Journal of Entrepreneurship, Management and Innovation (2025)
Volume 21 Issue 1: 99-120

DOI: https://doi.org/10.7341/20252116
JEL Codes: G32, O32

Capital structure specificity in knowledge-intensive industries: A comparative study of EU countries

***Magdalena Gostkowska-Drzewicka*[1], *Julia Koralun-Bereźnicka*[2]**

Abstract

PURPOSE: *This paper aims to examine and compare the capital structure patterns and financial decision-making determinants of knowledge-based firms and traditional industries in selected EU countries over the period 2000–2023. The study seeks to uncover sector-specific features, focusing on the unique financial behaviors of knowledge-intensive enterprises compared to their traditional counterparts. It also explores how factors such as asset structure, profitability, and growth opportunities influence capital structure decisions within these industries, thus providing implications for financial management in innovation-driven sectors.* ***METHODOLOGY:*** *The methodology involves analyzing data from 12 EU countries, categorized by industry (sectors M and J for knowledge-based firms and other sectors for traditional firms) and firm size. The research applies panel data modeling to evaluate the differences and influences on capital structure within these groups.* ***FINDINGS:*** *The study reveals that knowledge-based firms exhibit distinct capital structure characteristics, including a higher reliance on intangible assets and lower ratios of long-term debt compared to traditional firms. Specifically, the findings indicate that intangible assets are positively correlated with total and long-term debt in knowledge-based firms, meaning that an increase in intangible asset value is associated with a corresponding increase in total and long-term debt levels. This relationship aligns with the modified pecking order theory, which posits that firms prioritize funding sources based on their perceived cost and risk. The determinants of capital structure – such as profitability and growth opportunities – also demonstrate differing impacts, revealing the unique financial strategies employed by knowledge-based firms.* ***IMPLICATIONS****: This research highlights the importance of adapting financial strategies to the specific needs of knowledge-based firms, which often face unique challenges due to their reliance on intangible assets. Policymakers can use these findings to design targeted financial policies that support the growth and sustainability of innovation-driven enterprises, such as by offering incentives for intangible asset financing or by reducing barriers to accessing long-term debt. For practitioners, the insights highlight the need to align financial decision-making with sector-specific characteristics to optimize capital structure and drive competitive advantage.* ***ORIGINALITY AND VALUE:*** *This research makes a unique contribution by providing one of the first comparative analyses of capital structure determinants across knowledge-based and traditional firms in multiple EU countries over an extended timeframe (2000–2023). Unlike prior studies, which often focus on individual sectors or countries, this study offers a comprehensive and cross-sectoral perspective, enriching the understanding of how financial theories operate in diverse economic and institutional contexts. By addressing the financial behaviors of knowledge-intensive firms, the research bridges a critical gap in the literature and informs both academia and practice.*

Keywords: *capital structure, knowledge-based firms, traditional industries, panel data regression, EU countries, innovation-driven enterprises, modified pecking order theory, sector-specific analysis*

1 Magdalena Gostkowska-Drzewicka, Ph.D., Department of Corporate Finance, Faculty of Management, University of Gdańsk, ul. Armii Krajowej 101, 81-824 Sopot, Poland, e-mail: magdalena.gostkowska-drzewicka@ug.edu.pl (ORCID: https://orcid.org/0000-0002-4383-7711).
2 Julia Koralun-Bereźnicka, Ph.D., Assistant Professor, Department of Corporate Finance, Faculty of Management, University of Gdańsk, ul. Armii Krajowej 101, 81-824 Sopot, Poland, e-mail: julia.koralun-bereznicka@ug.edu.pl (ORCID: https://orcid.org/0000-0003-4498-0381).

Received 2 June 2024; Revised 27 December 2024; Accepted 7 January 2025.

INTRODUCTION

A company can survive in a competitive market only through continuous growth and development. Business growth is a quantitative phenomenon that involves expanding resources to scale operations, leading to an increase or maintenance of market share. In contrast, business development is qualitative and entails changes through the introduction of product, technological, and organizational innovations. Innovation is seen as a key factor in a company's success (Dash, 2023), as it provides a competitive advantage by implementing new and improved methods of operation. This involves the deliberate application of ideas, processes, products, or procedures that are new to the company, aiming to enhance its functioning (West, 2000). Górska-Warasewicz (2024) emphasizes that innovation leads to improved business performance. According to Li's (2024) research, innovation ability is an important factor in mitigating financial distress. The author proved that companies in financial distress that exhibit higher innovation ability tend to achieve better operational performance in the future. Drucker (1992) argues that innovations are a unique tool of entrepreneurship, enabling resources to create new wealth opportunities, primarily in the socio-economic sphere. Porter (1998) highlights that innovations are technological and represent better methods and ways of manufacturing. They can involve products, processes, new marketing approaches, and new distribution solutions.

The science sector plays a crucial role in the development of innovation. Therefore, an adequate research and development (R&D) base is an essential element of the environment for an innovation-oriented enterprise. R&D activities are defined as creative work undertaken systematically to increase knowledge resources and to create new applications for existing knowledge. These activities are always directed towards new discoveries based on original concepts and their interpretations. The goal of R&D activities is to achieve outcomes that can be commercialized (OECD, 2015). The specific role of R&D lies in creating unique knowledge that allows a company to gain a competitive advantage, ensuring its long-term development. Knowledge is an intangible resource, invisible and entirely dependent on the attitude and qualifications of the company's human capital (Skoczylas-Tworek, 2014). Entities for which knowledge forms the basis of their operations are called knowledge-based enterprises. These companies produce and sell goods and services developed through advanced technologies resulting from R&D work. Therefore, they convert scientific knowledge into new technology, which they then commercialize (Oakey et al., 1988).

Knowledge-based enterprises are a diverse group of entities, differing in internal aspects (e.g., strategy, organization, or market experience) and external aspects, such as operating in sectors with varying levels of technological development. A common characteristic of these entities is their high capital intensity (Giudici & Paleari, 2000; Coleman & Robb, 2012), stemming from a large share of R&D expenditures, a significant proportion of highly qualified employees often with research experience, and a focus on innovative products. This is reflected in the value of their intangible assets, which are the main source of value creation for knowledge-based firms (Martínez-Torres, 2014). Thus, knowledge is the foundation of their operations and can be seen as the most important strategic intangible resource of the enterprise and a source of competitive advantage (Sytnik & Kravchenko, 2021).

Knowledge-based entities primarily operate in sectors that require the use of advanced technological solutions. Transition into the knowledge economy manifests in the growing importance of intangible versus tangible assets (Rabinovich, 2023). Intangible assets have become a key factor in the operational efficiency of many enterprises. Moreover, the unprecedented improvement of new technologies is increasingly perceived as the source of future economic development and potentially a new engine to reverse the productivity slowdown observed in many OECD economies (Demmou et al., 2019). It is emphasized that knowledge-based enterprises are particularly important for peripheral regions and economies with marginal global significance. Socio-economic transformations occurring in emerging markets increase the importance of knowledge as a key resource for companies (Paredes-Chacín et al., 2024). This is particularly relevant as some of the countries analyzed in our study (i.e., Croatia, Hungary, and Slovakia) are classified as emerging markets. Moreover, through knowledge, companies can overcome market entry barriers and unfavorable competitive conditions faced by traditional businesses, such as those producing basic consumer goods or engaged in construction (Gorman et al., 2005).

However, knowledge-based firms cannot be identified solely with areas of the economy related to advanced technologies. Defining these entities clearly is thus challenging. These firms can be categorized as those that utilize unique, innovative, and technologically advanced solutions developed through higher-than-average R&D investments in their sector (Chapple et al., 2004). According to another definition, they are companies that incur above-average R&D expenditures in their country and have a higher proportion of scientific and technical staff in their employment structure

compared to other firms (Neville & Lucey, 2022). Additionally, a characteristic feature of knowledge-based enterprises is the rapid diffusion of innovations and high investment risk. The previously mentioned high capital intensity in this sector is directly related to investment risk, necessitating the acquisition of substantial financial resources. This issue is particularly challenging for knowledge-based start-ups. Innovation advancements and digital technologies strongly influence changes in firms' strategic choices, so there is a need to reconsider factors influencing corporate financing decisions, especially in high-tech sectors (Dobusch & Kapeller, 2018). Therefore, it can be concluded that the capital structure of knowledge-based enterprises is unique due to the nature of their activities.

Butzbach and Sarno (2019) conclude that a firm's capital structure preferences vary with its life cycle, which determines the availability of financial resources and the cost of capital. Newly established knowledge-based enterprises, like other firms in the early stages of their life cycle, face significant challenges in accessing financing. Capital raised through public offerings is practically unattainable for such entities because it requires an established history and adequate financial stability. Moreover, younger firms are less well-known than their older and more experienced competitors (Faulkender & Petersen, 2006). Even older knowledge-based firms can struggle to secure debt financing, both in the form of bank loans and bond issuance, due to the low proportion of tangible assets in their asset structure. These financial constraints prevent such firms from fully leveraging their potential to undertake innovative investments (He & Tian, 2018). As previously mentioned, innovative enterprises possess significant intangible assets, which can offer substantial future development opportunities. However, these assets are not effective as debt collateral because their unique nature makes them difficult to value and sell for use in another company (Revest & Sapio, 2012).

On the one hand, the prevailing view in the literature is that knowledge-based enterprises, especially high-tech firms, may have difficulties obtaining debt financing, whether in the form of bank loans or bond issuance (Colombo & Grilli, 2007). For this reason, innovative firms are more dependent on equity than debt financing (Falato et al., 2018). On the other hand, research by Gorman et al. (2005) indicates that the procedures used by lenders to assess knowledge-based firms do not differ significantly from those used for traditional companies. Also, Brown and Lee (2019) challenged the assumption that innovative firms have problems with credit access. Based on the survey of 8000 UK SMEs in the period following the financial crisis of 2008, they concluded that there is no difference in access to external finance for knowledge-based SMEs and other companies.

The literature includes numerous studies on the capital structure of knowledge-based enterprises. These studies cover various countries and present diverse approaches to the capital structure of entities in knowledge-intensive sectors. A significant portion of these analyses focuses on firms in the USA (e.g., Yang, 2022; Habibniya et al., 2022; Na, 2021). Other studies examine the capital structure of knowledge-based firms in specific countries such as Japan (Che-Yahya et al., 2022) and Ireland (Neville & Lucey, 2022). Only a few analyses address the financing patterns of innovative enterprises across multiple countries (e.g., Castro et al., 2015). Additionally, available studies often pertain to relatively distant research periods. For this reason, these studies overlook recent economic developments, particularly in the area of finance, which may significantly affect the capital structure of knowledge-based enterprises.

Research gaps are evident not only in the limited geographical or subjective scope of previous studies but also in the context of the analyzed capital structure factors and their connections with knowledge-based activities. Most studies focus on specific factors, presenting a narrow approach to understanding the determinants of capital structure. For instance, Yang (2022) examines the impact of commercial property ownership in the U.S. office market on the capital structure of telecommunications companies during an economic downturn. Similarly, Na (2021) analyzes the influence of an innovative firm's proprietary information on its debt financing preferences. Duan (2023) investigates how the threat posed by Non-Practicing Entities (NPEs), colloquially known as patent trolls, affects capital structure decisions in high-tech firms. In contrast, Thakor and Lo (2022) explore the interaction between product market competition, R&D investment, and the financing choices of R&D-intensive firms in the development of innovative products.

