A structural break in EU corporate leverage trends

PRELIMINARY, PLEASE DO NOT CIRCULATE

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Abstract

Contrary to concerns about rising corporate indebtedness, we show that corporate leverage has steadily declined over the past two decades for most EU firms. This trend has happened despite an environment of low interest rates and abundant liquidity before 2020 and has coincided with rising cash holdings and profitability. This paper investigates potential explanations based on bank credit tightening and secular stagnation. We find no evidence that tightening credit supply is driving this decline, as firms do not appear to be liquidity or credit constrained. Instead, we propose an explanation based on the rising importance of developed in-house intangible capital. Our theory accounts not only for declining leverage but also for broader economic trends such as rising market power and slowing business dynamism. Additionally, we contribute to the debate on why intangible-intensive firms rely less on debt. While the prevailing view attributes this to intangibles being poor collateral, we show that firms that rely more on intangibles reduce leverage less than others when banks tighten credit due to stricter collateral requirements. This suggests alternative explanations, such as differences in investment funding needs—e.g., lower cash-in-advance requirements for intangible assets.

Keywords. Corporate leverage, Technological change, intangible assets, secular trends.

JEL classifications. G32, G35, J24, J33

1. Introduction

The post-World War II period saw a historic expansion in financial intermediation, with private credit to GDP increasing substantially across advanced economies. Jordà et al. (2022) document that debt-to-GDP ratios of non-financial firms in developed countries more than doubled from 1945 to 2010,[1] and similar trends have been observed in China, where corporate debt now surpasses levels seen in most OECD economies (Beck et al. (2023)). Around the 2008 financial crisis, many firms struggled to deleverage after losing access to credit (e.g., Kaplan, 2019; Kalemli-Özcan et al., 2022).[2]

However, debt-to-GDP is an imperfect measure of corporate financial health, as it does not account for firms' repayment capacity, which depends on the value of their own assets. Moreover, since the capital income share has risen across many economies (Rognlie, 2016), using GDP as a denominator may overstate corporate indebtedness. A more direct measure of financial strength is the leverage ratio, which links debt obligations to the productive assets backing them. Yet, existing studies on corporate leverage tend to focus on publicly listed firms and gross debt, often neglecting net leverage. This can overstate firms' financial risk, especially given the steady rise in corporate cash holdings (Dao and Maggi, 2018). Indeed, flow-of-funds data suggest that since the 2000s, the non-financial corporate sector in most OECD countries has been a net lender on a flow basis (Beck et al., 2023).

This paper provides new evidence on long-term trends in corporate leverage in the European Union (EU) from 2000 to 2020, leveraging a uniquely large dataset from administrative sources across multiple countries. Contrary to the widely held perception of rising corporate indebtedness, we find that leverage has declined or remained stationary for most firms. This trend predates the 2008 financial crisis, beginning as early as 2005, and continued steadily through both boom and bust cycles. For instance, the average firm's leverage ratio fell from 0.43 in 2005 to 0.34 in 2019, with the decline accelerating during the period of extraordinarily low interest rates following the European Central Bank's (ECB) quantitative easing (QE) in 2016. The

[1] Graham et al. (2015) confirm this long-term trend among U.S. firms.

[2] McKinsey & Company's 2021 report The rise and rise of the global balance sheet states that corporate debt-to-GDP rose 27% between 2011 and 2020, while corporate profits stagnated.

implications of falling firm leverage for financial stability depend critically on its main drivers. This paper documents extensively the trend and explores possible drivers using granular data.

Beyond leverage, we document two additional trends that suggest broader structural shifts in firms' financial behavior. First, the rise in corporate cash holdings: Cash or cash-equivalent assets increased from under 8% of the balance sheet in 2000 to more than 12% in 2020 for the average firm in our data. Second, average profitability measured as operating profits over revenues has trended upward alongside leverage reductions and rising liquidity, from less than 3% to more than 5%[3].

These trends challenge conventional explanations based on declining corporate tax rates (Dallari et al., 2018), tightening bank credit supply (Beck et al., 2023) or secular stagnation (Eggertsson et al., 2019). While we acknowledge that these factors explain part of the leverage decline, they are at odds with some of the additional trends we find in the data. For instance, lower effective corporate tax rates could plausibly contribute to lower leverage and higher profitability. Yet, they cannot fully explain the surge in cash accumulation, provided the availability of investment opportunities and markets being sufficiently competitive. To this end, we document how the investment share of sales has remained stable across the firms in our data, despite fluctuating alongside the business cycle over the sample horizon. Similarly, if leverage decline were primarily driven by credit supply constraints, we would expect to observe clear signs of liquidity shortages, especially for small and medium-sized enterprises (SMEs). To this end, we compute multiple metrics of liquidity and credit constraints at the firm level from the ECB's SAFE survey (European Central Bank, 2025). Our data reveal no evidence of widespread liquidity constraints, in fact firms appear to be progressively less constrained over time. Moreover, firms' dividend payouts as a share of assets have increased over the sample period, further indicating that financial resources are not excessively constrained. Finally, the view on secular stagnation driven by diminishing investment opportunities (Gordon, 2012) ignores the rising importance of intangible capital and the vast opportunities for firm level investment that they provide through digitization, development of intellectual property and human capital intensive assets. These are

[3] Profitability numbers may appear low at first instance, but are driven by the large amount of small and medium firms present in our data and mask high heterogeneity (see Section 3).

oftentimes harder to measure, leading to the conclusion that corporate investment is stagnating, but have been shown to account for a large share of corporate asset formation (Corrado and Hulten, 2010).

In this paper, we focus on factors on the demand side of the credit market to provide a rationale for the trends observed in the data. We develop a dynamic firm-level model in which investment and financing choices are shaped by the growing role of developed in-house intangible capital. Our model incorporates heterogeneous firms operating under monopolistic competition, where market power emerges endogenously. Firms use two types of capital (tangible and intangible) alongside skilled and unskilled labor for production. Moreover, we explicitly model liquidity constraints, requiring firms to finance investment through internal funds, debt, or equity. Intangible capital is an asset partially tied to skilled labor, which limits firms' ability to use it in case human capital leave the firm. At the same time, this asset enables economies of scale within the firm, making it more competitive within its industry. In our framework, firms investing more heavily in intangible capital experience rising profitability due to their lower marginal cost, which allows for the buildup of retained earnings. Moreover, they further accumulate liquidity as a strategic retention mechanism to deter talent poaching. Because intangible capital depends on skilled workers' expertise and cannot be fully separated from them, firms must keep liquidity reserves to counter outside offers for key employees. This mechanism generates persistent increases in cash holdings, reduces firms' reliance on debt, and contributes to rising concentration and market power—trends that align with recent empirical findings on market structure in Europe. As long as investment in intangibles is hard to measure, our model also account for stagnating investment in traditional assets and increasing skill premium in wages.

Finally, we test a central assumption of our model: whether the lower leverage of intangible-intensive firms is due to lower need for external financing, rather than intangible capital being poor collateral, as it is commonly framed in the literature. If intangibles were poor collateral, we would expect firms in intangible-intensive industries to experience a stronger drop in leverage following credit tightening events. To test this, we employ a shift-share research design, using industry-level exposure to intangible capital proxied by selling, general, and administrative expenses (SG&A) at the industry level. We instrument EU firms' intangible intensity with the same measure in US industries, to instrument for unobserved factors driving both intangibel intensity and the credit cycle in the EU. We implement an event-study analysis based on credit tightening episodes across EU countries and examine their differential impact on leverage by industry. If the collateral hypothesis were correct, intangible-intensive firms should face sharper reductions in leverage following such shocks. However, our results show the opposite: leverage in these industries is less affected by credit constraints, supporting the view that lower leverage reflects lower demand for external financing rather than constrained supply. The rest of the paper proceeds as follows. In Section 2 we present a review of the literature and position our contribution in light of previous work. In Section 3 we present our data and the empirical trends we observe across EU firms. In Section 4 we discuss our model and its implications. Section 5 presents our shift-share design to understand how intangible intensive industries react to credit supply shocks due to collateral requirements. Finally, Section 6 concludes.

2. Literature Review

Our work is not the first one documenting declining corporate leverage. According to Beck et al. (2023), aggregate EU gross leverage declined modestly during the mid-2000s, surged briefly during the financial crisis, and then fell steadily from 36% in 2009 to 29% in 2021. Net leverage follows a similar pattern, particularly since 2016. Among individual EU states, leverage peaked in the mid-2000s in Germany, France, Austria, and the Netherlands. In periphery countries leverage declined substantially after 2009, and is now lower than in 1995. The primary exception is Central Europe (Poland, Slovakia, and the Czech Republic), where leverage rose from a low base as the region integrated into the EU. This prolonged decline in average leverage is matched in data on U.S. firms. Average US firm leverage has fallen by about 10 percentage points (pp) since 2004, with most of the decrease coming after the financial crisis (Dobridge et al., 2022). Leverage has fallen by 12pp among Japanese listed firms since 1999 (Khoo and Durand, 2017). Since 2008 leverage fell by 10pp in Australia and by 6pp in the United Kingdom (Beck et al., 2023). These trends suggest a structural shift in advanced economies rather than a European phenomenon.

Our study contributes to the literature via using firm level data to further document the phenomenon, linking it to other relevant trends we have observed over the same period.

We consider three structural factors as possible drivers: financial regulation, secular stagnation and rising importance of intangible capital.

Declining leverage may in part reflect a rise in financial constraints, potentially due to tighter regulation (Almeida et al., 2004; Whited and Wu, 2006). A well-established result in finance research is that a firm may reduce debt usage due to a tightening of financial constraints. This arises when a firm would like to raise debt to pursue positive-NPV investment opportunities, but creditors are unwilling to provide sufficient financing at a reasonable cost of capital. In particular, negative macroeconomic shocks can exacerbate information asymmetry between a firm and its creditors about the quality of investment opportunities or the ability to repay debt. Prior work measures financial constraints using proxies for asymmetric information such as firm size, age, a commitment to pay out dividends, or the amount of tangible assets (Fazzari et al., 1988; Whited and Wu, 2006; Almeida and Campello, 2007; Hadlock and Pierce, 2010).Another strand of literature shows that shocks to credit providers can percolate through to the real economy, by reducing corporate access to external financing for investment. Fundamentally strong firms may struggle to raise external financing, if they rely on creditors whose balance sheets have deteriorated. This is a significant concern for EU firms, which rely heavily on bank loans instead of public debt or equity issuance. Kalemli-Özcan et al. (2022) compare EU firms that had pre-existing lending relationships to banks with high versus low sovereign bond holdings during the financial crisis (a proxy for balance sheet weakness). They show that more highly levered firms cut investment by a greater amount during the crisis, an effect amplified by a pre-existing relationship to a weakened bank.These findings suggest that declining leverage across the EU could be driven by weaknesses in firms and banks that arose during the financial and Eurozone crises. Declining gross leverage since 2008 could be caused by a reluctance or inability of banks to lend to firms, and net leverage could decrease due to firms conserving cash in anticipation of becoming financially constrained. Notably, in order for this channel to explain most of the decline in leverage across our sample period, it must be that firms' available supply of credit remained depressed during the recovery period after the Eurozone crisis, despite record-low interest ratesIn the years after the crisis Kalemli-Özcan et al. (2022) show that EU firms with pre-existing relationships with hard-hit banks cut investment heavily. In addition, new EU bank capital norms under Basel III have clearly reduced bank incentives to lend to smaller firms since 2014. Yet the decline in leverage started before the 2008 crisis, and persists even once EU credit conditions had stabilized from the Euro crisis. ECB surveys document renewed bank willingness to provide credit (Beck et al., 2023). The decline in aggregate EU leverage accelerated after 2016. Strikingly this occurred at a time of loosening of monetary policy which reduced financing costs to historic lows.

We contribute to this literature by providing evidence against this interpretation, in fact in our data the incidence of firms that are credit or liquidity constrained is falling, while dividend payouts and profitability are increasing.

The steady decline in leverage coincides with two other major structural transformations in advanced economies. The first is a well-documented decline in business dynamism (e.g., Eggertsson et al., 2019; Eichengreen, 2015; Jones and Philippon, 2016; Gordon, 2012; **?**), which has contributed to an era of secular stagnation, even in periods of minimal interest rates. In a low-growth environment, firms may reduce borrowing due to weaker and more uncertain future prospects, while banks may also become more cautious in extending credit. This explanation aligns with research documenting rising secular stagnation (Eggertsson et al., 2019; Eichengreen, 2015; Jones and Philippon, 2016) and declining business dynamism across advanced economies (Gordon, 2012; **?**; Akcigit and Ates, 2021). These trends may be particularly pronounced for EU firms, which experienced prolonged economic weakness following the financial and Eurozone crises.

A second driver of declining leverage is the shift toward intangible capital, a defining feature of the digital transformation that began in the 1980s. Information technology has fundamentally changed corporate production and distribution, reducing reliance on physical assets and, consequently, the need for debt financing (Corrado and Hulten, 2010).

Unlike physical assets, intangible investments—such as software, brand value, and human capital—require different financing structures. Whereas physical capital often requires large up-front expenditures that can be debt-financed, intangible investment tends to be funded through retained earnings or equity (Döttling et al., 2023; Eisfeldt et al., 2023). Furthermore, firms operating in intangible-intensive industries may experience increasing returns to scale, allowing a small set of successful firms to grow rapidly with minimal debt (Crouzet et al., 2022; Hsieh and Rossi-Hansberg, 2023; De Ridder, 2024).

Thus, the decline in leverage may not reflect a lack of investment opportunities but rather a shift in the nature of corporate investment. Advanced economies have seen a rapid increase in the share of intangibles relative to total assets (e.g., Corrado and Hulten, 2010; Falato et al., 2022). Our model contributes to this literature by providing a theoretical framework that accounts for these mechanisms and aligns with observed empirical trends.

Our work also advances the empirical literature on the relationship between debt financing and intangible capital. Prior studies argue that intangible assets' low transferability and lack of explicit property rights make them poor collateral for debt financing (Dell'Ariccia et al., 2021; Falato et al., 2022; Crouzet and Eberly, 2023). We build on this research by showing that firms with high intangible intensity do not further reduce leverage in response to tighter collateral constraints. This suggests that the decline in leverage among intangible-intensive firms is primarily driven by a lower demand for credit rather than by supply-side constraints.

3. Data and Descriptive Evidence

Our empirical results rest on the CompNet dataset[4]. The Competitiveness Research Network (CompNet) dataset is a comprehensive micro-aggregated database originally designed to analyze firm-level competitiveness and productivity across European countries. Constructed through a collaborative effort among national central banks, statistical institutes, and research institutions, the dataset employs a distributed micro-data approach to ensure both confidentiality and cross-country comparability. CompNet gathers raw firm level data from various administrative national sources, including business registers, balance sheet information, and production surveys. Each participating country processes its firm-level data using a harmonized protocol, which standardizes industry coverage, variable definitions, estimation methodologies, and sampling procedures. This harmonization ensures that the aggregated indicators are comparable

[4]cfr. https://www.comp-net.org/

across countries. To maintain firm-level confidentiality, CompNet applies a micro-aggregation technique. This involves aggregating firm-level data into statistical moments (e.g., means, standard deviations, percentiles) at specific levels of aggregation, such as country, macro-sector, industry, or firm size class[5]. By doing so, the dataset provides rich insights into firm performance while adhering to confidentiality constraints. Finally, the dataset is available both in an unweighted and in a reweighted version, where the former presents moments as they are drawn from the administrative samples, while the reweighted applies sample reweighting to adjust for the real representativeness of the data according to official aggregate statistics[6].

We focus on firms with at least twenty employees, aggregated at the industry level, where industries are classified according to 2-digit NACE Rev.2 codes. Our sample consists of an unbalanced panel of weighted moments extracted from firm populations across 19 EU countries[7] spanning the years 2000 to 2020. Tables 1 and **??** provide further details on the available years for each country, the representativeness of our sample relative to the firm population, and the industry composition. We use reweighted data to ensure higher external validity of our findings, where moments extracted by the data are computed by adjusting the composition of our sample to official firm counts by country, industry and size class provided by Eurostat[8]. Our sample covers more than 50% of the firm population in the included countries and industries, with total firm counts of 332,073 firms when we pool together countries in their first available year and 367,204 in the last. Manufacturing firms constitute approximately one-third of the sample, with their share declining from 35% in 2006 to 30% in 2018.

We begin by presenting key empirical patterns characterizing European firms in our sample from the early 2000s up to the onset of the COVID-19 pandemic.

We start focusing on corporate leverage, measured as the ratio of total debt over total assets in each firm. From the data we observe the mean value of the ratio for each combination of year-country-industry available in our data. We first aggregate the trend into a weighted average

[5]The industry level is identified with the 2 digit NACE Rev. 2 classification, while macro sector with the 1 digit NACE Rev. 2 classification

[6]This is done using weights at the industry and sizeclass level from Eurostat's Structural Business Statistics and Business Demography.

[7]The sample includes Belgium, Croatia, Czech Republic, Denmark, Finland, France, Germany, Hungary, Italy, Latvia, Lithuania, Netherlands, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, and Sweden.

