven & Valencia, 2013).
CR	Country creditors' rights (Djankov, McLiesh, & Shleifer, 2007).
RDA	Research and development expenses to the total assets (Fama & French, 2002).
Legal Origin	Five dummies that equal one if the firm has Anglo-Saxon, French, German, Scandinavian or Socialist legal origin and zero otherwise (Djankov et al., 2007).