Thus, there is a lack of comprehensive studies on comparative analyses of capital structure factors in knowledge-based firms and entities from other traditional sectors on an international scale. First, the research gap involves determining whether significant differences exist in the capital structure of knowledge-based enterprises compared to other entities in selected European Union countries. To the best of our knowledge, the only research that presents the capital structure of both groups of enterprises in a larger group of countries in a cross-sectional way was conducted by Castro et al. (2015). However, this analysis covers a relatively distant period, i.e. 2000-2012, and focuses only on highly developed countries in Western Europe.

Second, it is relevant to identify and compare the impact of capital structure factors on firms in both groups. As previously mentioned, most of the available research adopts a narrow approach, focusing on only a limited set of factors. Only a few studies analyse a broader set of variables (e.g., Castro et al., 2015; Serrasqueiroa et al., 2016; Grabińska et al., 2021; Spitsin et al., 2022; Kim & Pukthuanthong-Le, 2008). Third, the research period covers the most recent available data, i.e., 2000–2023.

Consequently, the aim of this study is to identify and compare the financing patterns in sectors containing knowledge-based enterprises and traditional sectors in selected EU countries over the period 2000–2023. This paper aims to identify sector-specific characteristics by examining the distinct financial behaviors of knowledge-intensive enterprises in comparison to traditional firms. It investigates the impact of factors such as asset structure, profitability, and growth opportunities on capital structure decisions within these industries, offering insights into financial management in innovation-focused sectors.

This article contributes to the literature on capital structure and innovative entrepreneurship. First, it verifies the hypothesis regarding the specificity of capital structure and its determinants in knowledge-based enterprises. Second, it tests the hypothesis on the differing impact of capital structure factors on the debt levels of knowledge-based firms versus traditional businesses. Consequently, it provides evidence of the relationship between the unique nature of knowledge-based enterprises and their capital structure.

The structure of the article is as follows. First, a literature review is presented, consisting of a description of the theoretical foundations of capital structure formation and a review of empirical studies on the financing patterns of knowledge-based firms. Based on this review, research hypotheses are formulated. The methodology section describes the data scope and the research procedure based on panel models. Next, the research results are presented along with a discussion of the obtained findings. The article concludes with a summary that includes practical and theoretical implications, research limitations, and suggested directions for future research.

LITERATURE REVIEW

Theoretical background

Two opposing approaches dominate capital structure theories: the trade-off theory and the pecking order theory. These theories provide a foundational lens for understanding the financing behaviors of firms, including those in knowledge-intensive industries. According to the trade-off theory, firms shape their capital structure by balancing the costs and benefits of debt (Rajan & Zingales, 1995). The starting point for this theory is taxation (Modigliani & Miller, 1963; Fama & French, 1998) and bankruptcy costs (Opler & Titman, 1994). Tax savings from debt financing are associated with the use of the tax shield, which increases after-tax profits. However, when a company defaults on its obligations and faces financial difficulties, it leads to increased bankruptcy risk and associated costs. Therefore, capital structure should be a compromise between the current tax benefits of increased debt and the costs of higher financial leverage. This allows for the determination of an optimal capital structure, which is a specific combination of debt and equity (Myers, 1977). This optimal structure varies across industries due to differences in technological requirements, asset structures, and creditor trust, as reflected in the sector-specific average debt levels.

Individual sectors exhibit different financing patterns, which can be explained by trade-off theory, as firms strive to achieve the optimal capital structure mentioned above. This optimal level is assumed to be the average debt ratio or the median financial leverage for a given sector, reflecting the sector's conditions. The tendency of firms within the same sector to have similar capital structures results from their capital needs, determined by the technologies they use, asset structure, type of activity, and the trust of creditors, which in turn affects credit availability. Therefore, the median debt level in a sector is a measure of financial risk. Furthermore, empirical research indicates that being part of a sector with a higher average debt ratio is associated with a greater debt share in the capital structure of individual enterprises (Jõeveer, 2013).

The second theory is based on the information asymmetry between corporate insiders and external investors (Myers & Majluf, 1984; Myers, 1984). Castro et al. (2015) and Taglialatela and Mina (2024) demonstrated that information asymmetry is the most significant factor limiting debt in knowledge-based firms. The pecking order theory explains firms' preferences regarding the use of different financing sources. The order is as follows: first, internal sources such as retained earnings and cash surpluses along with short-term financial assets are used. After these are exhausted, firms turn to external sources. Initially, they use bank loans and borrowings, then decide to issue bonds, and only as a last resort,

issue equity. The literature emphasizes that the age of the firm plays a significant role in shaping the capital structure of knowledge-based firms. The aforementioned order of financing sources is mainly characteristic of older entities that can generate adequate internal resources and, therefore, have lower levels of debt (López-Gracia & Sogorb-Mira, 2008; Castro et al., 2015). In contrast, the hierarchy of financing sources for innovative enterprises at early development stages is usually different. Entities focused on R&D and possessing highly qualified staff tend to rely less on debt after exhausting internal funds and instead rely more on equity financing through share issuance. This means these firms follow a modified pecking order theory (Minola et al., 2013; Serrasqueiroa et al., 2016; Cosh et al., 2009). According to this concept, after internal funds are exhausted, firms issue equity to obtain capital due to the limited availability of debt.

Knowledge-based firms face unique challenges that complicate their capital structure decisions. These firms typically rely heavily on intangible assets, such as intellectual property and R&D outputs, which are difficult to use as collateral. Consequently, traditional debt financing is less accessible to them (Revest & Sapio, 2012). High R&D intensity, particularly in the early stages, exacerbates information asymmetry and financial distress risks (Hall, 2002), further limiting their ability to secure debt financing. As a result, knowledge-intensive firms often turn to equity issuance despite its high cost and potential signaling concerns for shareholders (Myers & Majluf, 1984; Ross, 1977).

Empirical studies on the capital structure of knowledge-based firms and hypotheses development

Firms within a given sector face not only financial risk but also industry-specific risk. This risk is related to the intensity of competition within the sector, the flexibility and variability of demand, production characteristics—particularly capital intensity—and the diversity of product assortment. The combined impact of these factors influences the volatility of operating results for firms within that sector. Furthermore, higher industry-specific risk decreases firms' propensity to incur debt and undermines creditor confidence (Palazzo, 2019).

Most available studies emphasize that knowledge-based firms are characterized by high capital intensity, particularly in the early stages of their life cycle. The primary sources of this capital intensity are investments in research and development (R&D) and marketing, which are essential components of any innovative project and require substantial financing. Consequently, these entities must seek large amounts of financial resources, both equity and debt. However, the capital structure of knowledge-based enterprises is not homogeneous. The demand for financial resources from various sources is primarily influenced by specific characteristics of knowledge-based entities, especially the high proportion of intangible assets and significant R&D expenditures (Hogan & Hutson, 2005; Hyytinen & Pajarinen, 2005).

Knowledge-based enterprises may have difficulty obtaining debt financing, both in the form of bank loans and bond issuance, due to the low proportion of tangible assets in their asset structure (Colombo & Grilli, 2007). As previously mentioned, these firms possess significant intangible assets. However, these assets are not effective collateral for debt because their unique nature makes them difficult to sell for use in another company (Revest & Sapio, 2012; Brierley, 2001). Moreover, firms with substantial intangible assets exhibit higher levels of information asymmetry (Hogan & Hutson, 2005), stemming from the difficulty in valuing these assets, creating an additional barrier to obtaining debt financing (Harris & Raviv, 1991). This effect is further confirmed by the negative impact of intangible assets and growth opportunities on financial leverage, which leads to reduced debt levels (Castro et al., 2015). However, as shown by Taglialatela and Mina (2024), the type and order of financing sources depend on the degree of information asymmetry associated with R&D activities, capital equipment, and the introduction of new products and processes specific to each firm. Furthermore, high R&D intensity, especially in early-stage firms, signals significant future growth potential, which is associated with high risk and increased expected financial distress costs (Hall, 2002). This significantly limits access to credit, as banks are reluctant to finance such firms. Consequently, high R&D expenditures lead to lower financial leverage.

High fixed costs associated with the salaries of highly skilled scientific and technical staff, along with other R&D expenditures, represent a significant financial burden for knowledge-based firms. As previously mentioned, due to difficulties in obtaining debt and the depletion of internal funds, these firms often resort to issuing equity. According to signaling theory, such actions are negatively perceived by existing shareholders as they indicate financial difficulties (Myers & Majluf, 1984). In such situations, firms incurring losses attempt to attract new shareholders (Ross, 1977). This action aims to reduce the burden of these losses on current shareholders. Moreover, issuing equity is viewed negatively due to the additional costs associated with the issuance. Therefore, it is assumed that an increase in equity capital through share issuance signals a future decline in the firm's value.

For these reasons, the pecking order theory assumes that entities with substantial intangible assets are less leveraged than other enterprises. Similarly, according to the trade-off theory, firms with significant intangible assets exhibit lower debt

levels (Rajan & Zingales, 1995). These assets are more likely to lose value when the firm's financial situation deteriorates, thus increasing expected bankruptcy costs (Myers, 1984).

On the other hand, the pecking order theory can explain the opposite relationship between capital structure and intangible assets in knowledge-based enterprises. The significant financial needs of these firms and the information asymmetry associated with their intangible assets increase the cost of equity capital from share issuance (Frank & Goyal, 2009). Consequently, this leads to higher financial leverage, as these entities will prefer cheaper debt capital. Moreover, substantial intangible assets may provide future development opportunities associated with a competitive advantage based on knowledge (Sytnik & Kravchenko, 2021). Neville and Lucey (2022) documented the positive impact of intangible assets on the value of a firm's generated income, which can serve as an additional incentive for creditors. Research by Gorman et al. (2005) indicates that the procedures used by creditors to assess knowledge-based firms and traditional firms do not differ significantly, further confirming the positive relationship between intangible assets and debt. Additionally, Na (2021) demonstrated that the primary factor determining the choice of financing sources in innovative American firms is their patents. These firms have specific debt preferences, initially opting for public debt, followed by private placements and bank loans. However, as these entities become more competitive, their financing patterns begin to reverse.

In practice, a knowledge-based enterprise may possess not only a significant proportion of intangible assets but also valuable tangible assets that can be used as debt collateral. Yang (2022) showed that American telecommunications firms with substantial commercial real estate assets have higher debt levels. His research indicates that this relationship was particularly significant during the economic recession, where real estate, used as collateral, significantly expanded financing opportunities. According to Habibniya et al. (2022), American telecommunications firms exhibit exceptionally high debt ratios.

Knowledge-based firms are under constant pressure for continuous development throughout their life cycle. As their fundamental resource, knowledge is continuously accumulated by these entities. However, due to technological obsolescence, these firms must periodically invest in renewing their assets. Therefore, knowledge-based enterprises, whose products have short life cycles and are accepted by the market, exhibit high growth rates throughout their life cycle (Kazanjian, 1988). If a firm fails to renew its technologies, its growth rate would drop to the market's average growth rate, leading to maturity and eventual elimination by competitors. According to the trade-off theory, firm age promotes higher leverage because older firms have better market reputations. In contrast, the pecking order theory explains the opposite relationship. Older firms show higher profitability due to their ability to generate and accumulate more profits (Frank & Goyal, 2009). However, due to the need for continuous development and significant growth potential, knowledge-based firms are compelled to seek additional financing sources to cover technological renewal costs, as internal funds may be insufficient. Consequently, this leads to increased financial leverage.