[8]See CompNet Userguide for additional details on the statistical procedure.

pooling all countries together, to have a sense of the behaviour of the average firm. We use book assets as weights of the aggregation. We then repeat the same exercise at the country level, to present cross country heterogeneity. The outcomes of this descriptive exercise are presented in Figure 1 for the overall average leverage and in Figure 2 for the country detail. Due to varying data availability, the composition of the sample differs slightly between the initial and final years of the dataset. On average, leverage was around 0.4 in the first five years of the sample, declining by approximately 8 percentage points in the final five years. Comparing 2005 and 2019—two years with relatively high country coverage—reveals a 23% decline in leverage, from 0.43 to 0.33. This overall downward trend masks significant heterogeneity across countries (Figure 2). While differences in average leverage may partially reflect variations in accounting standards, most countries exhibit a declining trend, with exceptions such as Belgium, Finland, and Spain, where leverage remains stable, or Poland, where it has increased.

This observed deleveraging trend is in line with the literature (Dobridge et al., 2022; Beck et al., 2023), yet somewhat unexpected according to general economic theory, given the persistent decline in interest rates and the increasing availability of liquidity over the sample period.

Figures 3 and 4 replicate our leverage analysis for firms' cash holdings, measured as the ratio of cash to total assets. We observe a steady increase in cash holdings, from just under 8% in 2000 to approximately 13% in 2021 — an increase of over 50%. This trend appears robust across countries and remains largely unaffected by economic downturns, including the aftermath of the 2008 financial crisis and the 2011 Sovereign Debt crisis. Notably, the COVID-19 shock coincides with an exceptional spike in liquidity levels.

Finally, we report figures computed in a similar way for the average profit margin, computed as the profit share of sales, where profits are defined as EBIT. Results are presented in Figure 5 and in Figure 6 as a separate trend by country. Profitability follows a cyclical pattern consistent with the business cycle but exhibits an upward trend, increasing from just below 3% in 2000 to over 5% in 2020. This increase is primarily driven by Eastern European economies and large EU countries such as France, Italy, and Spain. The relatively low profitability levels reflect the significant presence of small and medium-sized enterprises (SMEs) in the dataset, as well as the inclusion of low-margin industries such as Retail and Transportation.

The steady trends in leverage, cash holdings, and profitability raise questions about the role of credit constraints in explaining declining leverage. If firms were reducing leverage due to restricted credit supply, we would expect increasing signs of liquidity constraints, such as a reduction in liquidity available for firms.

To explore this, we employ two measures of credit constraints available in the CompNet dataset. The first, an "absolute" credit constraint measure, classifies firms as constrained if they report positive investment while simultaneously reducing debt and capital, or if they disinvest while maintaining a positive financing gap (fixed investment plus the change in working capital minus cash flow) (Ferrando and Ruggieri, 2018).

The second measure is derived from the ECB's Survey on Access to Finance of Enterprises (SAFE)[9]. The SAFE measure estimates credit constraints based on loan rejections, limited credit approvals, prohibitive borrowing costs, and discouraged borrowing. First, CompNet collects the parameters from a linear prediction model employed by the ECB to match the survey results with firm financial characteristics provided by the Orbis dataset[10]. The parameters vary by level of aggregation (combinations of industry-country) and by year, and are then used to predict a firm level score on the administrative data used by CompNet. Firms' scores are then ranked according to their values. At this point, a threshold value of the SAFE score above which we can define firms in a given level of aggregation as being credit constrained is calculated. The value of the threshold is time-varying and country-specific and is set so that the share of firms above this threshold at the country level is the same as the share of credit constrained firms for a given country-year reported in the SAFE survey. In a final step, the safe dummy variable for a given firm is assigned value 1 if the estimated SAFE score index is above the threshold, and 0 otherwise[11].

Figures 9 and 9 present the evolution of credit constraints using both definitions. The "ab-

[9]The SAFE is conducted by the ECB jointly with the European Commission twice per year. The survey intends to assess the financial conditions of firms in the euro area (the survey is also conducted for some non-euro area countries).

[10]The survey defines a firm as credit constrained if: the firm reports loan applications which were rejected; the firm reports loan applications for which only a limited amount was granted; the firm reports loan applications which were rejected by the firms because the borrowing costs were too high; the firm did not apply for a loan for fear of rejection (i.e. discouraged borrowers).

[11]See Ferrando and Ruggieri (2018) for more details on the variables included and the steps of the model.

solute" measure indicates an increase in credit constraints from 4.7% in 2003 to 7.1% in 2009, followed by a decline to 4.2% in 2021. The SAFE-based measure shows a broader decline, from 14% in 2000 to 3.3% in 2021, with a temporary rise during the 2008 crisis. Both measures suggest that credit constraints have eased over time, contradicting the hypothesis that declining leverage results from tighter credit supply.

Further supporting this conclusion, we observe that dividend payouts as a share of total assets have increased from 3% to 3.5% over the sample period (Figure 11). This trend suggests that firms have had increasing financial flexibility, as they have been able to allocate a greater portion of their assets to shareholder distributions rather than retaining earnings for precautionary liquidity or debt repayment. The rise in dividends also implies that firms are not facing significant financial distress or credit constraints, as constrained firms would typically prioritize liquidity preservation over returning capital to shareholders.

Simultaneously, firms' interest expenses—measured both as a share of total debt and total sales—have steadily declined over time (Figures 13 and 15). This decline can be attributed to the prolonged low-interest-rate environment, which has reduced the cost of borrowing across European economies. However, despite lower interest rates making debt financing more attractive, firms have not responded with increased leverage, indicating that demand-side factors, rather than borrowing costs alone, may be driving the observed trends.

In conclusion, while liquidity constraints could account for deleveraging in specific segments of the firm population—particularly among small and financially fragile firms—the broader evidence suggests that alternative factors are at play. These could include structural changes in firms' financing behavior, shifts in investment strategies favoring intangible over tangible assets, or changes in corporate risk preferences. The sustained rise in cash holdings and dividend distributions, coupled with falling interest burdens, indicates that firms are not merely reducing leverage due to financial distress or restricted credit access. Instead, they may be strategically adjusting their capital structure in response to evolving economic conditions, technological advancements, and shifting financial market dynamics.

As additional piece of eivdence, we report how investment share of sales has generally remained on a stable trend for the firms in our data, fluctuating alongside the business cycle:

from a level of around 5.5% in the pre 2008 crisis, it has increased by almost 50% in 2008 and then dropped to around 5% until 2016, where it has started to increase again(see Figure 17 and Figure 18 for country detail). Data on investment in CompNet include the total value of acquired or self-constructed land, machinery, equipment, buildings and other durables (including assets under construction, but not long-term financial assets), plus the acquisitions of intangible fixed assets (acquired - not developed in-house - intellectual property such as copyrights, patents, licenses, software etc.). A generally stagnating investment trend is in line with theories of secular stagnation (Gordon, 2012; Eggertsson et al., 2019): a generalized lack of investment opportunities might cause firms to overall reduce their investment, which may cause also leverage to decline as demand for debt reduces. In presence of a reduction in market competition, this may lead to increasing profitability and cash accumulation in the form of retained earnings, which would also be in line with reduction in signs of credit or liquidity constraints among firms. While this theory might partly explain our findings, we add to this interpretation by suggesting that investment opportunities have not decreased, but have become more selective (i.e. accessible to a lower amount of firms) and highly biased in favour of in-house intangible capital as a source of firm growth and profitability. This type of intangible investment is hard to measure, as it is typically accounted in the form of expenditure rather investment (see Section 5 for additional details). As an initial attempt to investigate the role of developed in-house intangibles, we show how leverage, cash holdings and profitability have evolved based on industry classification. Eurostat provides a version of the standard NACE industry classification based on knowledge intensity, where this is measured based on the skill composition of the workforce in each industry (Eurostat, 2025). Services are split in knowledge intensive and not-knowledge intensive Services, while Manufacturing is split in 4 categories (Low-Tech, Mid-Low Tech, Mid-High-Tech, High-Tech). We compute the weighted average of leverage, cash holdings and profitability in the resulting 6 industry aggregates each year of our sample and plot the results in Figure 19 presents the results. Focusing on Services, knowledge intensive services present higher cash holdings and profitability, as well as a more sustained growth rate over the sample horizon. The result is less clear for what concerns leverage, where the distance from less knowledge intensive services is minimal. Concerning manufacturing, high tech Manufacturing presents lower leverage, higher cash and profitability, as well as a higher increase in the latter two variables when compared to low and medium low tech Manufacturing. Medium high tech Manufacturing presents an exceptionally high level of leverage, but the trend is also declining. In general, we can find some suggestive evidence in favour of knowledge intensity in the firm contributing to lower leverage, higher cash holdings and profitability.

In the next section, we develop a model of investment in intangible capital and leverage decline, exploring demand-side factors that may not only explain deleveraging but also align with the broader trends identified in our analysis. Our analysis is centered around the role of internally developed intangible capital as key driver of firm heterogeneity in the cross section, and its changing relative productivity a main determinant of the aggregate trends we presented in this section.

4. The Model

This model has the purpose of understanding how technological trends happening at the firm level can have aggregate implications for macro-financial trends.

We start from the assumption that advanced economies are withstanding a technological long term trend characterized by increasing relevance of intangible capital in production. We conceptualize this asset as something that is developed in-house by firms and skilled workers and is a key driver of their performance. Examples of such trends are digitalization and rise of e-commerce, as well as increasing value of brand and other types of intellectual property or finally high impact of marketing on sales growth (Corrado and Hulten, 2010). We therefore lay down a framework centered around a firm level production function that can capture such features. This production function includes both types of capital and is meant to capture two basic features of intangible capital that make it distinguishable from tangible capital. The first one is internal economies of scale, that unevenly benefit firms that are able to deploy intangibles[12]. In this case, we assume it's due to their higher ability to tap into the potential of better quality human capital, hired in the form of skilled workers (Döttling et al., 2023).

[12] For other modeling approaches of this competitive advantage given by intangible capital see for instance Crouzet et al. (2022); Hsieh and Rossi-Hansberg (2023); De Ridder (2024).

The second assumption is limited appropriability: intangible capital is a co-investment between firms and skilled workers, who retain a part of the value of capital, posing a potential spillover risk for companies in case the worker is poached by a competitor (Similar to Crouzet et al. (2022) and Döttling et al. (2023)). This risk affects the marginal cost of investing in intangibles and firms keep it into account when they make their optimal investment decisions.

In the model time is discrete, the economy is populated by overlapping generations who live for two periods, providing labour when young and consuming when old. Time starts at $t = 0$ and goes on to infinity. There is an initial generation $t = -1$. Each generation is made of a representative household unit.

Each young generation is endowed with total total labour $\bar{L}$, a fraction ν made of skilled labour h, the rest of manual labour l. Moreover, the household holds initial wealth A_0 which can be invested into companies by a unique investment fund. Finally, the household owns a bank that can lend additional liquidity to firms at the interest rate r. We assume that skilled labour is relatively scarce, implying it can earn a higher salary than normal labour:

$$\frac{\nu}{1-\nu} < \frac{\alpha}{1-\alpha} \tag{1}$$

The household maximizes utility by consuming a consumption bundle of different goods produced in the economy, subject to its labour and investment income. For simplicity, at the moment we assume that all firm profits π_i are distributed to the household via dividends, but this assumption can be relaxed without harming the model outcomes presented below. Households are characterized by love for variety (Dixit and Stiglitz, 1977) and consume a bundle of goods indexed by the unit interval $\mathcal{J} = [0, 1]$. Each good $j \in \mathcal{J}$ comes in different varieties, where the discrete number of varieties per good is denoted by n_j. In year t the utility of the household from total consumption Y_t is therefore given by:

$$U(Y_t) = \left[\int_0^1 y_t(j)^{\frac{\theta-1}{\theta}} dj\right]^{\frac{\theta}{\theta-1}} \tag{2}$$

with $\theta > 1$ and where we denote with $y_t(j)$ total consumption of good j in year t. Furthermore, different varieties of good j are aggregated according to the function:

$$y_t(j) = \left[\sum_{i=1}^{n_j} y_{it}^{\frac{\eta-1}{\eta}} \right]^{\frac{\eta}{\eta-1}} \tag{3}$$

where y_{it} indicates demand for variety i of good j. Furthermore, $\eta > \theta$, so that substitution elasticity across multiple varieties of the same product is higher than across different goods.

The household chooses a mix of intermediate goods $\{y_{it}(i)\}$ from each industry j to maximize utility (2), subject to the budget constraint:

$$\int_0^1 \sum_{i=1}^{n_j} p_{it} y_{it} \; dj \leq q_t h_t + w_t l_t + \int_0^1 \sum_{i=1}^{n_j} \pi_{it} + r_t D_{it} \; dj = R_t \tag{4}$$

where p_{it} indicates the price of variety i of good j, q_t and w_t denote wages for skilled and unskilled workers respectively and $r_t D_{it-1}$ interest payment on debt issued by firm i in period $t-1$ and paid back at the beginning of period t. R_t indicates total expenditure in year t. Solving for y_{it} it is possible to derive equilibrium demand:

$$y_{it} = \left(\frac{p_{it}}{p_t(j)} \right)^{-\eta} \left(\frac{p_t(j)}{P_t} \right)^{-\theta} Y_t \tag{5}$$

with price indexes[13]:

$$p_t(j) = \left(\sum_{i=1}^{n_j} p_{it}^{1-\eta} \right)^{\frac{1}{1-\eta}} \quad , P_t = \left(\int_0^1 p_t(j)^{1-\theta} \right)^{\frac{1}{1-\theta}}$$

and $P_t Y_t = R_t$. Demand for good j of variety i is therefore inversely proportional to its price.

We can now turn to the supply side of the economy and assess how firms set prices, taking equilibrium demand (5) as given. We consider goods as synonym as industry, as an industry j is the collection of firms that produce different varieties of good j.

Within each industry, we assume that each variety of good j is produced monopolistically by

[13]So far our model resembles the set-up of the model by Atkeson and Burstein (2008), where instead of a final good producer and homogeneous preferences we introduce Dixit-Stiglitz demand for multiple goods of different varieties.

a firm, so that we have n_j firms for each industry. Firms compete à la Cournot within industry, facing equilibrium demand y_{it} defined in equation (5).

Dropping subscript i for better clarity, each firm is characterized by the production technology:

$$F(H_t, K_t, h_t, l_t) = A_t \left[\alpha (K_t^{\zeta} l_t^{1-\zeta})^{\rho} + (1-\alpha)(H_t^{\gamma} h_t^{1-\gamma})^{\rho} \right]^{\frac{1}{\rho}} \tag{6}$$

where A_t reflects a common productivity factor, $1-\alpha$ measures the relative productivity of intangible capital and high-skill labor versus physical inputs, γ and ζ capital productivity and ρ is the substitution parameter between physical and intangible factors.

We assume that in each period the firm scales up its production capacity and hires labour in order to meet demand y_{it}. In other words, the firm determines its optimal input mix of $\{K_{it}, H_{it}, h_{it}, l_{it}\}$ by minimizing cost of producing y_{it}.

We assume that each period is split into an investment and into a production phase. In the investment phase firms build up capital and hire workers, while in the production phase output is created and production factors are rewarded. We assume full depreciation at the end of each period[14].

In the investment phase, tangible and intangible capital are constructed upon paying the convex cost $c_K(K)$ and $c_H(H, \phi_i)$, respectively, where ϕ_i is a random parameter that captures the ability of a firm to retain and enhance human capital and is distributed according to the cdf $G(\phi)$. Firms take a random draw from $G(\phi)$ upon entry and maintain it unchanged as long as they are on the market. $c_H(H, \phi_i)$ is such that:

$$\frac{\partial c_H(H, \phi_i)}{\partial \phi_i} \leq 0, \; \frac{\partial^2 c_H(H, \phi_i)}{\partial^2 \phi_i} > 0 \tag{7}$$

while investment cost is assumed to be convex for both assets:

[14] While this may appear as a restrictive assumption at first sight, consider a period in our model as matching the length of a production cycle, or the life span of a particular kind of machinery. Given how we structure the demand side, this roughly coincides with the working life of one generation.

$$\frac{\partial c_m(x)}{\partial x} \geq 0, \; \frac{\partial^2 c_m(x)}{\partial^2 x} > 0, \text{ for } m \in \{H, K\} \tag{8}$$

We further assume that intangible capital is subject to an "expropriation risk". We assume that at the end of the investment phase and before production, with some probability the household has the chance to transfer intangibles to potential new entrant firm[15]. This random process is i.i.d. across firms and follows a Poisson process with parameter $\lambda(H)$, such that:

$$\frac{\partial \lambda(H)}{\partial H} \geq 0, \; \frac{\partial^2 \lambda(H)}{\partial^2 H} > 0 \tag{9}$$

implying that the expropriation risk is increasing in the stock of intangibles H. One way to think about this assumption is to imagine that firms with a higher stock of intangibles signal that they have better quality human capital (higher ϕ_i), therefore they attract more poaching offers by potential entrants aiming at stealing their business. The firm intangible capital can be seen as a continuum of projects, each with an associated share of h_t, each subject to a Poisson probability of meeting a potential poacher. It follows that for each firm the actual stock of intangibles that can be used for production is $e^{-\lambda(H)}H$.

To prevent the transfer of intangibles from happening, the firm can make a counteroffer to the household, compensating it for not expropriating the asset. The counteroffer amounts to the monetary value of the asset:

$$Q^H(H) = \left(1 - e^{-\lambda(H)}\right) H \tag{10}$$

In the case the firm cannot match the household poaching offer, the firm exits the economy as it cannot produce in the following phase and generate profits. The value of the intangible capital is used as seed investment to startup a new firm which will enter the economy with the same parameter ϕ of the exiting firm.