The aforementioned characteristics of knowledge-based firms affect all areas of their operations. Therefore, it is assumed that the capital structure of these firms, as well as its determinants, are primarily shaped by the sector effect.

The trade-off theory explains the lower debt levels in knowledge-based firms by highlighting the heightened bankruptcy costs associated with intangible assets, which tend to lose value quickly in financial distress (Myers, 1984). Meanwhile, the pecking order theory offers a contrasting perspective, suggesting that the high financial needs and growth potential of such firms may lead to greater reliance on debt, despite their intangible-heavy balance sheets. For instance, intangible assets can generate future growth opportunities and income streams, incentivizing creditors to extend financing (Neville & Lucey, 2022).

Drawing from the above theoretical insights, the capital structure of knowledge-intensive firms is expected to differ significantly from that of firms in other industries due to their reliance on intangible assets, high R&D expenditures, and sector-specific risks. Moreover, the determinants of capital structure, such as growth potential and asset structure, likely influence these firms differently. These theoretical arguments form the basis for the following research hypotheses:

H1: The capital structure metrics and their firm-specific determinants are significantly different in knowledge-based firms than in firms from other industries.
H2: The impact of capital structure determinants in knowledge-based firms varies from that in other industries.

METHODOLOGY

Data characteristics

The data used for the empirical section of this study originates from the BACH database (BACH, 2023), which offers standardized annual financial statistics for non-financial companies across twelve EU nations: Austria (AT), Belgium (BE), Germany (DE), Spain (ES), France (FR), Croatia (HR), Hungary (HU), Italy (IT), Luxembourg (LU), Poland (PL), Portugal (PT), and Slovakia (SK). These countries not only belong to different geographical regions but also exhibit varying levels of economic and innovation development, as shown in Figure 1(EUROSTAT, 2024).

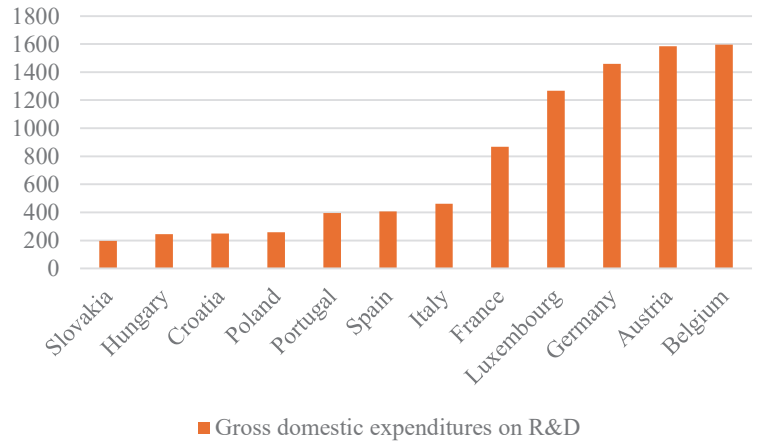

Figure 1. Gross domestic expenditures to the GDP in selected European countries in 2022 (Euro per inhabitant)

In 2022, the highest gross domestic expenditures on R&D among the selected European countries were recorded in Belgium and Austria, with these countries allocating €1,585.5 and €1,597 per capita, respectively. It is remarkable that, among the remaining countries, only Western European nations were included in the group with high intramural R&D expenditures.

Within the analyzed group, Poland, Slovakia, Croatia, and Hungary spent less than €500 per capita on gross domestic R&D expenditures. This group also includes countries that underwent economic and political transformation in the 1990s, as well as those located in Southern Europe. Interestingly, this situation applies even to Italy, which, despite ranking among the world's wealthiest countries, exhibits relatively low R&D spending.

Poland presents a particularly unique case. In 2018, Poland became the first Central and Eastern European (CEE) economy to be promoted by FTSE Russell's index provider from Emerging Market to Developed Market status (https://emerging-europe.com/analysis/poland-promoted-to-developed-market-status-by-ftse-russell/). This promotion places Poland among the 25 most advanced global economies. However, as Eurostat data demonstrate, Poland remains one of the EU countries with the lowest levels of intramural R&D expenditures, reflecting a disconnect between its economic classification and its R&D investment levels , as shown in Figure 1.

In highly developed economies such as Austria, Belgium, France, Germany, and Luxembourg, most of the financial resources for R&D activities are provided by enterprises. It is important to emphasize that the value of these expenditures is significantly higher than those incurred by government institutions. As shown in Figure 2, this pattern is characteristic of Western European countries.

In contrast, countries that underwent economic and political transformation in the 1990s, as well as those classified as Southern European countries, exhibit similar trends regarding the relationship between R&D expenditures by enterprises and those by government institutions. However, in most of these cases, corporate expenditures remain very low, typically below €300 per capita, as illustrated in Figure 2 (EUROSTAT, 2024).

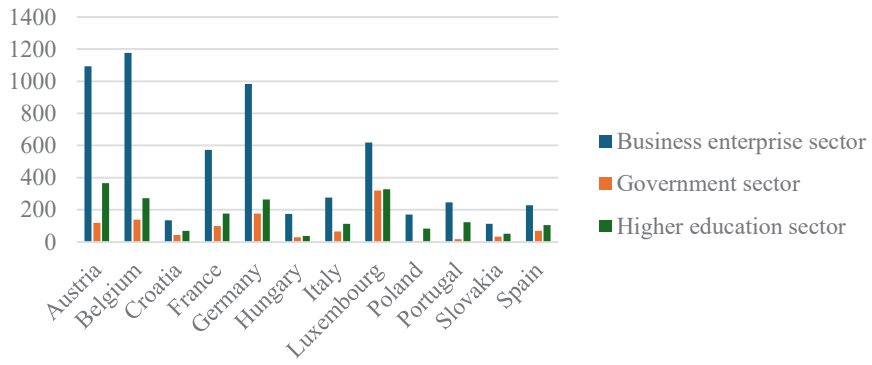

Figure 2. The value of intramural R&D expenditures in selected European countries in 2022, in a sectoral approach (Euro per inhabitant)

The BACH database, published by the European Committee of Central Balance Sheet Data Offices (ECCBSO), compiles aggregated data, including balance sheets, income statements, cash flow statements, and other financial metrics, alongside information regarding company size and sector classification. The database classifies companies according to the NACE system into 18 sectors listed in Table 1. The selection of countries was determined by the availability of data in the BACH database at the time of retrieval. All countries with comprehensive and consistent financial records within the database were included, ensuring the representativeness of the sample across the EU. However, this reliance on database coverage introduces potential limitations: not all EU countries were included, and the sample may not fully capture the diversity of economic or industrial conditions within the region. This limitation is acknowledged, and future research could benefit from expanding the scope to include additional countries and datasets.

Although this study provides insights into the financial strategies of knowledge-based firms, it also acknowledges the heterogeneity in the economic, institutional, and industrial development of the selected EU countries. The surveyed countries represent diverse levels of industrial advancement and economic conditions, which influence the operational environment for knowledge-based firms. However, the analysis does not focus explicitly on the broader conditions for the development of knowledge-based firms, such as national innovation systems or policy frameworks. Future research could address this limitation by integrating additional contextual variables reflecting the industrial and institutional structure of the surveyed countries.

Table 1. Classification of sectors according to the NACE system in the BACH database

NACE code	Sector description
A	Agriculture, forestry and fishing
B	Mining and quarrying
C	Manufacturing
D	Electricity, gas, steam and air conditioning supply water
E	Water supply, sewerage, waste management and remediation activities
F	Construction
G	Wholesale and retail trade, repair of motor vehicles and motorcycles
H	Transportation and storage
I	Accommodation and food service activities
J	Information and communication
K	Financial and insurance activities
L	Real estate activities
M	Professional, scientific and technical activities
N	Administrative and support service activities
P	Education
Q	Human health and social work services
R	Arts, entertainment and recreation
S	Other service activities

The analysis in this study covers all industrial sections available in the database, excluding the financial sector (K). The industries were categorized into two groups:

1) Companies from sections **J – Information and Communication** and **M – Professional, Scientific, and Technical Activities**.
2) The remaining industries in 12 countries and 3 size classes (small, medium, and large) during the period from 2000 to 2022.

The aim of this categorization was to extract companies involved in modern technologies and knowledge-based firms. While knowledge-based firms may be found across various sectors, the concentration of such enterprises is particularly strong within sectors **J** and **M** due to the nature of their activities, which focus on innovation, intellectual capabilities, and technological advancement. These two sectors house firms that heavily rely on intangible assets, advanced expertise, and innovative business models. Therefore, these sectors are essential for analyzing the financial behavior of knowledge-based firms due to their reliance on intellectual property, R&D, and intangible assets. By isolating these sectors, this study captures the specific financial features of innovation-driven industries.

The key sectors where enterprises operating in the field of modern technologies can be identified include:

- **Sector J – Information and Communication**: This sector covers a wide range of activities related to IT, telecommunications, programming, information services, and digital media. Companies in this sector are involved in the development, implementation, and maintenance of information and communication technologies, which include software, computer hardware, telecommunications, the internet, and digital services;
- **Sector M – Professional, Scientific, and Technical Activities**: This sector includes enterprises engaged in research and development (R&D) in the fields of technical sciences, engineering, biotechnology, nanotechnology, and other areas that can be considered technologically advanced. This sector also includes consulting and engineering services related to the implementation of new technologies.

While knowledge-based firms may be found across various sectors, it is most likely that the majority of them will be concentrated within sectors M and J. These two sectors are particularly significant in this regard as they encompass activities closely associated with innovation, scientific and technical expertise, and advanced information services. In other words, sectors M and J are most likely to house the majority of firms that are heavily reliant on intellectual capabilities and technological advancements. This concentration can be attributed to the nature of the activities within these sectors, which are integral to the development, application, and dissemination of knowledge. Table 2 provides a structured overview of the specific activities and functions within sectors M and J according to the NACE classification.

Table 2. Subsectors and activities in Sectors M and J according to NACE Classification

Sector M Subsectors	Activities in Sector M	Sector J Subsectors	Activities in Sector M
Legal, accounting, and tax consultancy activities	Legal services, accounting, bookkeeping, tax consultancy and auditing	Publishing	Includes the publication of books, magazines, newspapers, as well as digital and electronic publications. This area also encompasses the publishing of computer games.
Management and consultancy services	Business and management consulting, including strategic and organizational advice for companies	Production of films, video recordings, and television programs, recording of sound and music publishing	Includes the production of cinema films, television series, live television programs, as well as the production of music and audiobooks.
Architectural and engineering activities; technical testing and analysis	Services related to architectural and engineering design, as well as research and analysis in the field of engineering	Broadcasting	Includes broadcasting radio and television programs, over the internet, and other forms of digital distribution. Can occur at both public and private levels.
Scientific research and development	Activities related to conducting scientific research and developmental work in various fields of knowledge	Telecommunications	Involves providing telecommunication services, such as fixed-line and mobile telephony, internet access, and the transmission of data and communication in text, voice, image, or video forms.
Advertising and market research	Advertising and marketing services, including market and public opinion research	Programming and broadcasting	Refers to creating software and computer systems, including applications, databases, operating systems, and network systems.
Other specialised professional activities	Includes a wide range of specialised professional services not listed in other categories, such as photography, translations, and consultancy in specific fields	Information services	Includes services such as data processing, hosting, internet portals, the operation of internet search engines, and other services related to delivering information over the internet.

This concentration of knowledge-based firms within sectors M and J is a fundamental reason for analyzing their capital structure separately and comparing or contrasting it with the financing strategies of other industries. The distinct nature of these sectors, driven by intellectual property, innovation, and technology, often leads to unique financial needs and risk profiles that differ considerably from more traditional industries.

Knowledge-based firms, such as those involved in scientific research, technology development, and high-level consultancy, often invest heavily in R&D and rely on securing intellectual property rights. These factors necessitate a capital structure that can support long-term investment and tolerate periods of significant cash burn without immediate financial returns. Moreover, these companies may face greater volatility and uncertainty in their revenue streams, influencing their approaches to leverage and liquidity management.

In contrast, industries with more tangible assets and predictable cash flows, such as manufacturing or retail, might utilize more traditional financing strategies, often with higher levels of debt financing supported by their physical assets as collateral. Therefore, understanding the distinct capital structures in sectors M and J not only highlights the specific financial strategies needed to support innovation-driven business models but also helps in benchmarking and drawing contrasts with other sectors.

The specificity of these sectors in terms of both financing patterns as well as the proportion of intangible assets is visualised in Figure 3.

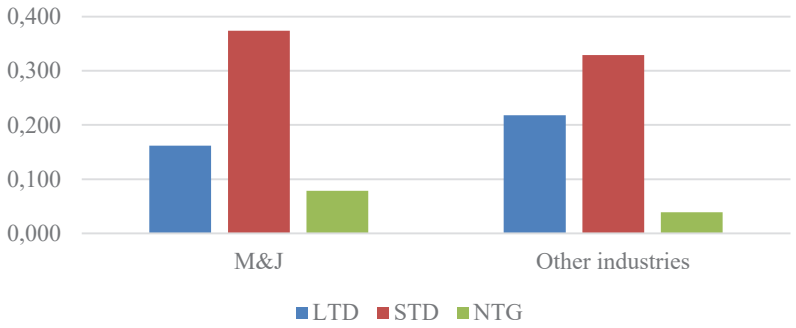

Figure 3. Capital structure ratios and the share of intangible assets in sectors M&J and other industries

Figure 3 illustrates a significant difference in the ratio of intangible assets (NTG) between the sectors M and J and other industries, with the two sectors registering a nearly double share of intangible assets compared to other industries. This suggests a pronounced focus on intangible assets such as patents, trademarks, or goodwill, which can be a reflection of a more innovative or intellectual property-driven business model. This emphasis on intangibles could indicate that the two sectors are leveraging unique business competencies or innovative products that are not as prevalent in other industries. Such a strategy might offer competitive advantages in markets where intellectual property and brand value play crucial roles in business success.

As for the debt ratios, sectors M and J exhibit a lower long-term debt ratio compared to other industries, suggesting a more conservative approach to long-term financial commitments or a reduced necessity for heavy capital investments. Conversely, it shows a higher short-term debt ratio, indicating a reliance on short-term borrowing to possibly capitalize on immediate opportunities, manage cash flows, or cover operational costs without long-term financial entanglements. These strategies reflect a focus on maintaining liquidity and flexibility, which is crucial for rapidly changing industries or those heavily investing in innovation and intangible assets.

The analyzed data is structured in three dimensions: 12 countries, 3 firm-size classes, and 23 years, with the most recent year being 2022 due to data release delays. Several dependent and explanatory variables are computed for each data point across these dimensions, as detailed in Table 3.

The set of variables used in the analysis aligns with other research in the field of finance and corporate structure, particularly in studies focusing on knowledge-based firms and innovation-driven industries. Debt ratios (total, long-term, and short-term) are standard measures in financial analysis utilized across many studies to assess leverage and financial stability, as seen in research by Rajan and Zingales (1995) and Faulkender and Petersen (2006), which analyze these ratios to discuss capital structure theories.

Asset ratios (asset fixity and intangible asset ratio) are also important for understanding the composition of assets in firms, particularly the proportion of intangible assets in knowledge-based industries, a topic explored in studies such as Erickson and Rothberg (2019). Additionally, depreciation to sales and effective tax rate metrics commonly evaluate operational efficiency and tax planning strategies. Importantly, depreciation acts as a non-debt tax shield, offering firms a way to reduce taxable income without increasing debt. Fama and French (1998) provide insights into how such tax strategies, including depreciation, influence financial decisions.

Table 3. Definition of variables employed

Variable character		Symbol	Ratio or dummy	Formula or specification
Dependent variables		TTD	Total debt ratio	Liabilities / Assets
		LTD	Long-term debt ratio	Non-current liabilities / Assets
		STD	Short-term debt ratio	Current liabilities / Assets
Explanatory variables	Firm specific variables	FXA	Asset fixity ratio	Fixed assets / Assets
		NTG	Intangible asset ratio	Nontangible assets / Assets
		DPR	Depreciation to sales ratio	Depreciation and amortization / Net turnover
		TAX	Effective tax rate	Tax on profit / Net turnover
		LCR	Liquidity current ratio	Current assets / Total assets
		AVR	Assets variability	Assets annual variation rate
		ROA	Return on assets	Net operating profit / Total assets
		SGR	Sales growth	Net turnover annual growth rate
		STF	Labor cost ratio	Staff costs / Gross value added
	Dummy variables	SIZE	Firm size dummy variables	SM, ME, LA
		CT	Country dummy variables	AT, BE, DE, ES, FR, HR, HU, IT, LU, PL, PT, SK
		IND	Industry dummy variables	A, B, C, D, E, F, G, H, I, J, L, M, N, P, Q, R, S
		YEAR	Dummy variables for years	2000–2023

Liquidity ratios (current ratio and assets variability) are crucial for liquidity management in sectors where cash flows may be unpredictable, such as technology and R&D intensive industries, aligning with studies by Myers and Majluf (1984) that discuss liquidity preferences under conditions of information asymmetry. Profitability and growth metrics are key indicators of operational effectiveness and market performance, widely examined in the literature on corporate growth and sustainability, including works by He and Tian (2018) and Yang (2022), which discuss the impact of financial strategies on growth.

Lastly, the labor cost ratio is particularly relevant for industries where human capital is a significant operational cost, with studies like Sytnik and Kravchenko (2021) exploring the relationship between labor costs and value added in knowledge-intensive firms.

Including dummy variables for firm size, country, industry, and years in the analysis (as detailed in Table 2) is aimed at controlling variability and isolating the effects of specific factors. Firm size dummies allow for assessment of financial strategies influenced by operational scale. Country dummies account for economic, regulatory, and cultural variations affecting financial metrics across regions. Industry dummies enable differentiation based on sector-specific dynamics such as capital intensity and regulatory environment. Finally, year dummies adjust for time-specific economic conditions and trends, providing a temporal context to the financial data, and enhancing the relevance of the analysis by accounting for external influences over the period from 2000 to 2023.

Methods

The methods employed in the empirical section of the study align with the primary objective, which is to investigate whether the capital structure and the factors influencing financing choices in knowledge-based firms differ from those in other sectors.

To test the first research hypothesis (H1), which posits that capital structure metrics and their firm-specific determinants differ significantly between knowledge-based firms and those from other industries, a one-way analysis of variance was conducted using industrial classification as the grouping factor, distinguishing knowledge-based firms (sectors M or J) from others.

The second hypothesis (H2), states that the impact of capital structure determinants differs between knowledge-based firms and other industries, was verified through panel data regression results conducted separately for the two groups: industries M and J versus other industries.

The model is defined by the formula (1):

$$D_{cist} = \beta_0 + \beta_1 FXA_{cist} + \beta_2 NTG_{cist} + \beta_3 DPR_{cist} + \beta_4 TAX_{cist} + \beta_5 LCR_{cist} + \\ + \beta_6 AVR_{cist} + + \beta_7 ROA_{cist} + \beta_8 SGR_{cist} + \beta_9 STF_{cist} + \gamma_s SIZE + \alpha_c CT + \\ \delta_i IND + + \rho_t YEAR + \xi_{cst}, \quad (1)$$

where:
D_{cist} – one of the three debt measures (TTD, LTD, STD) in firm size *s,* country *c*, industry *i* in year *t,*
β, γ, α, δ, ρ – coefficients,
ξ – random factor,
other variables as specified in Table 3.

The panel data model assumes consistency in financial reporting standards across countries, which is critical given the multi-country scope. While the BACH database adheres to standardized financial metrics, variations in the implementation or interpretation of accounting standards could influence results. Additionally, the stationarity of variables was assumed for the econometric analysis. Although these assumptions align with established methodologies, potential deviations could impact the robustness of the findings. Future extensions of this research may involve robustness checks or adjustments for non-stationary variables.

It should be noted that in the case of estimations for sectors M and J, industry dummies were included only for these two industries. For other industries, the remaining industry dummies were included accordingly.

First, the model was estimated using pooled OLS for the two groups of industries separately with different dependent variables representing various debt maturities, excluding dummy variables. After removing insignificant variables, panel specification tests determined the most suitable model for explaining the dependent variable. The Wald F test assessed the suitability of the pooled model by examining the joint significance of group means. Rejection of the null hypothesis indicated that the fixed effects (FE) model was more appropriate. The Breusch-Pagan test compared the pooled model to the random-effects (RE) model, with the null hypothesis favoring the pooled model and the alternative suggesting the RE model. The Hausman test then compared the RE and FE models, where the null hypothesis indicated the RE model was consistent and efficient, while the alternative suggested the FE model was both consistent and efficient (Tsionas, 2019).

In most cases, the FE model was found to be appropriate. The model was then re-estimated with all dummy variables, and the Wald test verified the joint significance of each group of dummy variables (country, industry, size, and year). If the RE model was indicated as appropriate by the panel specification tests, interpretations were based on the RE model. The results of this analysis are detailed in the following section.

RESULTS AND DISCUSSION

The aim of the article was to identify and compare financing patterns in sectors comprising knowledge-based enterprises and traditional sectors, as well as the determinants of financial decisions made by both groups of entities in selected European Union countries from 2000 to 2023. The study attempted to explain the financial decisions of both groups of enterprises based on two opposing concepts, namely the trade-off theory (Modigliani & Miller, 1963; Fama & French, 1998; Rajan & Zingales, 1995; Opler & Titman, 1994) and the pecking order theory (Myers & Majluf, 1984; Myers, 1984). The influence of capital structure factors was analyzed in the context of the specific characteristics of knowledge-based enterprises, namely capital intensity and the high proportion of intangible assets (Coleman & Robb, 2012; Hogan & Hutson, 2005; Hyytinen & Pajarinen, 2005).

The empirical analysis aimed to investigate the capital structure and the factors influencing financing choices in knowledge-based firms compared to traditional industries. The analysis was conducted using a one-way analysis of variance (ANOVA) and panel data regression, with separate evaluations for knowledge-based sectors (M and J) and other industries.

Table 4 presents the one-way ANOVA results, where the grouping factor is the classification of sectors as knowledge-intensive or traditional. The debt metrics and firm-specific variables are analyzed to determine if there are significant differences between these two groups. The F-statistics and p-values are reported, with significant values indicating notable differences in capital structure metrics and determinants between knowledge-based and traditional firms. However, no significant cross-industry differences were observed in terms of total debt ratio (TTD), tax burden (TAX), and sales variability (SVR).