Based on equations (7) and (9), investment in intangible capital is shaped according to two

[15] Similarly to the spillover risk in Crouzet et al. (2022), modelled after the assumption of "imperfect appropriability" of intangible capital.

main assumptions. First, this type of assets is the output of a joint investment between human capital and firms (as in Döttling et al. (2023)), so since human capital has contributed to its creation, the household retains part of the *de facto* ownership of the asset and can transfer it to potential firm's competitors within the industry, if willing to do so. Transfer of intangibles happen with frictions and constitute an expropriation risk for firms. Second, the effectiveness of investing in intangibles depends on human capital, so firms with higher ability to enhance it also face a lower cost to create these assets.

In addition, firms face an idiosyncratic risk of physical capital destruction, which is formalized as a Poisson process with parameter $\delta > 0$, so that the value of physical capital that is left unharmed and can be used for production is $e^{-\delta}H$. The firm can replenish capital by using reserve liquidity. Given the distribution of the risk of capital destruction, reserve cash to be held in form of precautionary savings amounts to:

$$Q^K(K) = \left(1 - e^{-\delta}\right) K \tag{11}$$

Overall, we denote the amount of cash allocated to prevent the spillover risk and the capital destruction risk (precautionary savings) in period t with $Q(K_t, H_t)$, so that total investment cost is:

$$\mathcal{C}(H_t, K_t, \phi_i) = c_K(K_t) + c_H(H_t, \phi_i) + Q(H_t, K_t) \tag{12}$$

Firms start each period with leftover cash from the previous period Q_{t-1}. To finance additional investment they raise equity E_t from the household, in exchange for the profits collected at the end of the second phase. Finally, firms can collect additional liquidity by borrowing D_t in the form of a bank loan and pay the loan back at the beginning of the next period with interest rate r_t.

To make the problem interesting, we assume that there is not enough equity to cover all investment costs that firm need to incur, so that in every periods there are some firms taking up bank loans:

$$A_0 < \int_0^1 \sum_i^{n_j} \pi_{it} dj \ \forall t \tag{13}$$

Additionally, we assume that firms have a marginal preference for debt over equity, so that the resulting pecking order of their sources of finance is own liquidity (as it implies no cost), followed by debt and finally equity.

We can now present the profit maximization problem for firm i in year t:

$$\begin{aligned}
\underset{\substack{H_{it}, K_{it}, h_{it}, l_{it} \\ D_{it}, p_{it}, Q_{it}}}{max} \quad & \pi_{it} = p_{it} y_{it} - (1 + r_t) D_{it} - q_t h_{it} - w_t l_{it} - \mathcal{C}(H, K, \phi_i) \\
\text{s.t.} \quad & A_t F(E(H_{it}), K_{it}, h_{it}, l_{it}) = y_{it} \\
& \mathcal{C}(H, K, \phi_i) \leq D_{it} + Q_{it-1} + E_{it} \\
& D_{it} \geq 0 \ , \ Q_{it-1} \geq 0, \ Q_{i0} > 0
\end{aligned} \tag{14}$$

The first line of the problem above present total firm level profits given the demand for intermediate goods derived in (5). The second line contains the production function, where the actual amount of H_t used for production depends on the expropriation risk described above. The third line presents the liquidity constraint faced by the firm. All liquidity used for investment in physical capital or precautionary allocation of liquidity can be financed only with debt or retained earnings. Finally, the last line prevents firms from being net creditors or rolling over debt over time.

To solve the model, we first derive the optimal input bundle of the production function $X^*_{it} = \{H, K, h, l\}^*_{it}$ by solving a cost minimization problem with $F(X^*_{it}) = y_{it}$. This allows to derive an equilibrium solution as a function of demand: $X^*(y_{it})$[16]. This can in turn be plugged into the profit function in (15) to solve for an unconditional profit maximization:

[16]See A for the derivation of the input specific equations.

$$
\begin{aligned}
\max_{D_{it},\, p_{it}} \quad & \pi_{it} = p_{it}y_{it} - (1+r_t)D_{it} - q_t h(y_{it}) - w_t l(y_{it}) - \mathcal{C}(H(y_{it}), K(y_{it}), \phi_i) \\
\text{s.t.} \quad & \mathcal{C}(H, K, \phi_i) \leq D_{it} + Q_{it-1} + E_{it} \\
& D_{it} \geq 0 \ ,\ Q_{it-1} \geq 0,\ Q_{i0} > 0
\end{aligned}
\tag{15}
$$

From equation (5), we know that firm level demand is also a function of price p_{it} and takes into account the full price distribution to compute indexes $p_t(j)$ and P_t. Rewriting the total cost of production and investment as:

$$
\hat{\mathcal{C}}(y_{it}, \phi) = q_t h(y_{it}) + w_t l(y_{it}) + \mathcal{C}(H(y_{it}), K(y_{it}), \phi_i) \tag{16}
$$

we can find the equilibrium price distribution as the vector $\mathbf{p}$ such that:

$$
\mathbf{p} = \left\{ p > 0 : p_{it} = \text{argmax } p_{it}y(p_{it}) - \hat{\mathcal{C}}(p_{it}, \phi_i) \ , \forall i \in \{1, n_j\}, \forall j \in \mathcal{J} \right\} \tag{17}
$$

The solution is therefore a fixed point algorithm in $\{X_{it}, p_{it}, \mathcal{C}_{it}\}_{i\in\{1,n_j\},\ j\in\mathcal{J}}$ that can be solved numerically given Y, q and w. We take w as numeraire and set it equal to 1.

Concerning financial variables, it is rational for firms to use all leftover liquidity from the previous period Q_{t-1} to finance investment, while since the distribution of ϕ is common information, the equity fund can anticipate that firms with higher ϕ will generate higher profits in expectation. Given that the model still involves risk from capital destruction or expropriation of intangible capital, it follows that the equity fund will diversify its investment portfolio offering equity E_i to firm i proportionally to its expected return. The investment fund can anticipate that in expectation firms with higher ϕ_i have a higher probability of generating higher profits, therefore it is more attractive to invest in them. At the same time, each firm faces idiosyncratic risk of exiting the market between the investment and the production phase as either intangible capital is expropriated or physical capital is destroyed - or both - if the realized loss due to the shock is higher than the firms liquidity reserves $Q(H_{it}, K_{it})$. For this reason, it is rational to diversify the investment and build a portfolio of companies to ensure positive returns[17].

$$E_{it} = \frac{\phi_{it}}{\int_0^1 \sum_{i=1}^{n_j} \phi_{it} dj} A_0 \tag{19}$$

Any remaining financial need will then be met by firms via issuing debt, which is therefore:

$$D_{it} = max\{0, \mathcal{C}_{it} - Q_{it-1} - E_{it}\} \tag{20}$$

Total interest payments will implicitly define the minimum $\underline{\phi}_t$ below which firms cannot break even through the equation:

$$\underline{\phi}_t = \{\phi_i \in S_G \ : \pi(\underline{\phi}_t) = 0\} \tag{21}$$

where S_G is the support of the cdf $G()$.

We finally pin down Y_t and q_t from market clearing condition on the goods market and skilled labour markets:

$$\begin{aligned} P_t Y_t &= \int_0^1 \sum_{i=1}^{n_j} p_{it} y_{it}(q_t, Y_t) dj \\ \nu \bar{L} &= \int_0^1 \sum_{i=1}^{n_j} h_{it}(q_t, Y_t) dj \end{aligned} \tag{22}$$

as both p_{it} and y_{it} are functions of Y_t and q_t. Q_{t-1} can be solved for by solving the model as t increases, given the initial distribution $\{Q_0\}$. Each firm will have a cash endowment that is the result of the leftover cash from the previous period, kept in the form of precautionary savings[18].

[17] In this case, the problem is simplified by the expectation that all firms will distribute dividends. In case this was not the case, the fund would not have an incentive to invest in the firm. In case the fund expected dividends to be a share ϵ_{it} of total profits, their expected value would also factor in the determination of the weights in equation (19), which would become:

$$E_{it} = \frac{\epsilon_{it}\phi_{it}}{\int_0^1 \sum_{i=1}^{n_j} \epsilon_{it}\phi_{it} dj} A_0 \tag{18}$$

[18] If we assume the firm not to pay out all profits as dividends, then any form of retained earnings would also sum up to the leftover cash.

As the spillover risk increases exponentially with the firm intangible capital, the overall cash distribution does not degenerate as no firm can grow their cash holdings fast enough[19].

Figure 20 shows the simulation result of a static equilibrium over a two industries economy, plotting key variables as a function of ϕ. The first row presents, from the left ot the right, firm level market shares, price cost markups and prices. It is possible to see how firms with higher levels of ϕ can charge a lower price, therefore attracting more demand at an increasing rate the more they are able to lower the price. This enables them to charge a progressively higher markup, computed as the share between the price and the marginal cost, a standard property of double nested CES demand and monopolistic competition (Atkeson and Burstein, 2008). This is a synonym of higher profitability. The mechanism that enables this find its foundations in the comparatively cheaper cost if investing in intangibles, which builds economies of scale that make the firm more competitive. In equilibrium, the second line of Figure 20 shows how firms with higher ϕ_i become more intensive in intangibles, increasing intangible capital deepening and cash holdings. As these firms employ more productive human capital, the share of skilled workers over the total workforce is actually declining in ϕ_i.

Figure 21 displays a simple transition from the previous equilibrium to another one where α has decreased from 0.5 to 0.3, implying an increase in relative productivity of intangible capital in the production function 6. It is possible to see how overall, the economy becomes more intensive in intangibles, which leads to higher markups and profitability, as well as higher cash holdings. Finally, it is also possible to notice that firms with higher levels of ϕ also reduce leverage, as they need less debt due to the abundance of leftover liquidity from previous periods. Since these firms are generally larger, they bring the average leverage also to decline, as we show in our empirical results[20].

[19] At the same time, the overlapping generation structure of demand ensures that firms eventually distribute dividends, otherwise they would not have access to the equity market as the young generation would not invest in a firm if that one would not grant any returns to be consumed when old.

[20] We are currently working at multiple simulations presenting a horse race between the ability of the model to match the data assuming different shocks: first, an overall increasing credit tighteness with debt being more costly (increasing r) and tight to the share of phisical capital K, second a declining A as a proxy of declining aggregate productivity.

4.1. Model Extension

We are currently working on an extension of the model that allows to test two alternative explanations of leverage decline: changing credit tightness and declining corporate tax. In the model extension, we introduce two changes: first, we introduce a government that collects a tax τ on corporate profits and distributes them to the household. We allow for a deduction of interest payment, to insert into the model a mechanism of tax shield on debt. More explicitly, taxes are a decreasing function of interest payments:

$$\tau_t = \tau(rD) = \bar{\tau}\kappa(rD),\ \frac{\partial \tau}{\partial rD} < 0 \text{ and } \tau(0) > 0 \tag{23}$$

Moreover, credit is cheaper for firms that can provide collateral, which we operationalize making interest rate a decreasing function of the firm capital stock:

$$r_t = r(K),\ \frac{\partial r}{\partial K} < 0 \text{ and } r(0) > 0 \tag{24}$$

These additional model components make it possible to test for the possibility of credit constraints getting tighter over the sample horizon via changes in r_t. Similarly, changes in corporate taxes (i.e. in $\bar{\tau}$) can also be tested.

5. Intangible Capital and Credit Supply Shocks

In this section, we investigate alternative explanations for the empirical regularity reported in the literature that industries that are more intensive in intangible assets have lower leverage. One potential explanation that has been suggested is that intangible capital provides poor collateral when a firm applies for a bank loan (Dell'Ariccia et al., 2021). Indeed, it is harder to measure the market value of intangible assets when compared to tangible, mainly because these assets have typically a firm specific value which makes them hard to transfer (Corrado and Hulten, 2010). As they are oftentimes "knowledge stored on a physical support" (Crouzet et al., 2022), enforcing property rights on many classes of intangible capital is also difficult, due to the non-excludability of knowledge itself. This reduces the share of rents from the asset that can be appropriated by the owner, among others also reducing the incentives to invest in such assets.

At the same time, intangible capital may be associated with less debt at the firm level also because investing in this class of assets requires less cash in advance. Intangible capital is often the outcome of an employment relationship between an employer and human capital, so that the main component of the investment cost in intangibles is made of personnel costs (National Science Board, 2024). Cloud computing has further enabled firms to outsource services and reduce fixed expenditures (Ewens et al., 2018; Hsieh and Rossi-Hansberg, 2023), reducing the capital cost of developing software and data.

The two theories presented above offer different implications for how firms may react to a shock in more stringent collateral requirements to obtain a bank loan. If intangible capital is associated with lower leverage due to its nature of poor collateral, then industries that tend to be more intangible capital intensive should be impacted more severely in terms of leverage growth than other industries, after controlling for assets. Vice versa, intangible intensive industries will be less impacted by the same shock, compared to other industries.

We use the CompNet data to empirically test the consequences of this specific kind of credit shock merging our CompNet data with aggregate results from the ECB run Bank Lending Survey (BLS). The Bank Lending Survey (BLS) is a quarterly survey conducted by the European Central Bank (ECB) in collaboration with national central banks of the Eurozone. The survey collects qualitative information on credit market conditions by assessing changes in bank lending standards, loan demand, and factors influencing credit supply and demand. The primary respondents to the survey are senior loan officers from a representative sample of significant euro area banks. These institutions provide insights into lending conditions for enterprises and households, covering developments in corporate loans, small and medium-sized enterprise (SME) financing, and mortgage and consumer credit markets. The results are published quarterly, offering a timely gauge of credit dynamics that complements quantitative data on bank lending. We focus on items of the questionnaire that ask whether credit standards or credit terms undergo a net tightening due to collateral requirements. The survey releases data on the share of interviewed individuals who answer 'yes', net of those who answer 'no'. The resulting index is therefore a measure of the tightening (easing) of access to credit due to collateral requirement whenever it takes on positive (negative) values. Figure 22 presents yearly changes in the index for a subset of the countries in our original sample between 2003 and 2020. These are also the countries we end up including in this analysis, as the others need to be excluded due to data availability (see below). It is possible to notice that the index is in line with a peak in credit tightening taking place around the years of the 2008 global financial crisis, while it was substantially eased in the years before and even more in the aftermath of 2016 QE.

For our empirical analysis, we interact this country level measure of credit shocks with an industry level trend measure of intangible intensity. The goal of the analysis is to construct a shift-share econometric exercise to identify the impact of credit shocks on changes in leverage (Borusyak et al., 2022). The effectiveness of this approach in achieving identification rests on the assumption of orthogonality between the assignment of the shocks and the exposure to such shocks. It is not hard to imagine how there might be some unobservable factor underlying the intensity in intangible assets of industry j in country c and credit shocks happening to the banking system in country c. For this reason, we instrument intangible intensity for industry j in country c with the intensity in intangibles of the same industry, but in the United States. The approach assumes that this variable is primarily driven by technological factors that are largely common between the US and the European countries in our sample. For example, the reliance of Professional Services on software, data, intellectual property and knowledge in Germany is correlated with that of the same industry in the US, while the tightness of bank credit in Europe does not play a role in determining intangible intensity of Professional Services in the US.

Measuring intangible capital presents significant challenges due to its inherent characteristics. Unlike physical assets, intangible assets such as data, patents, software, brands, and organizational capital lack a physical presence, making them difficult to quantify and value accurately. This intangibility leads to complications in accounting frameworks, as traditional methods are often inadequate for capturing the value of assets that do not have observable market prices Eberly (2022). Additionally, intangible assets can experience rapid and unpredictable depreciation or obsolescence, further complicating their measurement. The absence of secondary markets for many intangible assets means that their valuations cannot be easily benchmarked against market transactions, increasing the uncertainty in their assessment. As a result, firms and economists face substantial obstacles in integrating intangible capital into financial statements and economic analyses, which can lead to an incomplete understanding of a firm's true value and the economy's productive capacity Corrado and Hulten (2010).

In this study we focus on a proxy used in Eisfeldt and Papanikolaou (2013) and Eisfeldt and Papanikolaou (2014), made by SG&A expenditure in the firm. SG&A can serve as a useful proxy for the presence of intangible capital within a firm because they often include significant investments in brand development, customer relationships, employee training, and organizational knowledge. Unlike tangible assets, these expenditures do not appear as capitalized assets on a firm's balance sheet, yet they contribute to long-term competitive advantages. High SG&A spending, particularly on marketing, R&D, and employee compensation, suggests a firm's focus on building and maintaining intangible assets such as brand equity, human capital, and proprietary business processes. As a result, firms with substantial SG&A expenses may possess valuable but unrecorded intangible capital that drives future profitability and market value. We source SG&A data for US firms from Compustat and aggregate it at the same industry level as in CompNet.

Figure 23 presents average SG&A over sales (denoted by intangible intensity in the graph) by macro industry. The variable is highest in knowledge intensive services such as ICT, professional services and administrative and support services and it is overall stable over time in each industry. Figure 24 ranks industries into 5 quantiles based on their intangible intensity each year and plots average leverage over time in each quantile. We find that industries located in the top quintile of the intangilbe intensity distribution are those that experience the strongest decline in leverage.

Once we merge data on changes in credit constraints with the measure of intangible intensity, we prepare a dataset at the industry level including a set of additional control variables: the log of total assets, cash over total assets, intangible capital over total assets at book value[21],

[21] This variable is available in the CompNet dataset and captures intangible assets that have been purchased externally rather than developed in-house. These assets include goodwill, intellectual property legally protected such as patents or trademarks, licences and franchise and software. The variable is not available across all countries and is subject to heterogeneous reporting standards across countries, hence we include it as a control variable rather than as main explanatory variable in our regression.

investment as a share of tangible capital, ROA[22] and collateral over total assets[23]. This process leaves us with a sample covering the years between 2005 and 2019 and including Finland, France, Germany, Italy, Portugal and Spain [24].