Table 4. One-way ANOVA results with the grouping factor as the classification of sector as knowledge-intensive or traditional

Statistic	Debt metrics						Firm-specific variables					
	TTD	LTD	STD	FXA	NTG	DPR	TAX	LCR	ASG	ROA	SVR	STF
F	3.3	**222.1**	**115.9**	**507.5**	**347.0**	**13.2**	1.5	**6.8**	**21.5**	**29.8**	0.0	**11.9**
p	0.068	0.000	0.000	0.000	0.000	0.000	0.223	0.009	0.000	0.000	0.900	0.001

Note: The values of F statistics were **bolded** for p<0.1.

Table 5 shows the estimation results of panel regressions specifically for knowledge-intensive sectors (M and J), whereas Table 6 provides the estimation results of panel regressions for other sectors, excluding knowledge-intensive ones. The results reveal how different factors influence the capital structure of companies in knowledge-based sectors compared to traditional industries. The joint significance tests, Breusch-Pagan tests, and Hausman tests are included to ensure the robustness and validity of the models used.

Table 5. Estimation results of panel regressions for knowledge-intensive sectors (M and J)

	TTD		LTD		STD[1]	
Variable	Estimate	Std. error	Estimate	Std. error	Estimate	Std. error
const.	0.120***	0.120	0.167**	0.068	0.987***	0.060
FXA	0.078***	0.078	0.317***	0.078	-0.606***	0.074
NTG	0.175***	0.175	0.742***	0.155		
DPR			-0.591*	0.352		
TAX					0.386***	0.073
LCR	0.039***	0.039			-0.136***	0.038
AVR	0.017**	0.017				
ROA	0.216***	0.216	-0.764**	0.301		
SGR			0.000***	0.000	-0.000*	0.000
STF			-0.086**	0.042		
SIZE[2]	No		ME***, LA***		LA*	
CT[3]	BE***, HU***, DE***, ES***, FR***, HR***, IT***, PL***, PT***		BE***, HU***, DE**, ES***, IT***, PL***		BE***, HU***, DE***, ES***, FR***, HR***, IT***, LU***, PL***	
IND[4]	M***		M**		No	
YEAR[5]	2004***, 2005***, 2015*, 2016**		2004**, 2013*, 2014**		2011*, 2015**, 2016**, 2017*, 2018*, 2019*, 2020**, 2021**, 2022*	
No. obs.	401		403		403	
R^2	0.696		0.678		n/a	
AIC	-948.4		-1025.3		-1430.9	
Panel specification tests						
Joint sign. of diff. group means	F(48, 333) = 8.8 (0.000)		F(49, 335) = 8.3 (0.000)		F(11, 195) = 7.6 (0.000)	
Breusch-Pagan	LM = 304.2 (0.000)		LM = 373.3 (0.000)		LM = 32.2 (0.000)	
Hausman test	H = 16.3 (0.038)		H = 14.1 (0.079)		H = 3.9 (0.410)	
Joint significance robust F test						
Size	n/a		8.7 (0.000)		1.6 (0.200)	
Country	16.8 (0.000)		10.4 (0.000)		36.6 (0.000)	
Industry	7.8 (0.007)		4.4 (0.040)		n/a	
Year	4.3 (0.004)		3.5 (0.021)		104.6 (0.000)	

Notes: [1] – the model was estimated as random effects. Interpretation of parameters in relation to: [2] – small firms.

The estimation results provide evidence of the positive impact of intangible assets on the overall and long-term debt levels of knowledge-based firms. This relationship can be explained through the pecking order theory. As previously mentioned, significant information asymmetry, characteristic of knowledge-based firms, leads to an increased cost of equity capital, prompting these entities to choose cheaper debt capital (Frank & Goyal, 2009). The positive relationship between debt and intangible assets can also be linked to future growth opportunities associated with a competitive advantage based on knowledge (Sytnik & Kravchenko, 2021; Barney, 1991; Hitt et al., 2001). This indicates that the intangible assets held by knowledge-based firms enable them to generate significant income, positively influencing credit assessments and leading to increased debt levels. Conversely, Castro et al. (2015) found the opposite results, demonstrating a negative impact of intangible assets and growth opportunities on financial leverage, leading to reduced debt levels in European knowledge-based firms. Lim et al. (2020) highlight that identifiable intangible assets have a similarly positive impact on financial leverage as tangible assets, supporting firms' ability to obtain debt. Mann (2018) demonstrated that, in 2013, 38% of U.S. patenting firms used patent portfolios as collateral for secured debt. This indicates that certain types of intangible assets play a significant role in financing innovation.

Table 6. Estimation results of panel regressions for other sectors (A, B, C, D, E, F, G, H, I, L, N, P, Q, R, S)

	TTD		LTD		STD[1]	
Variable	Estimate	Std. error	Estimate	Std. error	Estimate	Std. error
const.	1.149***	0.057	-0.084**	0.035	1.070***	0.034
FXA	-0.279***	0.055	0.293***	0.047	-0.635***	0.028
NTG					0.064**	0.030
DPR			0.547***	0.146		
TAX						
LCR	-0.113***	0.013	0.021*	0.012	-0.153***	0.010
AVR					0.040*	0.022
ROA	-0.559***	0.101			-0.224***	0.052
SIZE[2]	ME**		ME***, LA***		No	
CT[3]	BE***, HU***, DE***, ES***, FR***, HR***, IT***, PL***, PT***		DE***, FR***, HR***, PL***, PT***		BE***, HU***, DE***, ES***, FR***, HR***, IT***, PL***, PT***	
IND[4]	B*, D***, E***, F***, G**, H***, I*, L***, N***, P***, Q***, R***, S**		B***, D***, F***, G*, H***, I*, L***, N***, Q***		F*, N**, P**	
YEAR[5]	2003–2007***, 2009**, 2010**		2003*, 2004**, 2008**, 2010–2022***		2007*, 2021**	
No. obs.	7202		2718		2718	
R2	0.558		0.592		0.813	
AIC	-5258.0		-5502.3		-7650.0	
Panel specification tests						
Joint significance	F(380, 2288) = 11.9 (0.000)		F(387, 2295) = 8.5 (0.000)		F(391, 2307) = 9.2 (0.000)	
Breusch-Pagan	LM = 4269.7 (0.000)		LM = 3027.2 (0.000)		LM = 3976.0 (0.000)	
Hausman test	H = 28.3 (0.002)		H = 76.1 (0.000)		H = 50.7 (0.000)	
Joint significance robust F test						
Size	5.6 (0.018)		8.7 (0.000)		n/a	
Country	42.3 (0.000)		40.0 (0.000)		26.6 (0.000)	
Industry	7.5 (0.000)		11.7 (0.000)		3.7 (0.011)	
Year	3.1 (0.003)		4.4 (0.000)		3.5 (0.031)	

Notes: [1] – the model was estimated as random effects. Interpretation of parameters in relation to: [2] – small firms, [3] – Austria, [4] – agriculture sector (A), [5] – year 2000. Significance at the level of * – 10%,** – 5%, *** – 1%.

In traditional firms, this positive relationship was observed only with short-term debt, indicating differences in the impact of intangible assets on capital structure between the two groups.

The asset structure of knowledge-based firms also promotes long-term debt, as explained by trade-off theory. Tangible assets serve as good collateral, reducing potential bankruptcy costs and encouraging higher financial leverage (Cevheroglu-Acar, 2018). Similar findings were reported by Yang (2022), who showed that American telecommunications firms with substantial commercial real estate had higher debt levels. Furthermore, these firms exhibited exceptionally high debt ratios (Habibniya et al., 2022). However, for overall and short-term debt, the asset structure's impact in knowledge-based firms was negative, as firms with significant tangible assets are less prone to issues arising from information asymmetry, lowering the cost of equity issuance and reducing their propensity to incur debt (Li & Islam, 2019). In both knowledge-based and traditional firms, these relationships were consistent.

Regarding the non-debt tax shield, an opposite impact on long-term debt was found in both groups. In knowledge-based firms, the impact was negative, consistent with both the pecking order and trade-off theories. According to the pecking order theory, firms accumulating funds through depreciation have less need for debt capital due to broader internal financing options (Kovacova et al., 2022). The trade-off theory posits that the non-debt tax shield can substitute the debt tax shield, leading to a negative relationship with debt levels (Poornima & Kumar, 2022). In traditional firms, a positive relationship was observed, explained by agency theory, which suggests firms increase debt to counteract the irrational use of free cash flow resulting from increased depreciation by managers (Jensen & Meckling, 1976).

In knowledge-based firms, the impact of tax burdens on short-term debt was positive, aligning with the trade-off theory (Fleckenstein, 2020), indicating limited use of the tax shield effect, primarily in working capital loans. In traditional firms, tax burdens were statistically insignificant.

In the first case, higher liquidity enables companies to undertake riskier projects and finance them through bank loans, as the lower risk of solvency issues makes lenders more willing to provide funding (Ramli et al., 2019). In the second case, it suggests that knowledge-based firms prioritize the use of their accumulated cash reserves and equivalents, thereby reducing their need for external borrowing (Garcia-Rodriguez, 2021). Such behavior is partially consistent with the pecking order and trade-off theory. In traditional firms, similar relationships were observed in the aforementioned debt areas. However, the impact of liquidity on long-term debt in this group was positive. The research findings are largely consistent with those of Castro et al. (2015), who demonstrated similar relationships between debt and financial liquidity in both European technology firms and other entities.

The impact of risk on overall debt in the group of knowledge-based firms was surprising, as it led to an increase in overall debt. This phenomenon can be attributed to the interventionist policies of the EU and member states regarding the activities of knowledge-based firms, which influence their financial decisions. Similar conclusions were reached by Jaworski and Czerwonka (2021), who found that the debt levels of the studied enterprises increased with rising financial risk in the sector. It can thus be assumed that the positive relationship between risk and debt is a specific feature of firms extensively using various support instruments and consequently subject to regulatory influences affecting their financial performance. However, this issue is difficult to interpret definitively and requires further in-depth research. Interestingly, in the group of traditional firms, risk positively affected short-term debt. This can be explained by the limited access to bank credit for high-risk firms. After exhausting internal financing, such entities are forced to rely on short-term obligations. This situation is characteristic, for example, of the construction sector (Badu et al., 2012).

Profitability was found to be a factor limiting debt in both knowledge-based firms and traditional enterprises. High-profitability firms typically exhibit low levels of financial leverage as they prefer internal financing. This relationship aligns with the pecking order theory. These conclusions are consistent with previous studies, such as those by Neville and Lucey (2022), Castro et al. (2015), and Che-Yahya et al. (2022). However, excessive dependence on internal finance can negatively affect firms' innovativeness. To address this issue, firms could increase their reliance on new equity finance and debt finance, particularly bank finance and trade credit finance (Ayalew & Zhang, 2024). This argument has been supported by other studies. Wellalage and Fernandez (2019) found a positive relationship between external finance and both product and process innovation. Similarly, Cui and Yang (2018) showed that equity financing constraints reduce Chinese firms' R&D investments, with this negative effect being particularly pronounced in industries heavily dependent on external financing.

Equity finance plays a crucial role for innovative firms, especially those with greater external financing needs, as it enables them to benefit from going public (Acharya & Xu, 2017). By overcoming financing frictions and improving access to capital, equity financing enhances innovation. Moreover, it allows investors to share in upside returns and facilitates the

funding of innovation investments by transferring idiosyncratic innovation risks to diversified investors through public equity markets (Bernstein, 2015).

Another factor significantly influencing the debt levels of knowledge-based enterprises is growth opportunities, which leads to an increase in long-term debt while simultaneously reducing short-term debt. The positive relationship between long-term debt and growth opportunities can be explained by the pecking order theory. According to this concept, the information asymmetry between managers and investors and the associated need to reduce information costs cause firms to prefer a specific order of financing sources for their investments. Therefore, commercial debt is considered a "more internal" source of financing than the issuance of bonds or equity (Garcia-Rodriguez, 2021). The positive relationship between long-term debt and growth opportunities can be attributed to the nature of knowledge-based enterprises. As mentioned earlier, knowledge-based firms, under the pressure of continuous development and significant growth potential, are compelled to seek additional financing sources. Moreover, these enterprises have considerable opportunities to obtain preferential loans and credits. Conversely, the negative relationship between growth opportunities and short-term debt aligns with the trade-off theory. The realization of growth opportunities is typically associated with high risk and increased expected financial distress costs, which limits debt (Lerner et al., 2022). Furthermore, knowledge-based firms, having access to preferential loans, reduce their short-term debt. Similar, mixed findings are consistent with previous analyses. The positive relationship between growth opportunities and financial leverage was demonstrated by Castro et al. (2015) in early-stage and declining-phase technology firms. According to these authors, during the maturity period, the impact of growth opportunities on financial leverage was negative.

The last capital structure factor analyzed was employment costs. In knowledge-based firms, these costs have a negative impact on financial leverage. High fixed costs associated with the salaries of highly skilled scientific and technical staff, as well as other R&D expenditures and the associated information asymmetry, are characteristic of these entities. These expenses represent a significant financial burden and consume a substantial portion of the generated income (Neville & Lucey, 2022). Due to banks' reluctance to finance risky ventures, these firms are forced to issue equity. These findings align with previous studies indicating that knowledge-based firms follow the modified pecking order theory. This theory suggests that companies relying on the external acquisition of technology (i.e., with high intangibility) are more successful in attracting external financing, whereas firms focusing on internally generated innovation through R&D activities tend to deter external capital (Kędzior et al., 2020; Taglialatela & Mina, 2024; Minola et al., 2013; Serrasqueiro et al., 2016; Cosh et al., 2009).

However, recent changes in the financing environment for innovation-driven businesses have alleviated some of the challenges associated with low capital availability and high capital costs through FinTech credit (Thakor, 2020). Girardone et al. (2024), using a sample of 3,491 non-financial firms operating in 38 OECD countries between 2015 and 2021, explored the impact of FinTech credit on firms' cost of capital and capital structure. They observed a significant reduction of approximately 5.5% in the cost of debt and 3% in the cost of equity. Moreover, their findings highlight that FinTech credit has a particularly pronounced effect on firms operating in more innovative industries.

The comparative analysis of Tables 5 and 6 reveals both similarities and differences in the intensity and significance of size, industry, country, and year effects on the financing patterns and capital structures of knowledge-intensive sectors (M and J) versus traditional sectors (A, B, C, D, E, F, G, H, I, L, N, P, Q, R, S), reflecting the varying financial behaviors and constraints across these two broad groups of industries.

The size effect is significant in both knowledge-intensive and traditional sectors but manifests with varying intensity. In knowledge-intensive sectors, firm size significantly affects long-term debt (LTD), with both medium and large firms exhibiting significantly different debt levels compared to small firms. For short-term debt (STD), only large firms differ significantly from small firms, while total debt (TTD) shows no size effect. This pattern might reflect the resource constraints of small firms in accessing long-term financing, particularly in innovation-driven sectors where intangible assets dominate and limit collateral availability.

In traditional sectors, the size effect is slightly broader. Both medium and large firms show significant differences from small firms in total and long-term debt, likely highlighting their superior access to both types of financing. However, similarly to knowledge-intensive sectors, firm size does not significantly affect short-term debt, suggesting a shared reliance across all sizes on short-term liquidity management. These results show that while larger firms generally benefit from enhanced credit access across all sectors, the impact of size on long-term financing is more pronounced in traditional sectors due to their greater reliance on tangible assets.

The effect of firm size has been confirmed in many other studies, such as Che-Yahya et al. (2022), Castro et al. (2015), and Magri (2009). As Hadhri et al. (2016) highlighted, firm size determines access to innovative solutions, enables risk diversification, and creates the potential to obtain the benefits of economies of scale. The differences in innovativeness between smaller and larger firms may arise from the greater productivity, assets, and financial power typically possessed by larger businesses (Civelek et al., 2021). For these reasons, larger firms are generally able to invest more in innovative activities. Conversely, smaller firms are more specialized and exhibit better internal communication. This allows them to continuously introduce new products to the market, develop improved processes, change organizational structures, and enter new markets (Avermaete et al., 2003).

The country effect is robust in both groups, significantly influencing all types of debt (TTD, LTD, STD). Firms in countries like Belgium, Hungary, and Germany differ markedly from Austria, the reference country, in their debt structures. This consistency across Tables 5 and 6 highlights the importance of national financial systems and regulatory environments in shaping access to debt. However, the degree of variation is likely greater in traditional sectors, given the broader range of industries and their dependence on country-specific financial market characteristics. In contrast, the country effect in knowledge-intensive sectors may be tempered by the relatively homogenous financial needs of firms focused on R&D and innovation, which often benefit from EU-level support mechanisms and policies favoring knowledge-driven industries.

The variation in debt levels among European enterprises across different countries has been demonstrated in many other studies, such as Kędzior (2012). At this point, it is important to highlight the significant differences in local conditions across the analyzed countries. These conditions influence the level of innovation development in each country, as shown in Figure 1 and Figure 2.

Sectoral differences are significant in both groups but exhibit varied intensity. In knowledge-intensive sectors, the industry effect is confined to total and long-term debt, where the Professional, Scientific, and Technical Activities sector (M) differs significantly from the Information and Communication sector (J). These differences likely arise from slight variations in asset tangibility and business models, despite the sectors' shared focus on intangible, knowledge-based activities. Short-term debt shows no industry effect, reflecting the similar liquidity management strategies of these two closely related industries.

In traditional sectors, the industry effect is more persistent, significantly influencing total, long-term, and short-term debt. This reflects the diverse financial behaviors of traditional industries, where asset structures, market stability, and operational risks vary widely. For example, manufacturing sectors with high asset tangibility likely exhibit greater reliance on long-term debt, while seasonal industries like agriculture rely more on short-term financing. It is natural, however, to observe a slightly weaker industry effect in the group of knowledge-based sectors, which is composed of only two NACE sectors (M and J), compared to the group of other sectors, which is inherently larger and more diverse. Similar findings were obtained by Castro et al. (2015), who showed that the debt levels of European technology firms and entities from other sectors differ. The industry effect has also been confirmed in other studies, such as those by Kokoreva et al. (2023) and Che-Yahya et al. (2022).

Similar conclusions can be drawn regarding the year effect, indicating that the capital structure of the examined enterprises changed over the years. The year effect is evident in both groups, capturing temporal variations in debt levels relative to the reference year 2000. These changes could be attributed to fluctuations in the economic situation and related variations in the availability and cost of capital (Brown & Lee, 2019; Yang, 2022).

In knowledge-intensive sectors, significant year effects align with broader economic trends, such as post-crisis recovery or policy-driven shifts favoring innovation financing. Similarly, traditional sectors show pronounced year effects, particularly during periods of economic upheaval, highlighting the influence of macroeconomic conditions on debt usage.

A remarkable difference is the intensity of the year effect. In traditional sectors, the year effect is more widespread across debt types, reflecting their sensitivity to cyclical economic changes. In knowledge-intensive sectors, the year effect might be reduced by the targeted financial support and policy stability that often protects innovation-driven firms during economic downturns.

In summary, the study's results indicate that knowledge-based firms primarily shape their capital structure according to the pecking order theory. This is demonstrated by the negative relationships between debt and profitability, non-debt tax shield, financial liquidity, and, to some extent, asset structure, along with the positive relationship between growth opportunities and debt. These findings align with previous studies, such as those by Castro et al. (2015), Che-Yahya (2022), and Neville and Lucey (2022).

In contrast, the negative relationship between debt and employment costs suggests that the capital structure of knowledge-based firms can be partially explained by the modified pecking order theory (Taglialatela & Mina, 2024; Minola et al., 2013; Serrasqueiro et al., 2016; Cosh et al., 2009). Traditional firms displayed similar patterns. The capital structure of these entities can best be explained by the pecking order theory, as evidenced by the negative relationships between debt and profitability, partially asset structure and liquidity, and the positive relationship between growth opportunities and debt. Additionally, the positive impact of the non-debt tax shield on debt aligns with agency theory. It is worth noting that in both groups, the positive impact of asset structure on long-term debt aligns with the trade-off theory. Moreover, in traditional firms, the positive relationship between long-term debt and financial liquidity provides further support for the trade-off theory.

These observations provide support for the first hypothesis, which suggests that the capital structure of knowledge-based firms is distinctive and differs from that of other firms. The second hypothesis was only partially confirmed, as the impact of some capital structure determinants on the debt of knowledge-based firms and traditional entities differs only to a certain extent.

CONCLUSION

The research findings support the first hypothesis, which assumes a differentiation between the financing patterns of the two groups of firms and their determinants. These differences are primarily reflected in the influence of intangible assets and employment costs on the debt of the analyzed companies. Knowledge-based firms align with the pecking order theory; however, to some extent, patterns characteristic of the modified pecking order theory also emerged within this group. This indicates that these firms primarily rely on internal sources of financing, turning to external financing, especially bank loans, only after exhausting internal funds. However, due to high capital requirements associated with substantial R&D investments and accompanying risks, these firms may face difficulties in obtaining bank loans. Consequently, they are often compelled to seek more expensive capital through equity issuance. This issue is partly mitigated by a well-developed support system for innovative activities, as such entities can access a wide range of financial instruments dedicated to them by the European Union and individual national governments, such as preferential loans.

Traditional firms, on the other hand, shaped their capital structure primarily in line with the pecking order theory, although some of their financing patterns also align with the agency and trade-off theories. These conclusions also support the first hypothesis.

The second hypothesis was only partially confirmed. The impact of capital structure factors varied only to a certain extent between the two groups of analyzed companies. These differences were especially evident in the relationships between debt and intangible assets, non-debt tax shields, and employment costs on the capital structure of the examined firms.

These findings directly address the research questions by demonstrating distinct patterns in financing behavior between knowledge-based and traditional firms and revealing the varied impact of specific determinants on their capital structures. The observed reliance on equity issuance in knowledge-based firms, for example, highlights the sector-specific financing challenges hypothesized at the study's outset.

The analysis reveals that their intensity and scope differ, while size, country, industry, and year effects are significant in both knowledge-intensive and traditional sectors. Traditional sectors exhibit broader variability across countries, industries, and years, reflecting their diverse asset bases and financing needs. In contrast, knowledge-intensive sectors demonstrate more focused variations, influenced by their reliance on intangible assets and alignment with policies supporting innovation. These findings highlight the unique financial behavior of knowledge-based industries and the broader structural heterogeneity of traditional sectors.