On the data we run a set of regressions using a local projection framework, estimating the impact of changes in credit tightness in year t on changes in leverage between year t and $t+h$, where $h \in [0,7]$. As leverage is a persistent variable, we allow for a long time horizon for it to react to credit supply shocks. The main regression equation we use is the following:

$$\begin{aligned}\Delta l_{jc(t,t+h)} =& \alpha_0 + \alpha_c + \alpha_t + \beta_{1h} \Delta CC_{c,(t-1,t)} \cdot \frac{1}{\underline{s}} \sum_{\tau=t-s}^{t} Int.Intens_{j\tau} + \\ & \beta_{2h} \Delta CC_{c(t-1,t)} + \beta_{3h} \frac{1}{\underline{s}} \sum_{\tau=t-s}^{t} Int.Intens_{j\tau} + \mathbf{X}_{jct} \cdot \gamma + \epsilon_{jct}\end{aligned} \tag{25}$$

The regression is run using moments aggregated from the underlying firm level population, so the unit of analysis is at the industry level. j, c and t denote industry, country and year. The dependent variable $\Delta l_{(t,t+h)}$ is changes in leverage between year t and $t+h$, $\Delta CC_{c,(t-1,t)}$ indicates changes in credit constraints in country c between $t-1$ and t, while $Int.Intens_{jt}$ indicates intangible intensity in industry j and year t. In the regression we average this variable in the 3 years before the shock[25] to obtain a more robust measure of the exposure to the credit shock. $\mathbf{X}_{jct}$ includes control variables (see above) and α_c and α_t denote country and year fixed effects. The regression includes three main coefficients to test the implications of credit tightening on firm leverage: on the one hand, β_{2h} capture the average impact of changes in credit tightness on leverage between year t and year h. β_{3h} on the other hand captures how changes in leverage between year t and year h are affected by average intangible intensity in years $t-2$, $t-1$ and t. Finally, our main coefficient of interest is β_{1h}, as it captures the

[22]This variable is defined in the CompNet dataset as operating profit over the average between current year and previous year total assets value.

[23]This variable is defined in the CompNet dataset as the value of nominal capital over total assets, where capital is the sum of tangible and intangible capital at book value.

[24]Relaxing the number of control variables to be included in the regression allows for a larger sample to be included, while results are qualitatively unchanged.

[25]As additional robustness test, we also try averaging in the previous 2 or 4 years, but the results do not change.

interaction between intangible intensity and credit shocks. Comparing this coefficient to β_{2h} gives a measure of whether firms in intangible intensive industries react to credit shocks driven by changes in collateral requirements differently than other firms. If β_{1h} is significant and points in the opposite direction of β_{2h}, it implies that changes in collateral requirements have the opposite effect on these firms if compared with the rest of the economy.

The main hypothesis we test have the following implications for the sign of β_{1h} and β_{2h}. If intangibles are associated to lower leverage because they provide poor collateral, we expect β_{2h} and β_{1h} to be both negative and significant: tighter collateral requirements would lead to a reduction in leverage on average and intangible intensive firms would experience a stronger reduction. On the other hand, if intangibles are associated to lower leverage because firms demand less debt overall, we should expect β_{2h} to be negative and significant, while β_{1h} positive and significant: tighter collateral requirements would lead to a reduction in leverage on average, but intangible intensive firms would experience a lower reduction.

Regression coefficients are reported in Figure 25. The Figure presents three panels, where we plot β_{2h}, β_{3h} and β_{1h} in Panels A, B and C respectively. Each panel presents the estimated coefficient and 95% confidence intervals for different values of h on the x axis. Panel A shows a negative coefficient declining on the estimation horizon h. The coefficient matches the expected direction of the effect: ceteris paribus a net credit tightening (loosening) due to collateral requirements makes it more (less) costly for firms to issue new debt, bringing firms to reduce (increase) leverage in the following years. While this effect is not significant on impact, our results imply that an increase in net credit tightness by 1% between year $t-1$ and year t bring to a reduction in the leverage ratio for the average firm by around 0.5% in year $t+1$ compared to year t, and 2.5% in year $t+7$ compared to year t. Panel B shows the coefficient of intangible intensity on leverage, which displays on average a negative coefficient, albeit not significant. Panel C presents the main coefficient of interest, i.e. the differential effect that credit shocks have on intangible intensive firms. This coefficient is positive although not significant at the 5% level until $h = 4$, while it is significant at the 10% level for $h = 2$ onwards. The coefficient increases in magnitude as the horizon grows, partly compensating the negative impact of credit tightening on leverage.

We next focus on a set of robustness tests to confirm the stability of our estimates. First, we repeat the estimations averaging Intangible Intensity over 2 and 4 years instead of 3. Results are reported in Figure B.2 and Figure B.3, respectively, confirming our findings. One source of concern regarding our design is that in our sample we are pooling together both episodes of credit tightening and credit loosening, assuming that the effects of these two types of events are symmetric. To drop this potentially restrictive assumption, we run our estimation separately for periods of tightening of credit constraints and for periods of loosening. Results are reported in Figure 26 for when we restrict to tightening only and in Figure 27 for loosening only[26]. Restricting to only periods of credit tightening confirms our findings and increases the magnitude of the coefficients by around 1p.p., while focusing on periods of credit loosening has essentially not significant effect on leverage changes. It follows that what drives the β_{1h} coefficient we obtained in the main regression are periods of credit tightening. As an additional concern, when we measure the impact of credit tightening on leverage growth over horizon $h > 1$, we may actually compute the cumulated impact of multiple shocks - possibly in different directions and magnitude - harming the actual identification of a causal impact. We therefore repeat the regressions so far, but this time, for each regression over horizon h, we identify credit shocks that are more than 1.5 times in absolute value any other credit shocks that follows in the next h years. This allows to only focus on exceptional years, which reduces the probability of actually confounding the impact of a credit shock in those years with those that follow. The drawback of this approach is that we can count on a smaller sample size, therefore we reduce the maximum horizon of the regression to $h = 3$.

Results for the baseline specification are presented in Figure 28, which confirms both the magnitude and the direction of both the average coefficient of credit shocks β_{2h} and of the interaction terms β_{1h}. Also in this case, we restrict to period of pure credit tightening and pure credit loosening. Due to data limitations we are forced to further limit the maximum horizon to $h = 2$, pure credit tightening episodes are presented in Figure 29 and pure credit

[26] Also in this case, we run the regression averaging intangible intensity over three years before the shock. Results with varying the number of years to 2 and 4 are available in Figure B.4 and Figure B.5 for hepisodes of credit tightening only and in Figure B.6 and Figure B.7 for periods of credit loosening only.

loosening episodes are presented in Figure 30[27]. Still, the results confirm our findings in the main regressions.

These results are inconsistent with the hypothesis that intangible firms are more susceptible to credit tightening due to their assets constituting poor collateral, as these firms do not reduce leverage as consistently as the other firms when faced with tighter credit due to collateral requirements. In fact, the regression results are coherent with other motivations behind falling leverage among intangible intensive firms, for instance lower demand for credit.

6. Conclusions

This paper documents a steady and prolonged decline in corporate leverage in the near-universe of firms from two major EU economies, broadly consistent with aggregate leverage patterns in advanced economies. Granular data on a large sample of firms across EU countries offers perspective beyond evidence on large listed firms. We find that debt usage has been decreasing at a similar rate in good and bad times, among multiple types of firms, industries and countries. Such common trends seem hard to reconcile with rising financial constraints, and points to structural changes in the real economy.

Credit demand may fall under secular stagnation, with declining tangible investment despite interest rates at historical lows. Declining economic prospects reduces credit demand and its supply. Emerging sectors focus on intangible capital creation, which is created over time with significant human capital investment rather than acquired upfront. Innovative firms tend to have much lower or even negative leverage.

The evidence points to a strong secular decline in investment funding needs, and rising usage of internally created intangibles in growing firms. In fact, the decline in leverage appears more rapid for technologically advanced industries. A persistent challenge to assess the relative contribution of these structural changes is lack of good measures of intangibles, under- or unreported on balance sheets under current accounting rules. We will explore how to assess credit demand is changing in the new economic environment.

[27] Also in this case we try computing intangible intensity over different time horizons (2 and 4 years) and results do not change.

We present a modeling framework focused on the rising relative productivity of intangible capital. This theoretical setup can account for multiple trends we observe in the data, such as declining leverage, increasing cash holdings and profitability. Our model also matches the empirical evidence on increasing market power and dispersion in firm growth and size, phenomena that have already been highlighted by the literature on declining business dynamism.

Our paper also sheds light on the mechanism behind the association between intangible intensity and corporate leverage at the firm level. It does so with a shift share econometric design aimed at identifying the causal impact of credit shocks driven by changing collateral requirements on firm leverage growth, assessing the differential impact this has on intangible intensive firms. We show that these firms have lower susceptibility to this kind of shock than average. This suggests that the poor collateral nature of intangibles might not be the dominant determinant behind these firms' lower reliance on debt. Theories that focus on different financial needs behind investment in intangible capital (such as lower cash in advance, for instance) might be better suited for understanding the general corporate finance trends we observe in modern companies.

The impact on financial stability of declining leverage is mixed as it depends on the drivers of the trend. The secular stagnation view suggests lower leverage may not imply a decline in corporate credit risk. The general equilibrium effect of falling credit demand include a steady reallocation of credit towards financing existing assets, such as housing. As mortgage credit funds a more cyclical asset class, this may increase correlated risk in the future (Beck et al., 2023). Future research on a larger set of countries is necessary to address long-term stability concerns.

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Table 1: Country Coverage

	Years	Number of Firms (CompNet)		Number of Firms (Population)	
Country		First Year	Last Year	First Year	Last Year
Belgium	2000-2020	6915	11197	15200	16054
Croatia	2002-2021	3872	6070	6462	6834
Czech Republic	2008-2020	15375	9808	21216	21586
Denmark	2001-2020	10288	9755	15198	12670
Finland	1999-2020	6044	9471	8473	10611
France	2003-2020	79801	86442	107491	97193
Germany	2001-2018	-	-	36607	186987
Hungary	2003-2020	11957	11936	16267	15347
Italy	2006-2020	53001	51432	94578	75769
Latvia	2007-2019	4155	4271	5765	4466
Lithuania	2000-2020	4409	6183	5788	7067
Netherlands	2007-2019	19506	23399	28977	27022
Poland	2002-2020	27733	31747	38656	48972
Portugal	2010-2020	18231	19261	18598	20982
Romania	2005-2020	23654	21788	25172	25447
Slovakia	2004-2019	3987	13160	5521	14877
Slovenia	2006-2021	2717	3380	3209	4418
Spain	2008-2020	20187	23846	77145	70137
Sweden	2003-2020	12635	15669	16999	19370

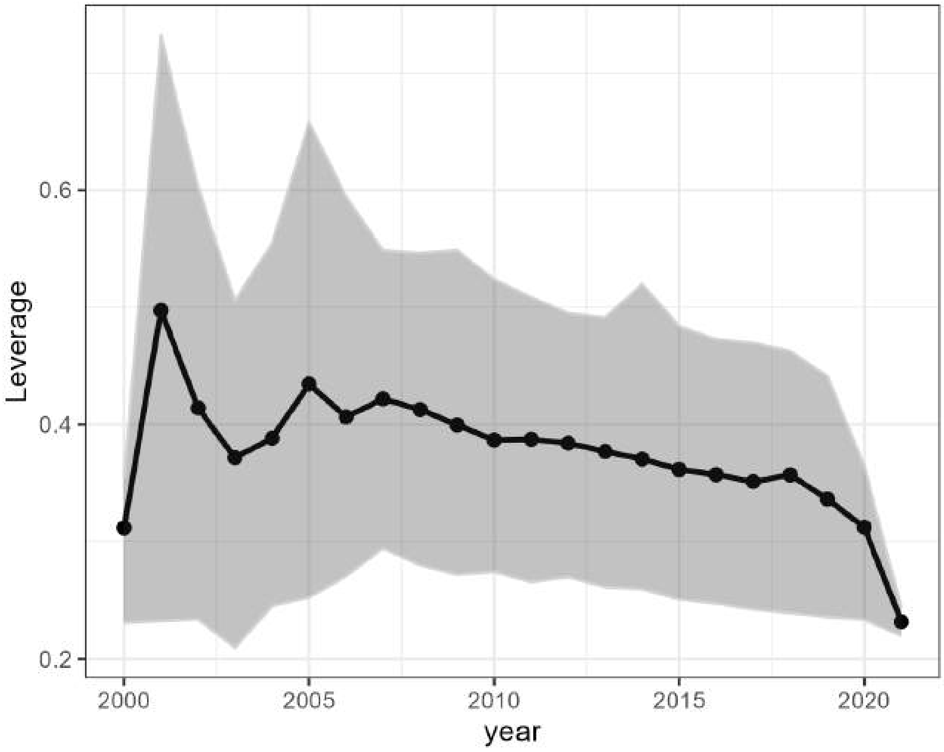
Note: The table presents the number of firms in the sample by country and year. The "CompNet" columns represent firms from the Competitiveness Network dataset, while "Population" columns refer to the full population of firms in the country. Missing values in Germany are indicated by a dash (-) and are due to confidentiality requirements.

Table 2: Macro-Sector Coverage

	Number of Firms (CompNet)		Number of Firms (Population)	
Macrosector	First Year	Last Year	First Year	Last Year
Manufacturing	92618	110545	197383	175831
Construction	33890	41176	53560	71740
Wholesale & Retail Trade	60685	84292	95686	144618
Transportation	18147	29701	32974	52765
Accommodation & Food Serv.	12619	28290	25958	66096
ICT	10096	17844	17763	29820
Real Estate	3933	4708	6488	8530
Professional Services	14060	26133	41614	50530
Admin & Support Services	15125	30847	32595	60398

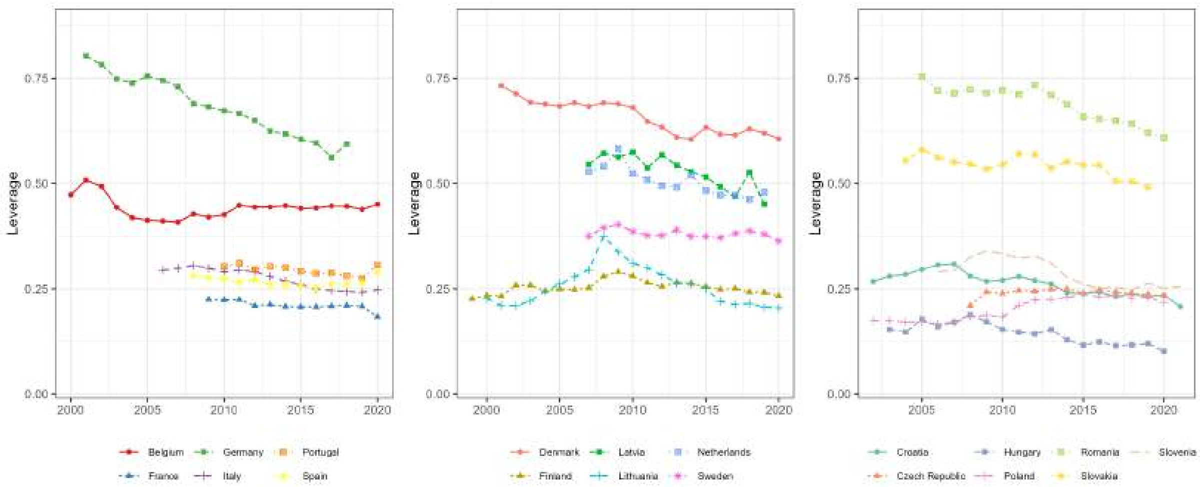
Note: The table presents the number of firms in the sample by macrosector (1 digit level of NACE REv.2 classification) and year. The "CompNet" columns represent firms from the Competitiveness Network dataset, while "Population" columns refer to the full population of firms in the country.

Figure 1: Time-Series Evolution of Corporate Leverage



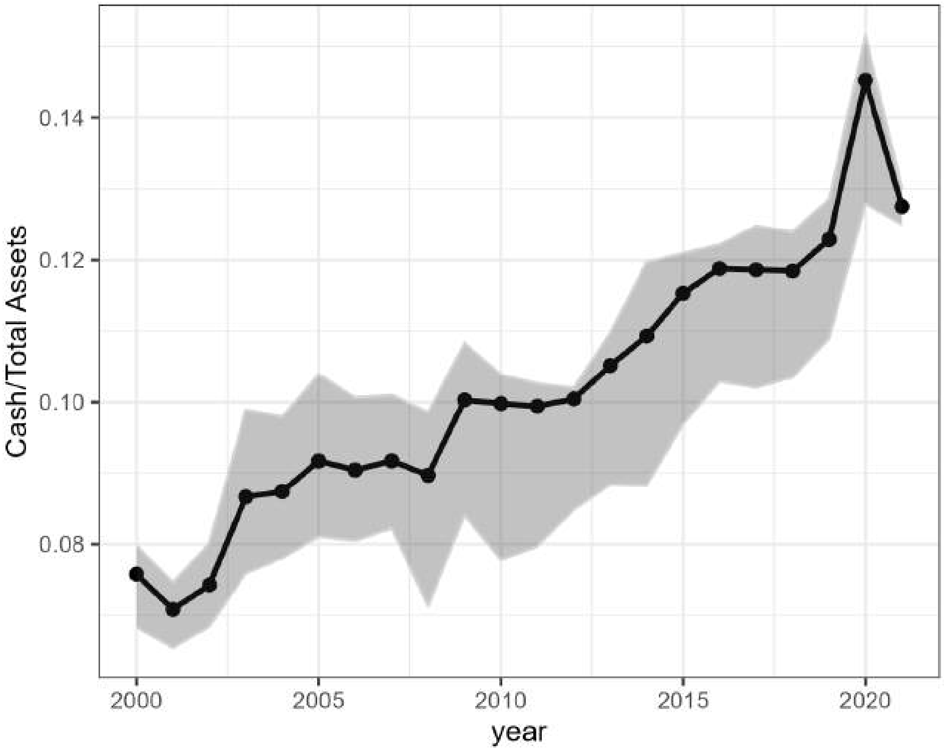
Weighted average of gross corporate leverage in the solid line, while the shaded area include leverage values between the 25th and 75th quantiles. Total Assets are used as weights. Gross leverage is defined as total debt over total assets at book values.