The results of this study have several practical and theoretical implications. First, by understanding the characteristics of variables describing the capital structure of knowledge-based firms and traditional businesses, analysts can use these findings to identify what constitutes a typical capital structure for each group of firms. Second, the identified similarities and differences in capital structure, along with the influence of various factors, enhance the current knowledge of financial decision-making in both knowledge-based firms and traditional businesses. Knowledge-based enterprises should avoid excessive reliance on internal finance, as it could negatively affect their innovativeness. Instead, they could enhance their dependence on new equity finance and debt finance, particularly bank loans and trade credit. Furthermore, given the potential for obtaining cheaper and more accessible capital, innovative firms should increasingly utilize alternative financing sources, especially FinTech solutions. Third, the results may prove useful for policymakers and investors

operating in the analyzed countries. Most importantly, due to the crucial role of innovation, especially its link to the socio-economic situation of a country, there is a need to intensify efforts to stimulate the development of knowledge-based enterprises. These efforts should focus on areas that hinder or limit the scale of innovation projects. Given the challenges associated with financing innovative activities, it is essential to create additional governmental support instruments and continue existing programs for both early-stage and established firms. Moreover, due to the greater risk of innovative activities compared to traditional ones, policymakers should implement initiatives that provide not only increased financial support but also educational assistance for knowledge-based enterprises. Collaboration with institutions such as patent and trademark registration offices is also essential to reduce barriers for these businesses when implementing innovative products and strategies.

Due to limitations associated with the data obtained from the BACH database, the analysis includes only selected European countries. Furthermore, the available data are highly aggregated, which has led to a significant generalization of the results. Another issue was the inability to include a variable that is crucial in the context of knowledge-based activities, namely, research and development expenditures. This factor was partially represented by employment costs; however, it is important to note that these costs are only a part of the overall research and development expenditures.

These limitations outline directions for potential further research. First, future studies should be expanded to include all European Union countries. Additionally, broadening the sample to encompass non-European contexts or emerging markets would enable an assessment of whether the findings are consistent across diverse economic environments.

Second, they should consider individual, disaggregated sectors and specifically selected groups of enterprises within these sectors. Collecting more detailed data at the firm level, rather than relying on aggregate industry-level data, would provide a more precise understanding of capital structure patterns. These firms should be chosen according to the definition of knowledge-based enterprises (Neville & Lucey, 2022), i.e., entities that have above-average research and development expenditures in their country and a higher proportion of scientific and technical staff compared to other firms.

Third, the unexpected positive impact of risk on total debt in the group of knowledge-based firms, likely related to the interventionist policies of the EU and member states regarding these entities, needs further, in-depth investigation as it is challenging to interpret definitively.

Finally, examining how macroeconomic fluctuations and policy reforms influence the capital structure choices of knowledge-intensive firms would contribute to a better understanding of the sector's specific characteristics.

References

Acharya, V., & Xu, Z. (2017). Financial dependence and innovation: The case of public versus private firms. *Journal of Financial Economics, 124*(2), 223-243. https://doi.org/10.1016/j.jfineco.2016.02.010

Avermaete, T., Viaene, J., Morgan, E. J., & Crawford, N. (2003). Determinants of innovation in small food firms. *European Journal of Innovation Management, 6*(1), 8-17. https://doi.org/10.1108/14601060310459163

Ayalew, M.M., & Zhang, J.H. (2024). Financial structure and innovation: Firm-level evidence from Africa. *Asian Review of Accounting*, 1-34. https://doi.org/10.1108/ARA-11-2022-0276

Badu, E., Edwards, D.J., & Owusu-Manu, D. (2012). Trade credit and supply chain delivery in the Ghanaian construction industry. Analysis of vendor interactions with small to medium enterprises. *Journal of Engineering, Design and Technology, 10*(3), 360-379. https://doi.org/10.1108/17260531211274729

Barney, J. (1991). Firm resources and sustained competitive advantage. *Journal of Management, 17*(1), 99-120. https://doi.org/10.1177/014920639101700108

Bernstein, S. (2015). Does going public affect innovation? *The Journal of Finance, 70*(4), 1365-1403. https://doi.org/10.1111/jofi.12275

Brierley, P. (2001). The financing of technology-based small firms: A review of the literature. *Bank of England Quarterly Bulletin, 41*(1), 64-83.

Brown, R., & Lee, N. (2019). Strapped for cash? Funding for UK high growth SMEs since the global financial crisis. *Journal of Business Research, 99*(C), 37-45. https://doi.org/10.1016/j.jbusres.2019.02.001

Butzbach, O., & Sarno, D. (2019). To what extent do regional effects influence firms' capital structure? The case of Southern Italian SMEs'. *International Journal of Financial Studies, 7*(1), 1-20. https://doi.org/10.3390/ijfs7010003

Castro, P., Tascón, M.T., & Amor-Tapia, B. (2015). Dynamic analysis of the capital structure in technological firms based on their life cycle stages. *Spanish Journal of Finance and Accounting, 44*(4), 458-486. https://doi.org/10.1080/02102412.2015.1088202

Cevheroglu-Acar, M. G. (2018). Determinants of capital structure: Empirical evidence from Turkey. *Journal of Management and Sustainability, 8*(1), 31-45.

Chapple, K., Markusen, A., Schrock, G., & Yamamoto, D. (2004). Guaging metropolian 'high-tech' and 'i-tech' activity. *Economic Development Quarterly, 18*(1), 10-29. https://doi.org/10.1177/0891242403257

Che-Yachya, N., Matsuura, Y., An, L.T.N., & Issa, N.M. (2022). Financial sources and firms' innovation outputs: Analysis of Jasdaq Market. *International Journal of Business and Society, 23*(3), 1317-1341. https://doi.org/10.33736/ijbs.5166.2022

Civelek, M., Ključnikov, A., Fialova, V., Folvarčná, A., & Stoch, M. (2021). Major obstacles in innovative activities of family-owned SMEs: Evidence from Czechia. *Economics and Sociology, 14*(2), 137-149. https://doi.org/10.14254/2071-789X.2021/14-2/7

Coleman, S., & Robb, A. (2012). Capital structure theory and new technology firms: Is there a match? *Management Research Review, 35*(2), 106-120. https://doi.org/10.1108/01409171211195143

Colombo, M.G., & Grilli L. (2007). Funding gaps? Access to bank loans by high-tech start-ups. *Small Business Economics, 29*(1), 25-46. https://doi.org/10.1007/s11187-005-4067-0
Cosh, A., Cumming, D., & Hughes, A., (2009). Outside enterpreneurial capital. *The Economic Journal, 119*(540), 1494-1533.
Cui, B., & Yang, C. (2018). Equity financing constraints and R&D investments: Evidence from an IPO suspension in China. *China Finance Review International 8*(2), 158-172. https://doi.org/10.1108/cfri-06-2017-0074.
Dash, A. (2023). Do customer centricity and innovativeness mediate the relationship between total quality management and the corporate success of SaaS companies? *Benchmarking: An International Journal, 31*(3), 903-919. https://doi.org/10.1108/BIJ-05-2022-0281
Demmou, L., Stefanescu, I., & Arquie, A. (2019). *Productivity growth and finance: The role of intangible assets - a sector level analysis*, OECD Economics Department Working Papers 1547, 1-48. https://dx.doi.org/10.1787/e26cae57-en
Drucker, P.F. (1992). *Innowacja i przedsiębiorczość. Praktyka i zasady.* Polskie Wydawnictwo Ekonomiczne.
Duan, R. (2023). Patent trolls and capital structure decisions in high-tech firms. *Journal of Banking and Finance, 155,* 106987, 1-20. https://doi.org/10.1016/j.jbankfin.2023.106987
Erickson, G.S., Rothberg, H.N. (2019). Toward a deeper understanding of competitive knowledge assets. *Electronic Journal of Knowledge Management, 17*(1), 79-88.
Falato, A., Kadyrzhanova, D., & Sim, J.W. (2018). Rising intangible capital, shrinking debt capacity, and the US corporate savings glut. Shrinking debt capacity, and the US corporate savings glut. *Journal of Finance, American Finance Association, 77*(5), 2799-2852, https://doi.org/10.1111/jofi.13174
Fama, E. F., & French, K. R. (1998). Taxes, financing decisions and firm value. *The Journal of Finance, 53*(3), 819–843. https://doi.org/10.1111/jofi.1998.53.issue-3
Faulkender, M., & Petersen, M. (2006). Does the source of capital affect capital structure? *Review of Financial Studies, 19*(1), 45-79.
Fleckenstein, M., Longstaff, F.A., & Strebulaev, I.A. (2020). Corporate taxes and capital structure: A long-term historical perspective. *Critical Finance Review, 9*(1-2), 1-28. http://dx.doi.org/10.1561/104.00000069
Frank, M. Z., & Goyal, V. K. (2009). Capital structure decisions: Which factors are reliably important? *Financial Management, 38*(1), 1–37. https://doi.org/10.1111/fima.2009.38.issue-1
Garcia-Rodrigez, I., Romero-Merino, M.E., & Santamaria-Mariscal, M. (2021). Capital structure and debt maturity in nonprofit organizations. *Nonprofit and Voluntary Sector Quarterly, 51*(6), 1451-1474. https://doi.org/10.1177/0899764021106550
Girardone, C., Nieri, L., Pisera, S., & Santulli, R. (2024). Does FinTech credit affect firms' cost of capital and capital structure? *The European Journal of Finance*, Early Access, 1-21. https://doi.org/10.1080/1351847X.2024.2383643
Giudici, G., & Paleari, S. (2000). The provision of finance to innovation: A survey conducted among Italian technology-based small firms. *Small Business Economics, 14*(1), 37-53.
Gorman, G.G., Rosa, P.J., & Faseruk, A. (2005). Institutional lending to knowledge-based businesses. *Journal of Business Venturing, 20*(6), 793-819.
Grabińska, B., Kędzior, D., Kędzior, M., & Grabiński, K. (2021). The Impact of CSR on the capital structure of high-tech companies in Poland. *Sustainability, 13, 5467*, 1-20. https://doi.org/10.3390/su13105467
Górska-Warasewicz, H. (2024). Relationship between entrepreneurial orientation, innovative co-branding partnership, and business performance. *Journal of Entrepreneurship, Management and Innovation, 20*(2), 139-159. https://doi.org/10.7341/20242027
Habibniya, H., Dsouza, S., Rabbani, M.R., Nawaz, N., & Demiraj, R. (2022). Impact of capital structure on profitability: Panel data evidence of the telecom industry in the United States. *Risks, 10*(157), 1-19. https://doi.org/10.3390/risks10080157
Hadhri, W., Arvanitis, R., & M'Henni, H. (2016). Determinants of innovation activities in small and open economies: The Lebanese business sector. *Journal of Innovation Economics Management, 21*(3), 77- 107. https://doi.org/10.3917/JIE.021.0077
Hall, B. (2002). The financing of research and development. *Oxford Review of Economic Policy, 18*(1), 35-51.
Harris, M., & Raviv, A. (1991). The theory of capital structure. *The Journal of Finance, 46*(1), 297-355.
He, J., & Tian, X. (2018). Finance and corporate innovation: A survey. *Asia-Pacific Journal of Financial Studies, 47*(2),165-212. https://doi.org/10.1111/ajfs.12208
Hitt, M. A., Bierman, K., Shimizu, L., & Kochhar, R. (2001). Direct & moderating effects of human capital on strategy and performance in professional service firms. *Academy of Management Journal, 44*, 13-28.
Hogan, T., & Hutson, E. (2005). Capital structure in new technology-based firms: Evidence from the Irish software sector. *Global Finance Journal, 15*(3), 369-387. https://doi.org/10.1016/j.gfj.2004.12.001
Hyytinen, A., & Pajarinen, M. (2005). Financing of technology-intensive small businesses: Some evidence on the uniqueness of the ICT sector. *Information Economics and Policy, 17*(1), 115-132. https://doi.org/10.1016/j.infoecopol.2004.03.005
Jaworski, J., & Czerwonka, L. (2021). Determinants of enterprises' capital structure in energy industry: Evidence from European Union. *Energies, 14*(7), 1-21. https://doi.org/10.3390/en14071871
Jensen, M.C., Meckling, W.H. (1976). The theory of the firm: Managerial behavior, agency costs and ownership structure. *Journal of Financial Economics, 3*(4), 305-360.
Jõeveer, K. (2013). What do we know about the capital structure of small firms? *Small Business Economics, 41*(2), 479-501. https://doi.org/10.1007/s11187-012-9440-1
Kazanjian, R. K. (1988). Relation of dominant problems to stages of growth in technology-based new ventures. *Academy of Management Journal, 31*(2), 257-279. https://doi.org/10.2307/256548
Kędzior, M., Grabińska, B., Grabiński, K., & Kędzior, D. (2020). Capital structure choices in technology firms: Empirical results from polish listed companies. *Journal of Risk Financial Management 13*(221),1-20. https://doi.org/10.3390/jrfm13090221
Kędzior, M. (2012). Capital structure in EU selected countries - micro and macro determinants. *Argumenta Oeconomica, 1*(28), 69-117.
Kim, J., & Pukthuanthong-Le, K. (2008). Leverage and IPO under-pricing: high-tech versus low-tech IPOs. *Management Decision, 46*(1), 106-130. https://doi.org/10.1108/00251740810846770
Kokoreva M., Stepanova A., & Povkh K. (2023). The new strategy of high-tech companies – hidden sources of growth. *Foresight and STI Governance, 17*(1), 18-32. https://doi.org/10.17323/2500-2597.2023.1.18.32
Kovacova, M., Krajcik, V., & Blazek, R. (2022). Valuing the interest tax shield in the central European economies: Panel data approach. *Journal of Competitiveness, 14*(2), 41-59. https://doi.org/10.7441/joc.2022.02.03
Lerner, A.F., Flach, L. (2022). Capital structure as a determinant of growth opportunities in companies listed on B3. *Revista de Administração, Contabilidade e Sustentabilidade, 12*(4), 16-27. https://ssrn.com/abstract=4890505