Figure 2: Time-Series Evolution of Corporate Leverage - Country detail



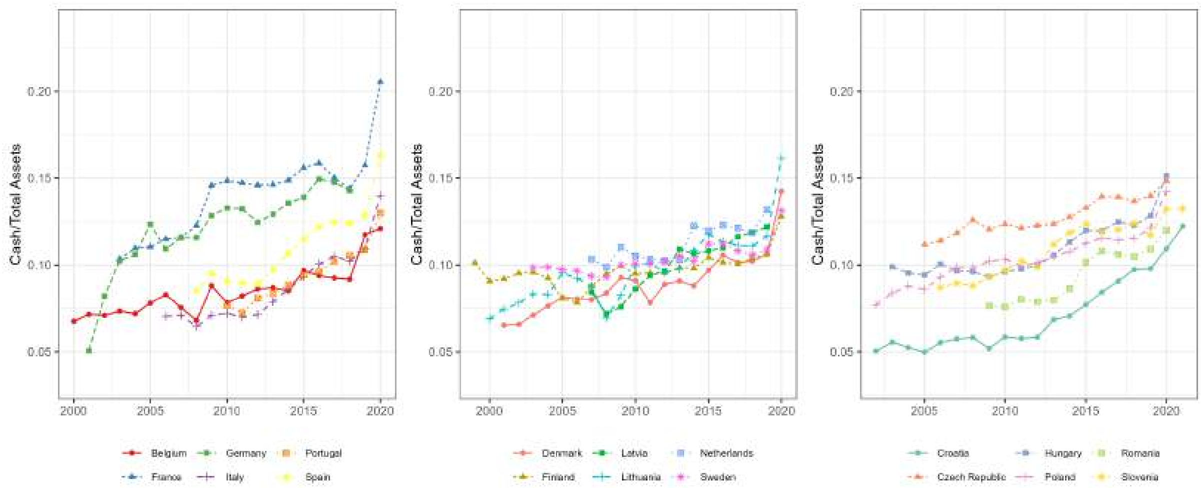
Weighted average of gross corporate leverage by country. Total Assets are used as weights. Gross leverage is defined as total debt over total assets at book values.

Figure 3: Time-Series Evolution of Cash Holdings



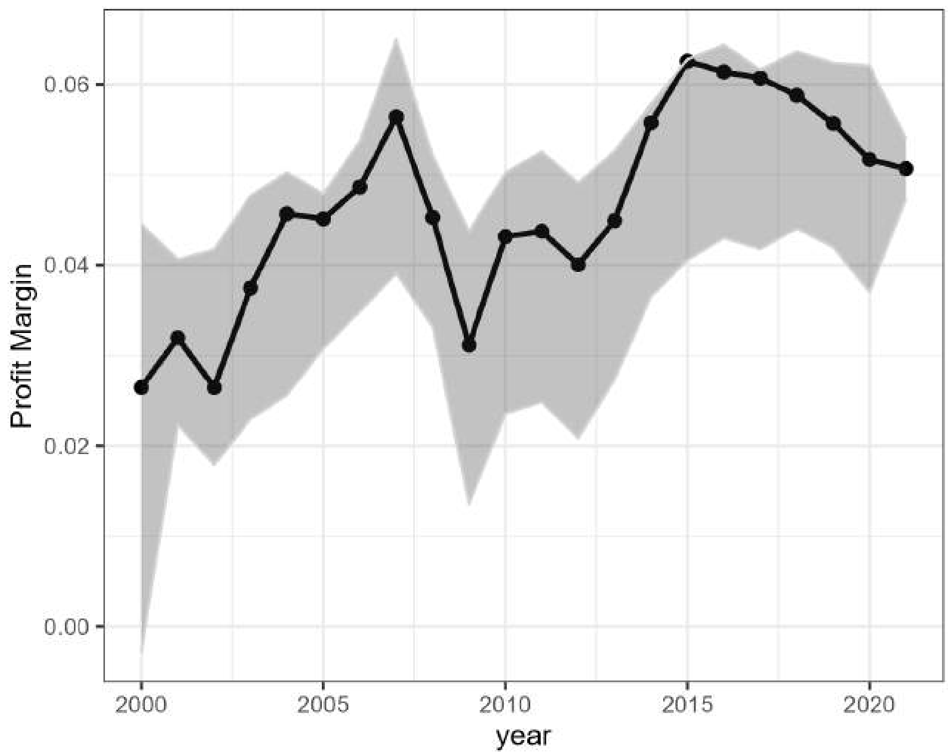
Weighted average of cash holdings as a share of total assets in the solid line, while the shaded area include values between the 25th and 75th quantiles. Total Assets are used as weights.

Figure 4: Time-Series Evolution of Cash Holdings - Country detail



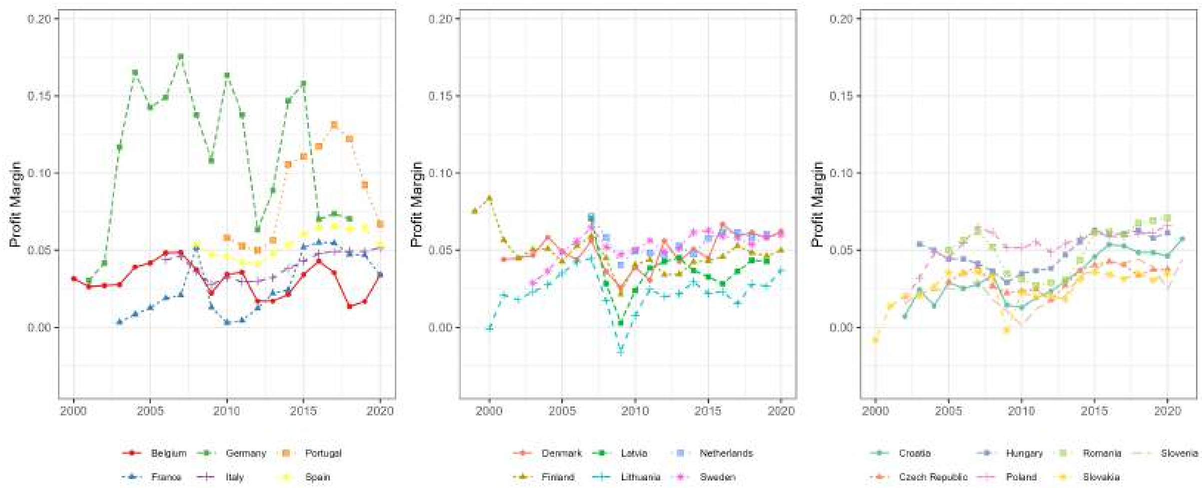
Weighted average of gross corporate leverage by country. Total Assets are used as weights.

Figure 5: Time-Series Evolution of Profit Margin



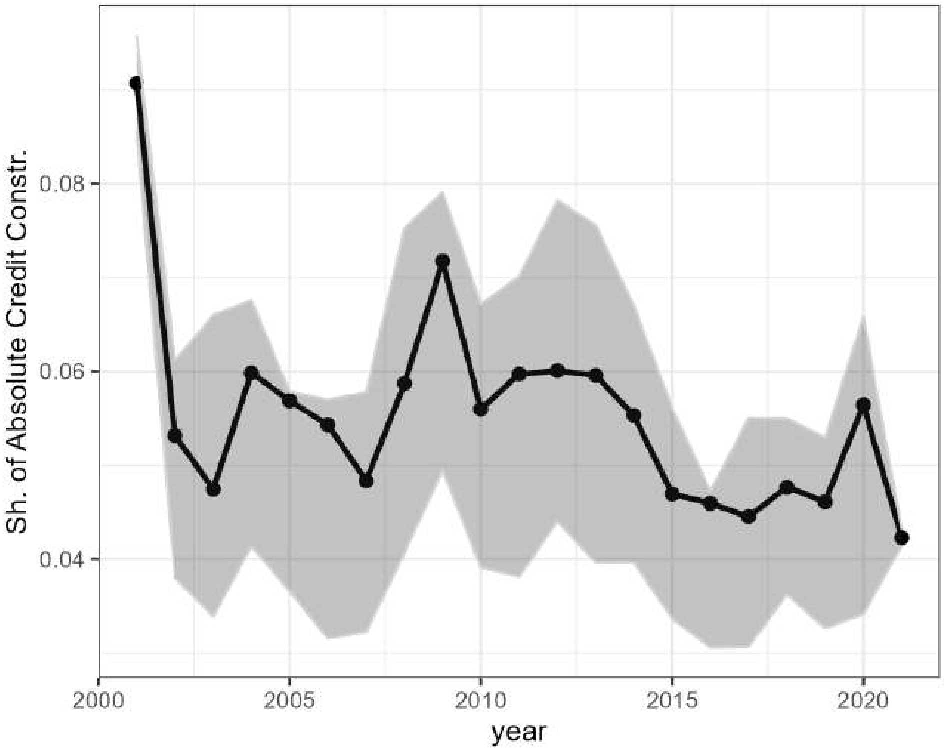
Weighted average of operating profits (EBIT) as a share of sales in the solid line, while the shaded area include values between the 25th and 75th quantiles. Total Assets are used as weights.

Figure 6: Time-Series Evolution of Profit Margin - Country detail



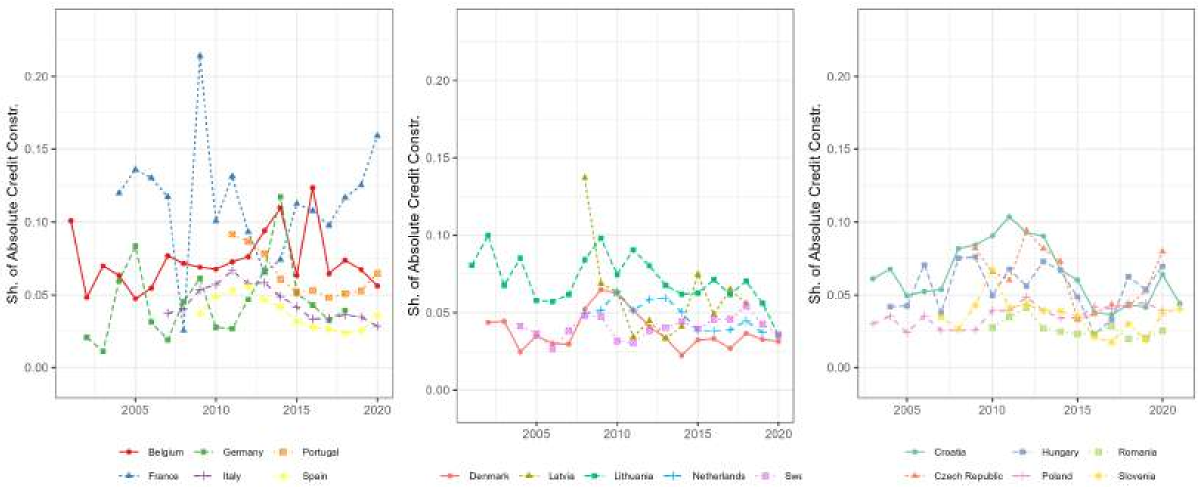
Weighted average of operating profits (EBIT) as a share of sales by country. Total Assets are used as weights.

Figure 7: Time-Series Evolution of Share of Constrained Firms



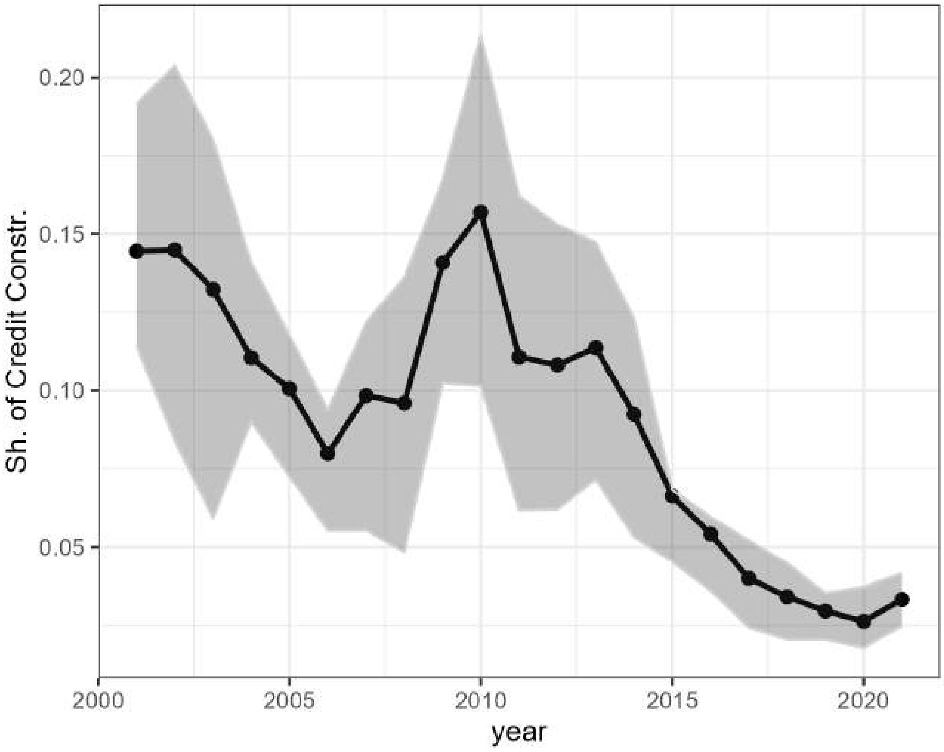
Weighted average of industry level share of credit constrained firms, while the shaded area include values between the 25th and 75th quantiles. Total Assets are used as weights. A firm is considered credit constrained if it has positive investment and total investment higher than the current cash flow as well as a concurrent reduction of debt and capital. Alternatively, a firm is considered constrained if, although disinvesting, has a positive financing gap.

Figure 8: Time-Series Evolution of Share of Constrained Firms - Country detail



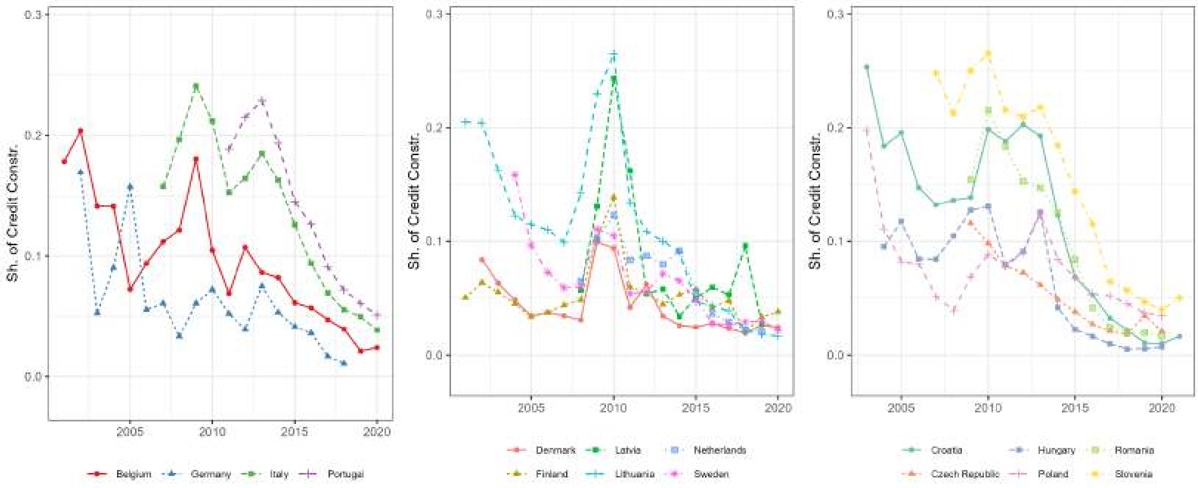
Weighted average of industry level share of credit constrained firms, by country. Total Assets are used as weights. A firm is considered credit constrained if it has positive investment and total investment higher than the current cash flow as well as a concurrent reduction of debt and capital. Alternatively, a firm is considered constrained if, although disinvesting, has a positive financing gap.

Figure 9: Time-Series Evolution of Share of Constrained Firms, SAFE definition



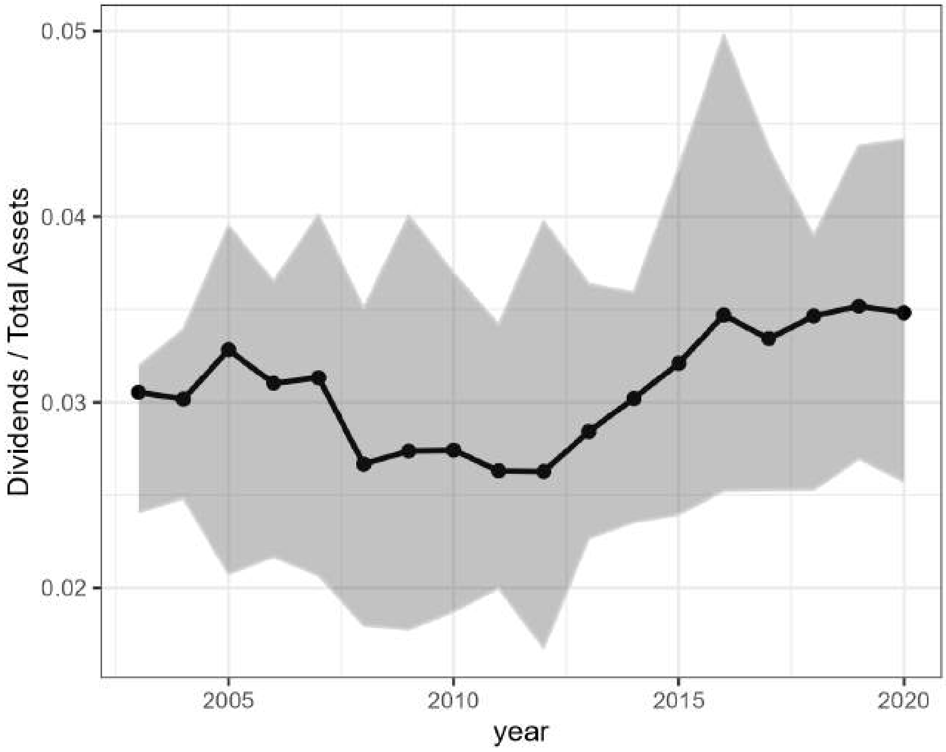
Weighted average of industry level share of credit constrained firms, while the shaded area include values between the 25th and 75th quantiles. Total Assets are used as weights. A firm is considered credit constrained based on the methodology described in Ferrando and Ruggieri (2018).

Figure 10: Time-Series Evolution of Share of Constrained Firms, SAFE definition - Country detail



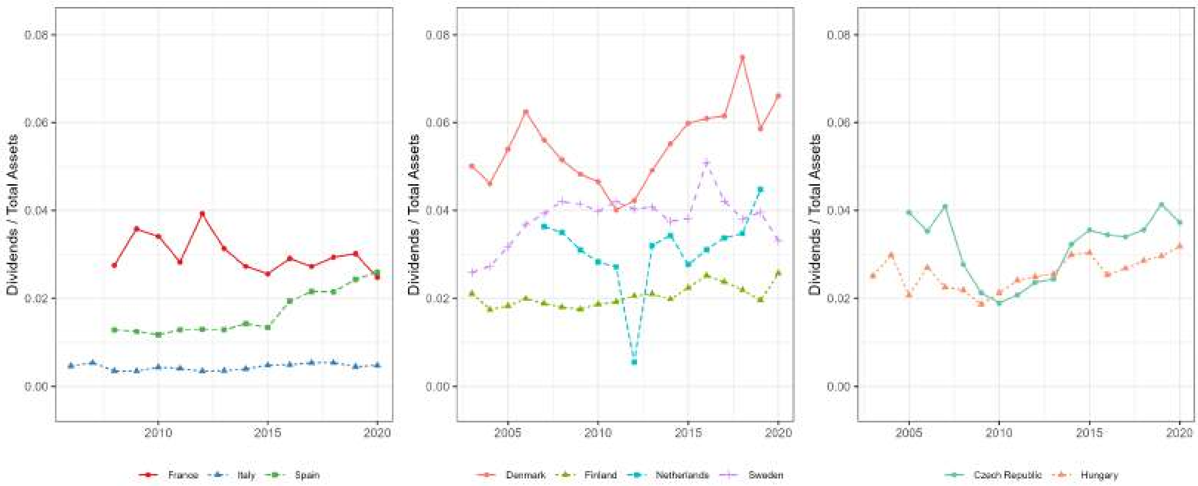
Weighted average of industry level share of credit constrained firms, by country. Total Assets are used as weights. A firm is considered credit constrained based on the methodology described in Ferrando and Ruggieri (2018).

Figure 11: Time-Series Evolution of Dividends



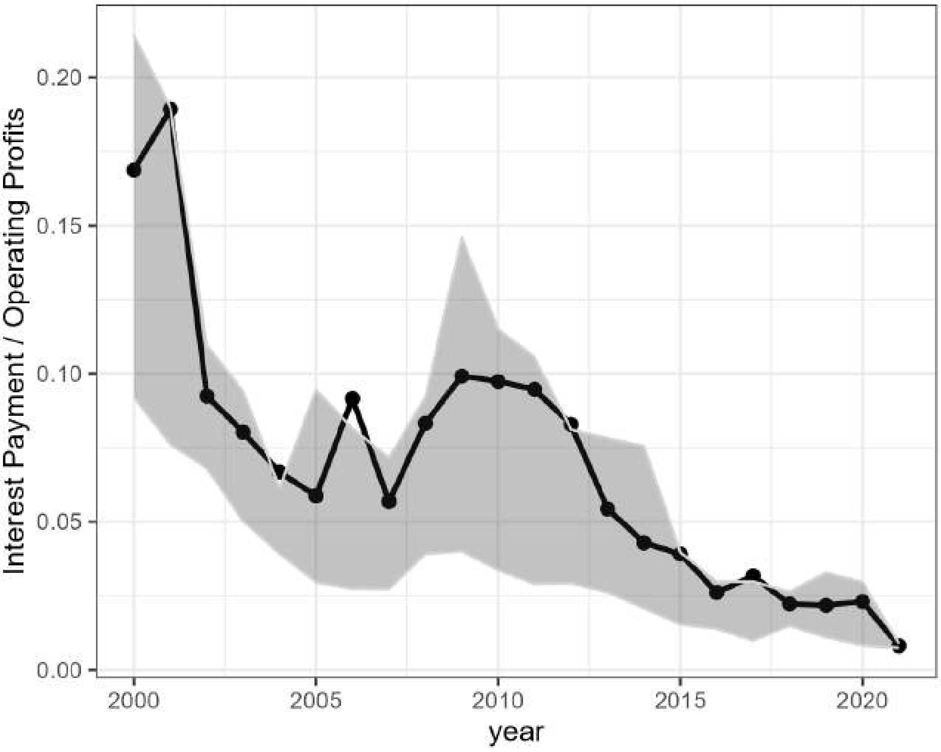
Weighted average of dividends over total assets, while the shaded area include values between the 25th and 75th quantiles. Total Assets are used as weights.

Figure 12: Time-Series Evolution of Dividends - Country detail



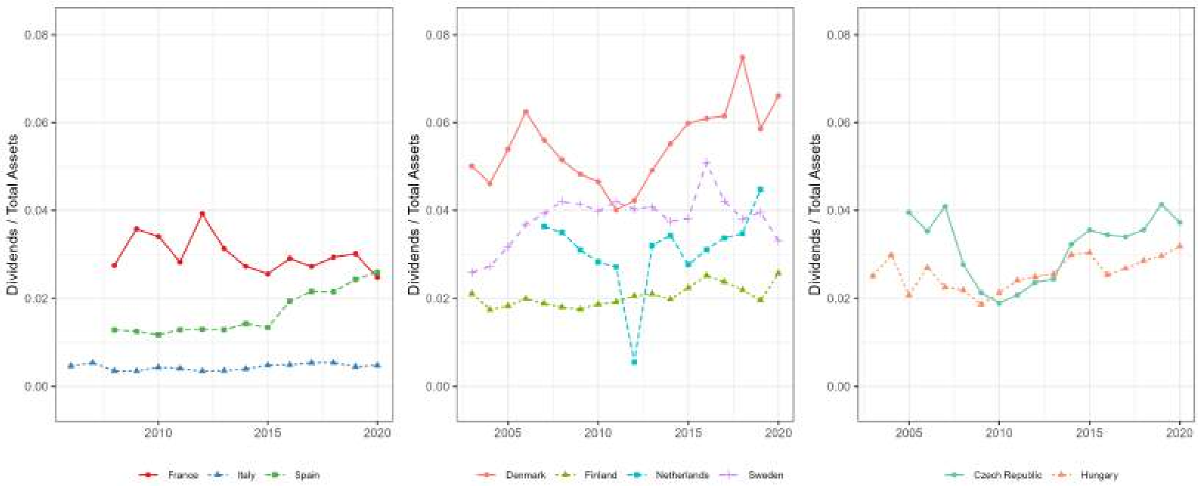
Weighted average of dividends over total assets by country. Total Assets are used as weights.

Figure 13: Time-Series Evolution of Interest Burden



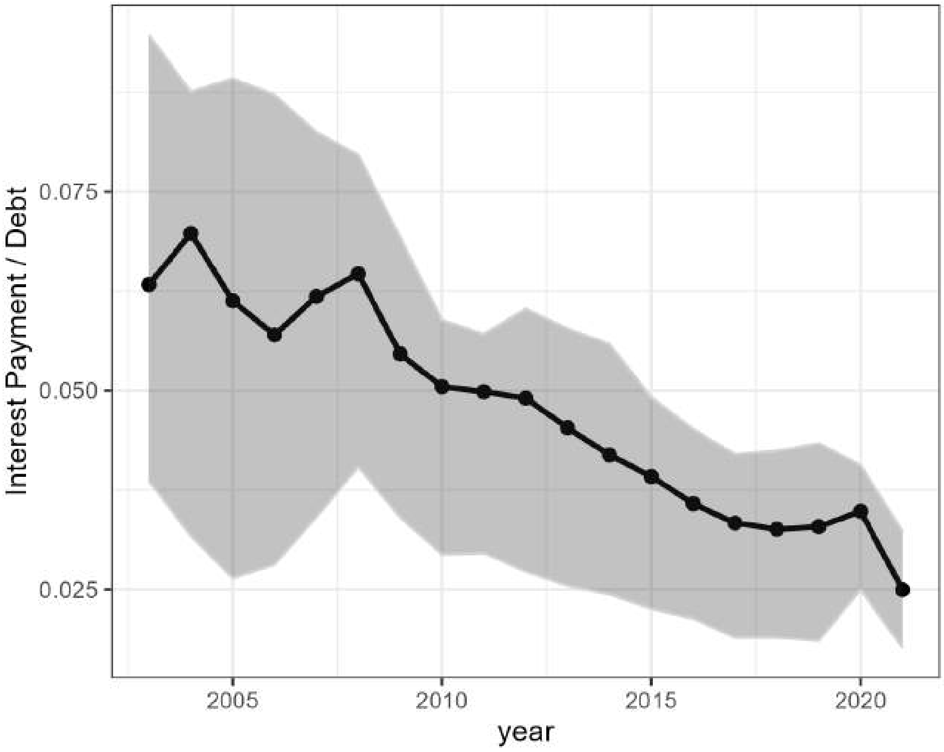
Weighted average of interest burden, while the shaded area include values between the 25th and 75th quantiles. Total Assets are used as weights. Interest Burden is defined as interest payments over operating profits

Figure 14: Time-Series Evolution of Interest Burden - Country detail



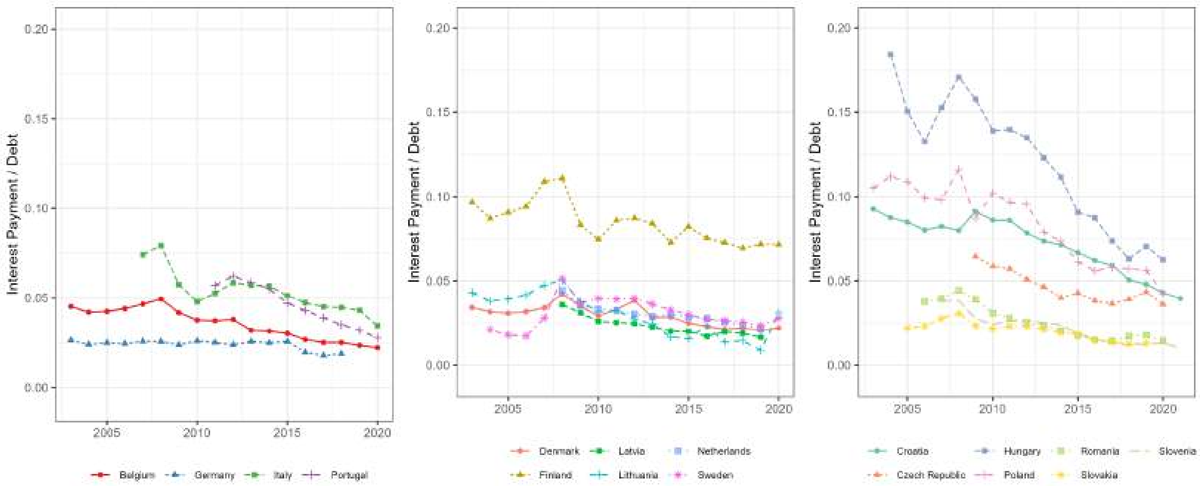
Weighted average of interest burden by country. Total Assets are used as weights. Interest Burden is defined as interest payments over operating profits

Figure 15: Time-Series Evolution of Interest over Debt



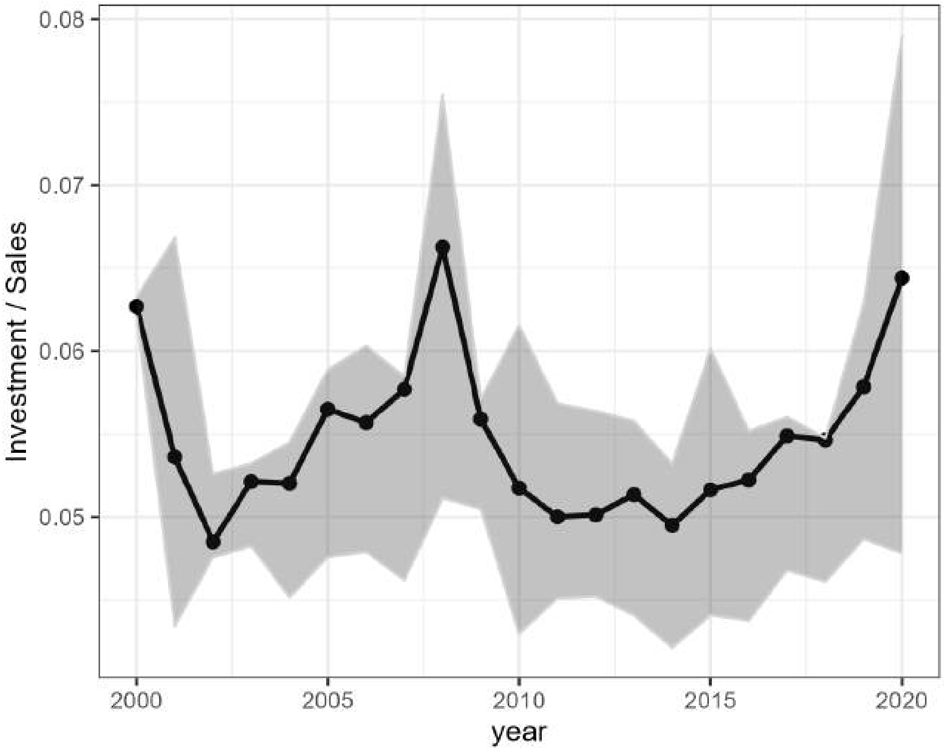
Weighted average of interest payments as a share of total debt, while the shaded area include values between the 25th and 75th quantiles. Total Assets are used as weights.

Figure 16: Time-Series Evolution of Interest over Debt - Country detail



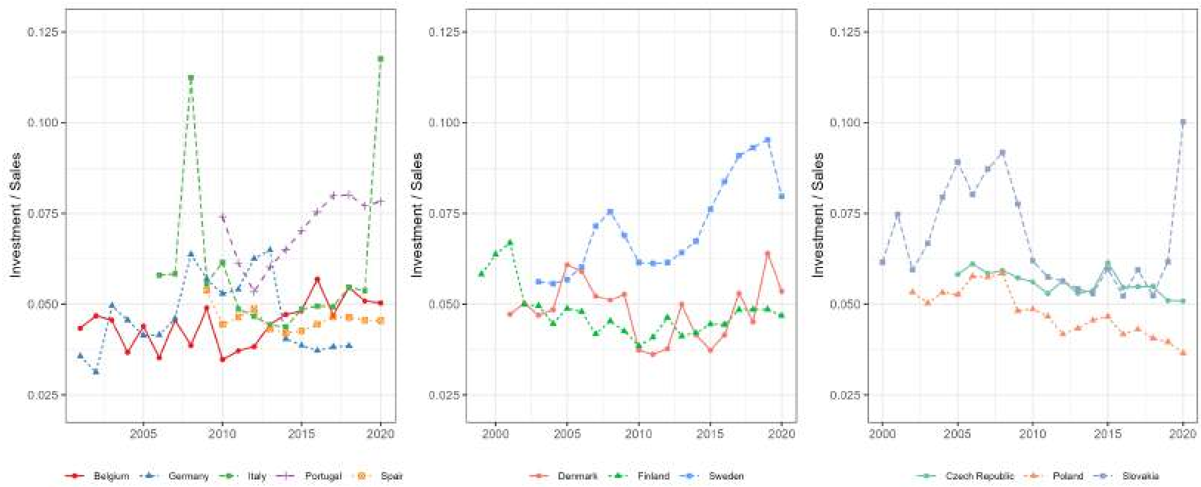
Weighted average of interest payments as a share of total debt by country. Total Assets are used as weights.