Li, K., (2024). Does innovation relieve corporate financial distress? Asia-pacific financial markets. *Springer Science and Business Media LLC*, pp. 1-36. https://link.springer.com/article/10.1007/s10690-023-09445-4
Li, L., & Islam S.Z. (2019). Firm and industry specific determinants of capital structure: Evidence from the Australian market. *International Review of Economics & Finance, 59*(C), 425-437. https://doi.org/10.1016/j.iref.2018.10.007
Lim, S.C., Macias A.J., & Moeller, T. (2020). Intangible assets and capital structure. *Journal of Banking & Finance 118*(C), 1-59. https://doi.org/10.1016/j.jbankfin.2020.105873
López-Gracia, J., & Sogorb-Mira F. (2008). Testing trade-off and pecking order theories financing SMEs. *Small Business Economics, 31*(2), 117–136.
Magri, S. (2009). The financing of small innovative firms: the Italian case. *Economics of Innovation and New Technology, 18*(2), 181-204. https://doi.org/10.1080/10438590701738016
Mann, W. (2018). Creditor rights and innovation: Evidence from patent collateral. *Journal of Financial Economics 130*(1), 25-47. https://doi.org/10.1016/j.jfineco.2018.07.001
Martínez-Torres, M.R. (2014). Identification of intangible assets in knowledge-based organizations using concept mapping techniques. *R & D Management, 44*(1), 42-52.
Minola, T., Cassia, L., & Criaco G. (2013). Financing patterns in new technology-based firms: An extension of the pecking order theory. *International Journal of Entrepreneurship and Small Business, 19*(2), 212-233.
Modigliani, F., & Miller, M.H. (1963). Corporate income taxes and the cost of capital: A correction. *American Economic Review, 53*(3), 433-443.
Myers, S.C. (1984). The capital structure puzzle. *Journal of Finance, 39*(3), 575–592. https://doi.org/10.1111/j.1540-6261.1984.tb03646.x
Myers, S.C. (1977). Determinants of corporate borrowing. *Journal of Financial Economics, 5*(2), 147-175. https://doi.org/10.1016/0304-405X(77)90015-0
Myers, S.C., & Majluf, N.S. (1984). Corporate financing and investment decisions when firms have information that investors do not have. *Journal of Financial Economics, 13*(2), 187-222. https://doi.org/10.1016/0304-405X(84)90023-0
Na, H.J. (2021). Innovation on the choice of debt financing source: Evidence from innovative firms. *Studies in Economics and Finance, 38*(5), 901-925. https://doi.org/10.1108/SEF-09-2020-0362
Neville, C., & Lucey, B.M. (2022). Financing Irish high-tech SMEs: The analysis of capital structure. *International Review of Financial Analysis, 83*(C), 102219. https://doi.org/10.1016/j.irfa.2022.102219
Oakey, R. Rothwell, R., & Cooper, S. (1988). *The Management of Innovation in High-Technology Small Firms*. Pinter.
OECD. (2015). *Frascati Manual. Guidelines for Collecting and Reporting Data on Research and Experimental Development*. Retrieved from https://www.oecd.org/publications/frascati-manual-2015-9789264239012-en.htm
Opler, T. C., & Titman, S. (1994). Financial distress and corporate performance. *The Journal of Finance, 49*(3), 1015-1040. https://doi.org/10.1111/j.1540-6261.1994.tb00086.x
Palazzo, B. (2019). Cash flows risk, capital structure, and corporate bond yields. *Annals of Finance, 15*(3), 401-420. https://doi.org/401-420. 10.1007/s10436-018-00342-9
Paredes-Chacín, A.J., Díaz-Bejarano, S., Marín-González, F., & Vega-Ramírez E. (2024). Relationship between knowledge transfer and sustainable innovation in interorganizational environments of small and medium-sized enterprises. *Journal of Entrepreneurship, Management and Innovation, 20*(1), 47-64. https://doi.org/10.7341/20242013
Poornima, B.G., & Kumar, P. (2022). A study on the capital structure determinants of FMCG companies in India. *International Journal of Finance Engineering, 9*(2), 1-14. https://doi.org/10.1142/S2424786321500080
Porter, M.E. (1998). *The Competitive Advantage of Nations*. Free Press.
Rabinovich, J. (2023). Tangible and intangible investments and sales growth of US firms. *Structural Change and Economic Dynamics, 66*, 200-212. https://doi.org/10.1016/j.strueco.2023.05.001
Ramli, N.A., Latan H., & Solovida G.T. (2019). Determinants of capital structure and firm financial performance—A PLS-SEM approach: Evidence from Malaysia and Indonesia. *The Quarterly Review of Economics and Finance, 71*(C), 148-60. https://doi.org/10.1016/j.qref.2018.07.001
Rajan, R. G., & Zingales, L. (1995). What do we know about capital structure? Some evidence from international data. *The Journal of Finance, 50*(5), 1421-1460. https://doi.org/10.1111/j.1540-6261.1995.tb05184.x
Revest, V., & Sapio, A. (2012). Financing technology-based small firms in Europe: What do we know? *Small Business Economics, 39*(1), 179-205. https://doi.org/10.1007/s11187-010-9291-6
Ross, S.A. (1977). Some notes on financial incentive-signaling models, activity choice and risk preferences. *The Journal of Finance, 33*(3), 777-792.
Serrasqueiroa, Z., Maçãs Nunesa, P., & da Rocha Armadac, M., (2016). Capital structure decisions: Old issues, new insights from high-tech small- and medium-sized enterprises. *The European Journal of Finance, 22*(1), 59-79. https://doi.org/10.1080/1351847X.2014.946068
Skoczylas-Tworek, A. (2014). Zarządzanie informacją i wiedzą jako determinanty stymulowania przewagi konkurencyjnej przedsiębiorstwa w dobie kryzysu ekonomicznego. In A.P. Balcerzak (Ed.), *Przedsiębiorstwo oparte na wiedzy* (pp. 17-34). Instytut Badań Gospodarczych, Polskie Towarzystwo Ekonomiczne.
Spitsin, V., Vukovic, D.B., Spitsina, L., & Özer, M. (2022). The impact of high-tech companies' performance and growth on capital structure. *International Business Journal, 32*(6), 1059-5422. https://doi.org/10.1108/CR-03-2021-0042
Sytnik, N., & Kravchenko, M. (2021). Application of knowledge management tools: Comparative analysis of small, medium, and large enterprises. *Journal of Entrepreneurship, Management and Innovation*, *17*(4), 121-156. https://doi.org/10.7341/20211745
Taglialatela, J., & Mina, A. (2024). Innovation, asymmetric information and the capital structure of new firms. *Economics of Innovation and New Technology, 33*(7), 955-978. https://doi.org/10.1080/10438599.2023.2265821
Tsionas, M. (2019). *Panel Data Econometrics. Theory*. Elsevier Academic Press.
Thakor, R.T., & Lo, A.W. (2022). Competition and R&D financing: Evidence from the biopharmaceutical industry. *Journal of Financial and Quantitative Analysis, 57*(5), 1885-1928. https://doi.org/10.1017/S0022109021000284
Thakor, A.V. (2020). Fintech and banking: What do we know? *Journal of Financial Intermediation 41*, 100833. https://doi.org/10.1016/j.jfi.2019.100833
Wellalage, N.H., & Fernandez, V. (2019). Innovation and SME finance: evidence from developing countries. *International Review of Financial Analysis, 1*, 101-370. https://doi.org/10.1016/j.irfa.2019.06.009
West, M.A. (2000). *Rozwijanie kreatywności wewnątrz organizacji*. Polskie Wydawnictwo Naukowe.
Yang, J. (2022). Commercial property exposure and corporation financing choice. *International Journal of Business, 27*(2), 1-28. https://doi.org/10.55802/IJB.027(2).006

Biographical notes

Magdalena Gostkowska-Drzewicka (Ph.D.) is a lecturer in the Department of Corporate Finance at the University of Gdańsk, Faculty of Management. She is a graduate of the University of Gdańsk. She specializes in corporate finance, especially capital structure analysis. She is the author or co-author of over 40 publications and 3 books.

Julia Koralun-Bereźnicka, habilitated Ph.D., is an Assistant Professor in the Department of Corporate Finance at the University of Gdańsk, Faculty of Management. She specializes in corporate finance, particularly the impact of country, industry, and company size on corporate performance and capital structure. She has authored and co-authored numerous publications and has received several awards for her research.

Authorship contribution statement

Magdalena Gostkowska-Drzewicka: Conceptualization, Funding Acquisition, Investigation, Writing, Reviewing & Editing, Revisions. **Julia Koralun-Bereźnicka:** Data Curation, Formal Analysis, Methodology, Investigation, Writing, Reviewing & Editing, Revisions.

Conflicts of interest

The authors declare no conflict of interest.

Citation (APA Style)

Gostkowska-Drzewicka, M., & Koralun-Bereźnicka, J. (2025). Capital structure specificity in knowledge-intensive industries: A comparative study of EU countries. *Journal of Entrepreneurship, Management and Innovation 21*(1), 99-120. https://doi.org/10.7341/20252116