Figure 17: Time-Series Evolution of Investment Share



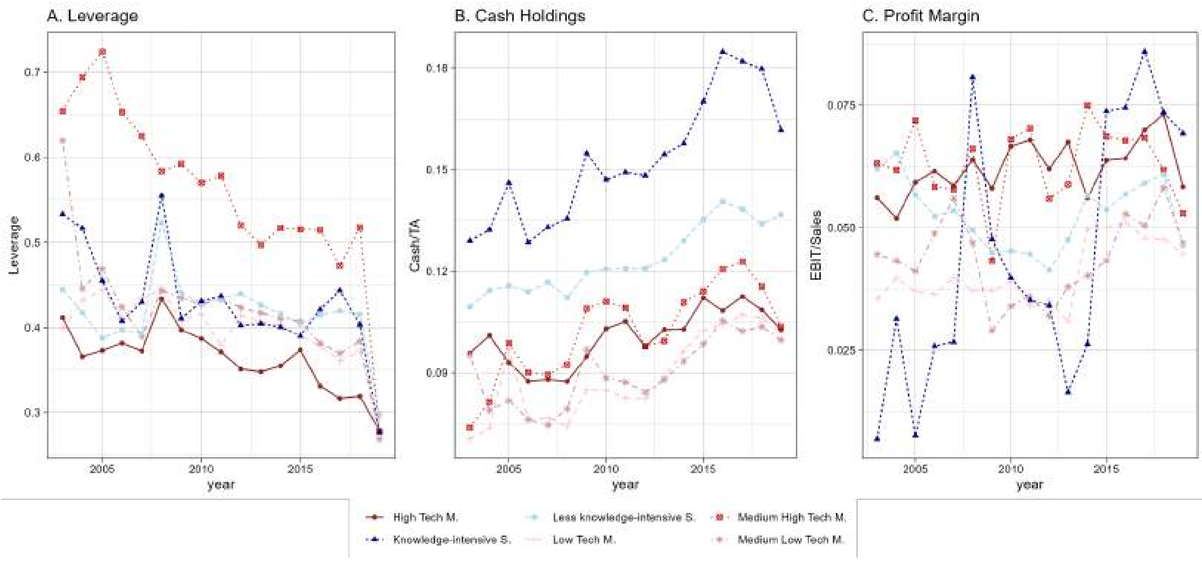
Weighted average of total investment as a share of total sales, while the shaded area include values between the 25th and 75th quantiles. Total Assets are used as weights. Data on investment in CompNet include the total value of acquired or self-constructed land, machinery, equipment, buildings and other durables (including assets under construction, but not long-term financial assets), plus the acquisitions of intangible fixed assets (acquired - not developed in-house - intellectual property such as copyrights, patents, licenses, software etc.).

Figure 18: Time-Series Evolution of Investment Share - Country detail



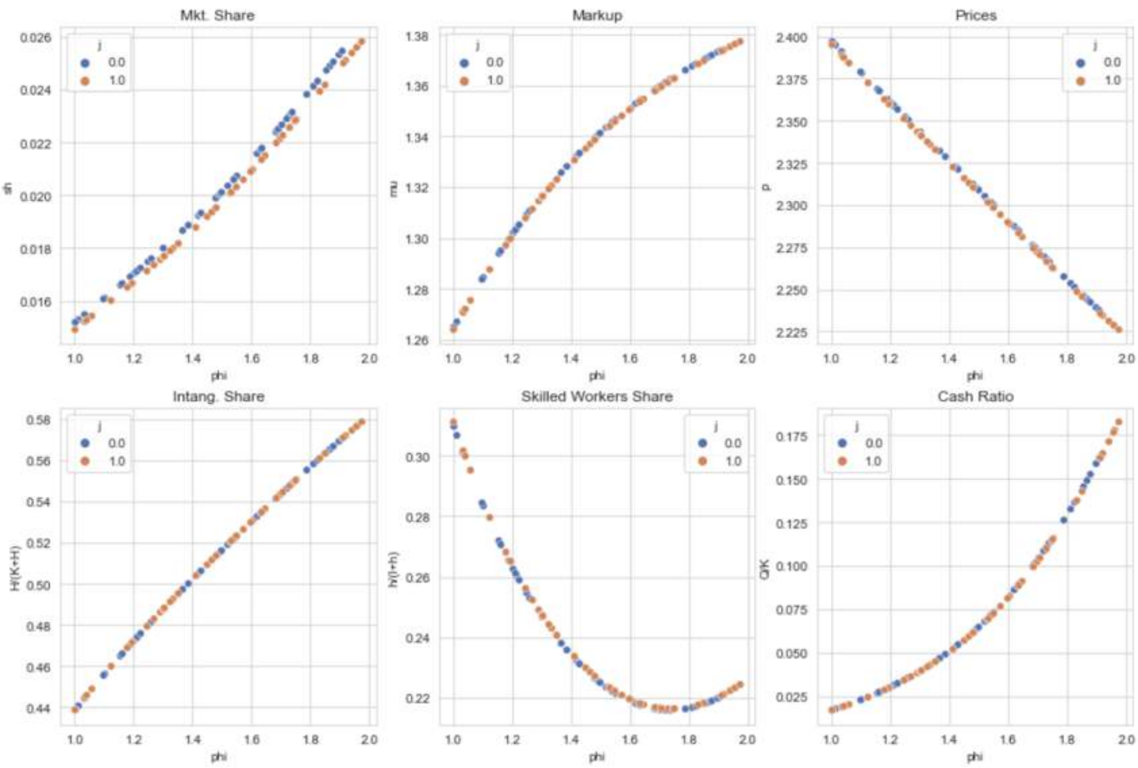
Weighted average of total investment as a share of total sales by country. Total Assets are used as weights. Data on investment in CompNet include the total value of acquired or self-constructed land, machinery, equipment, buildings and other durables (including assets under construction, but not long-term financial assets), plus the acquisitions of intangible fixed assets (acquired - not developed in-house - intellectual property such as copyrights, patents, licenses, software etc.)

Figure 19: Leverage, Cash and Profitability by Industry Level Knowledge Intensity



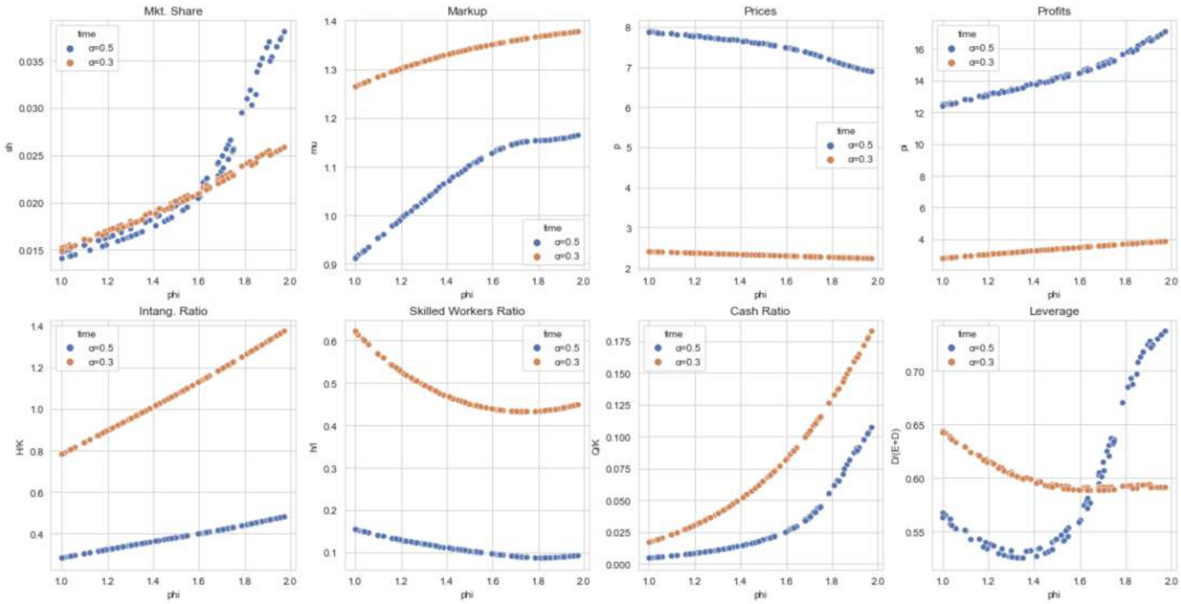
Panel A. Weighted average of leverage as total debt over total assets by industry level knowledge intensity. panel B. Weighted average of cash holdings as share of total assets by industry level knowledge intensity. Panel C. weighted average of EBIT over total sales by industry level knowledge intensity. Breakdown of Manufacturing and Services in different classes based on knowledge intensity is available at Eurostat (2025). Total Assets are used as weights.

Figure 20: Static Equilibrium



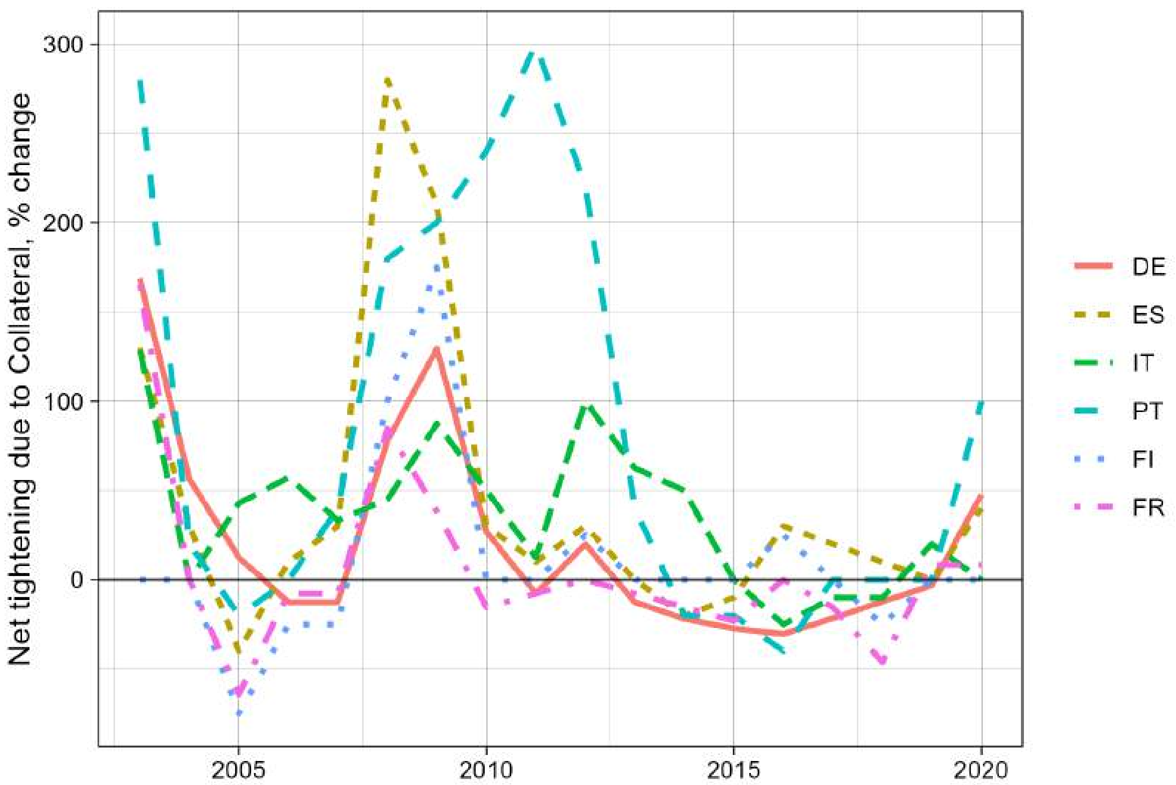
Simulation results of Static Equilibrium key variables by ϕ over a two industries economy.

Figure 21: Transition to Higher Relative Productivity of Intangible Capital



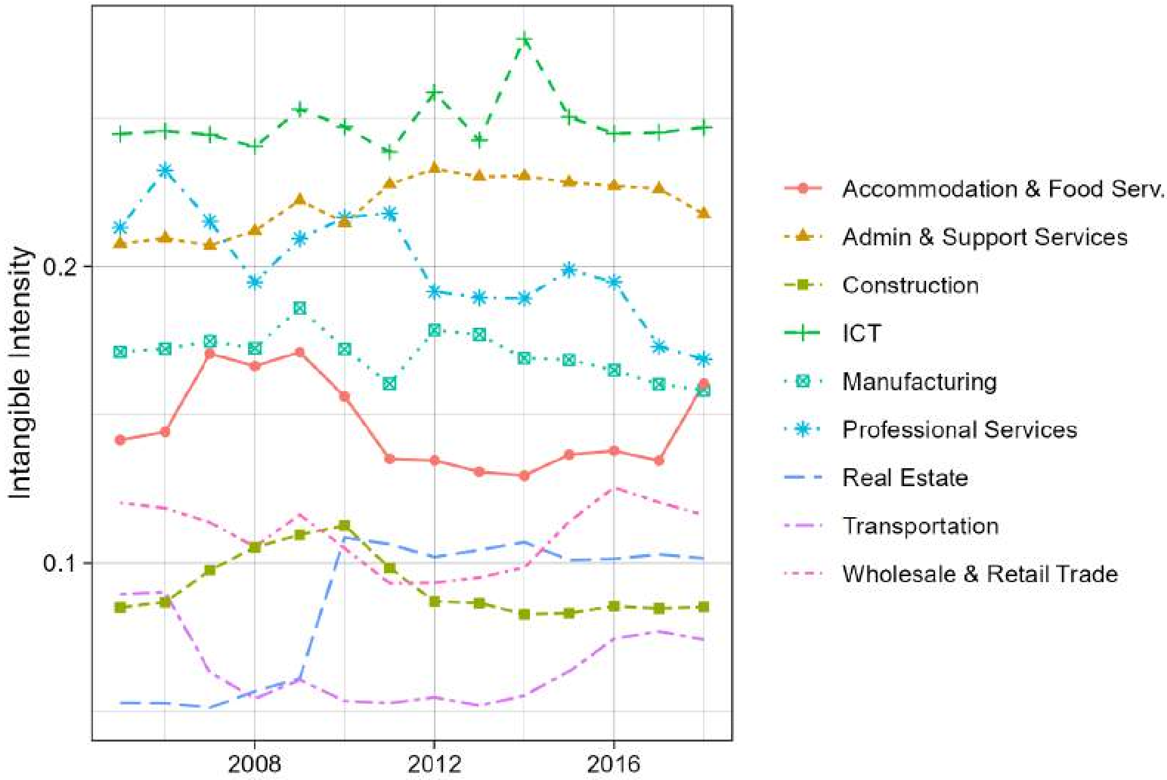
Simulation results of two periods model, after a change in the value of α from 0.5 to 0.3. Key variables by ϕ over a two industries economy.

Figure 22: Changes in Credit Tightness



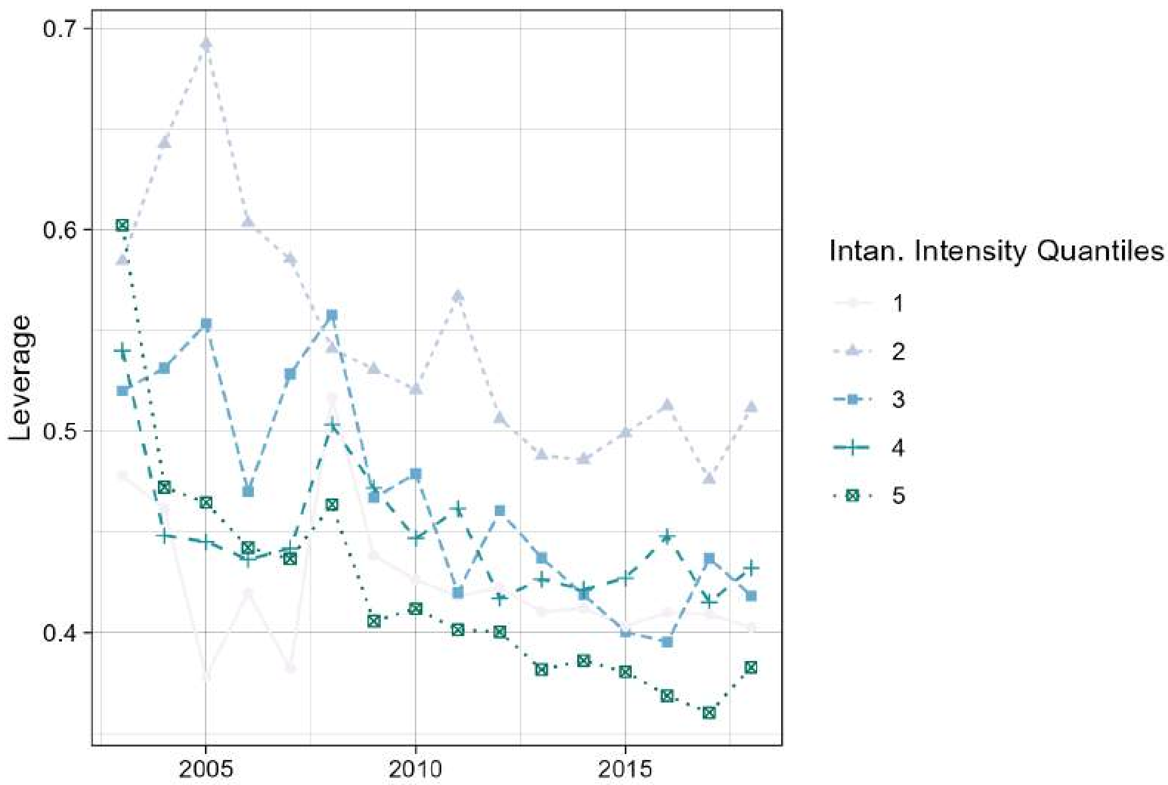
Outcomes of ECB Bank Lending Survey question on changes in credit conditions due to collateral requirements. On the y-axis it is reported the change in the difference between the share of interviewed banks reporting a net tightening of credit conditions and those reporting a net easing.

Figure 23: Intangible Intensity over Time



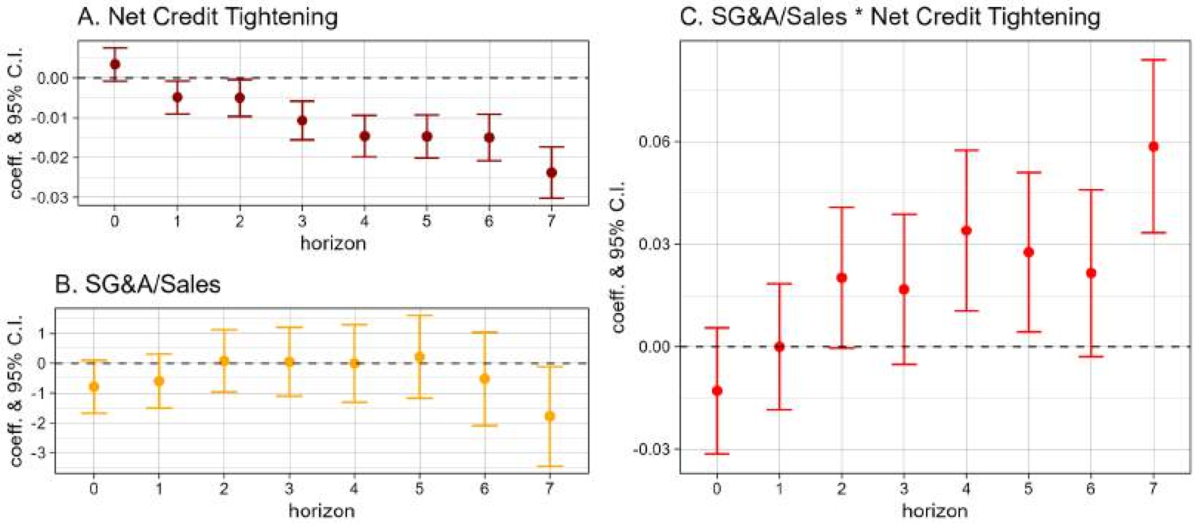
Intangible Intensity is defined as SG&A over sales. Average SG&A over sales are plotted over time by macro industry. Real SG&A average exoenditure per industry is sourced from the Compustat data, while sales come from the CompNet dataset. Values at the industry level are aggregated at the macro sector level via weighted average, using total assets as weights.

Figure 24: Leverage Change by Intangible Intensity



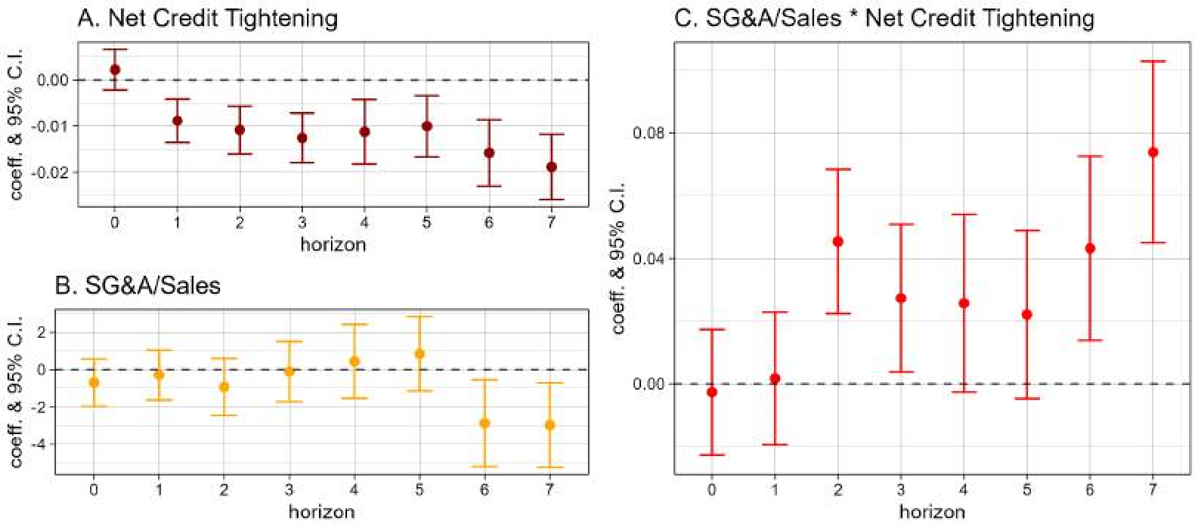
Intangible Intensity is defined as SG&A over sales. Real SG&A average expenditure per industry is sourced from the Compustat data, while sales come from the CompNet dataset. We rank industries and split them into 5 quantiles based on intangible intensity, where the 5th quantile is made of the industries with the highest ratio of SG&A over sales. We then compute average leverage by quantile year and plot the level over time. Mean values use total assets as weights.

Figure 25: Regression Results of Leverage Growth on changes in Credit Constraints due to Collateral Requirements



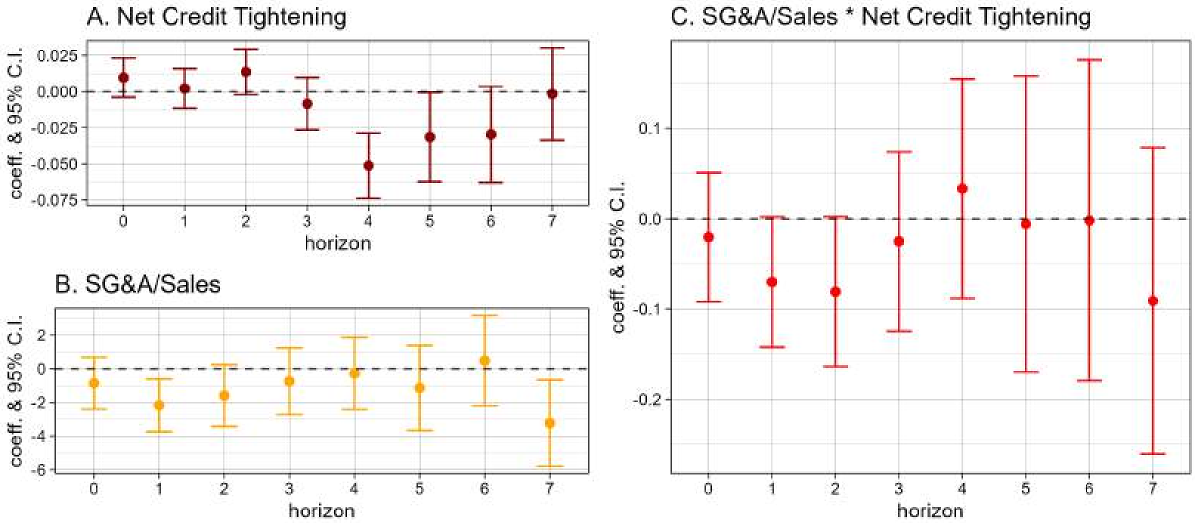
The Figure reports coefficients and 95% confidence intervals of a regression of changes in leverage between year t and $t+h$ on credit shocks between year $t-1$ and year t, based on regression equation (25). Coefficients and confidence intervals are reported on the y axis, while horizon h on the x axis. Panel A presents estimation results of coefficient β_{2h}, i.e. the average effect of changes in credit constraints on leverage. Panel B presents the average coefficient of Intangible Intensity β_{3h}, averaged between years $t-2$ and t. Panel C presents coefficient β_{1h}, on the interaction term between Intangible Intensity and changes in credit constraints. Intangible Intensity in equation (25) is defined as SG&A over Sales, as described in Section 5.

Figure 26: Regression Results of Leverage Growth on changes in Credit Constraints due to Collateral Requirements - Tightening only



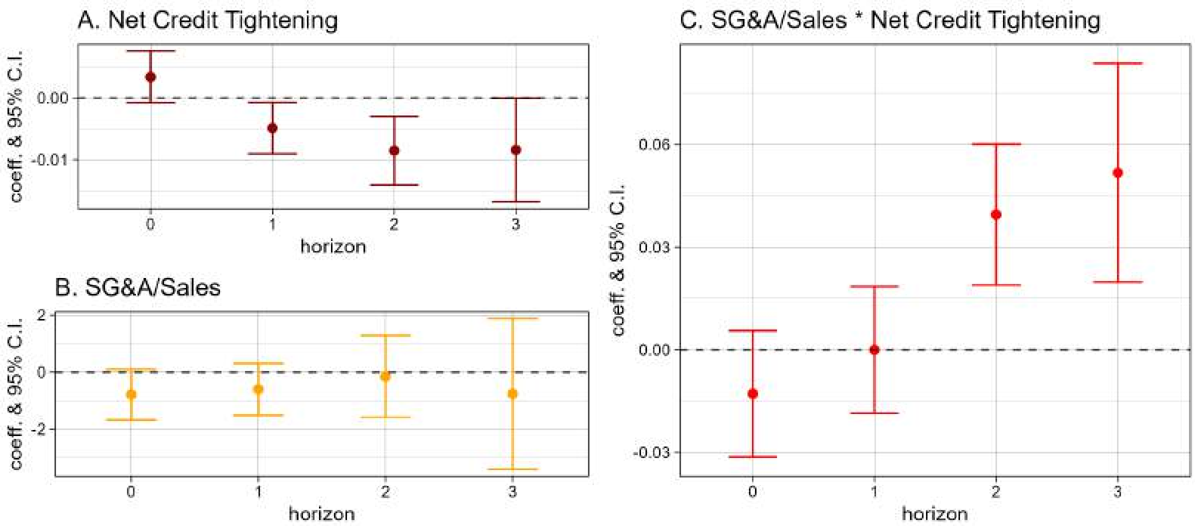
The Figure reports coefficients and 95% confidence intervals of a regression of changes in leverage between year t and $t+h$ on credit shocks between year $t-1$ and year t, based on regression equation (25). Sample restricted to only credit tightening episodes. Coefficients and confidence intervals are reported on the y axis, while horizon h on the x axis. Panel A presents estimation results of coefficient β_{2h}, i.e. the average effect of changes in credit constraints on leverage. Panel B presents the average coefficient of Intangible Intensity β_{3h}, averaged between years $t-2$ and t. Panel C presents coefficient β_{1h}, on the interaction term between Intangible Intensity and changes in credit constraints. Intangible Intensity in equation (25) is defined as SG&A over Sales, as described in Section 5.

Figure 27: Regression Results of Leverage Growth on changes in Credit Constraints due to Collateral Requirements - Loosening only



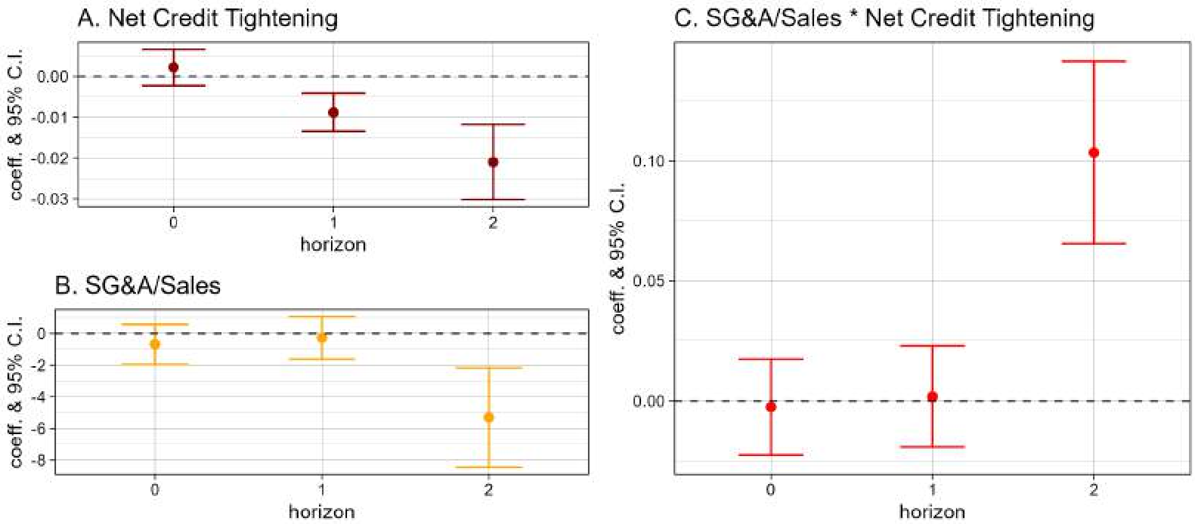
The Figure reports coefficients and 95% confidence intervals of a regression of changes in leverage between year t and $t+h$ on credit shocks between year $t-1$ and year t, based on regression equation (25). Sample restricted to only credit loosening episodes. Coefficients and confidence intervals are reported on the y axis, while horizon h on the x axis. Panel A presents estimation results of coefficient β_{2h}, i.e. the average effect of changes in credit constraints on leverage. Panel B presents the average coefficient of Intangible Intensity β_{3h}, averaged between years $t-2$ and t. Panel C presents coefficient β_{1h}, on the interaction term between Intangible Intensity and changes in credit constraints. Intangible Intensity in equation (25) is defined as SG&A over Sales, as described in Section 5.

Figure 28: Regression Results of Leverage Growth on changes in Credit Constraints due to Collateral Requirements - Robust Definition of Credit Shock



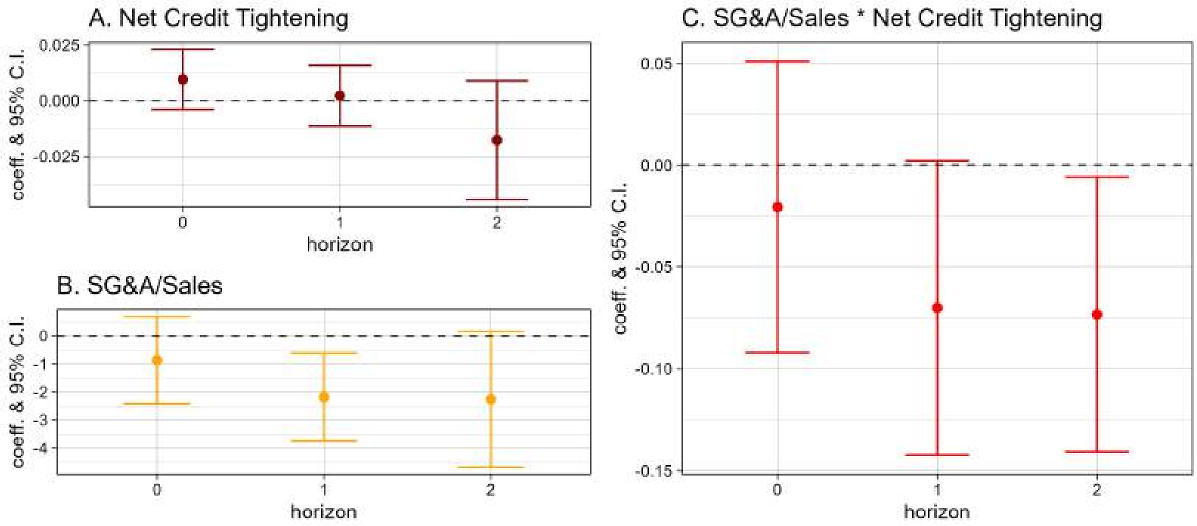
The Figure reports coefficients and 95% confidence intervals of a regression of changes in leverage between year t and $t+h$ on credit shocks between year $t-1$ and year t, based on regression equation (25). Sample restricted to only credit shocks that are 1.5 times in absolute value any other credit shock that follows in years $t+1$ to $t+h$. Coefficients and confidence intervals are reported on the y axis, while horizon h on the x axis. Panel A presents estimation results of coefficient β_{2h}, i.e. the average effect of changes in credit constraints on leverage. Panel B presents the average coefficient of Intangible Intensity β_{3h}, averaged between years $t-2$ and t. Panel C presents coefficient β_{1h}, on the interaction term between Intangible Intensity and changes in credit constraints. Intangible Intensity in equation (25) is defined as SG&A over Sales, as described in Section 5.

Figure 29: Regression Results of Leverage Growth on changes in Credit Constraints due to Collateral Requirements - Robust Definition of Credit Shock & Credit Tightening Only



The Figure reports coefficients and 95% confidence intervals of a regression of changes in leverage between year t and $t+h$ on credit shocks between year $t-1$ and year t, based on regression equation (25). Sample restricted to only credit tightening shocks that are 1.5 times any other credit tightening shock that follows in years $t+1$ to $t+h$. Coefficients and confidence intervals are reported on the y axis, while horizon h on the x axis. Panel A presents estimation results of coefficient β_{2h}, i.e. the average effect of changes in credit constraints on leverage. Panel B presents the average coefficient of Intangible Intensity β_{3h}, averaged between years $t-2$ and t. Panel C presents coefficient β_{1h}, on the interaction term between Intangible Intensity and changes in credit constraints. Intangible Intensity in equation (25) is defined as SG&A over Sales, as described in Section 5.

Figure 30: Regression Results of Leverage Growth on changes in Credit Constraints due to Collateral Requirements - Robust Definition of Credit Shock & Credit Loosening Only



The Figure reports coefficients and 95% confidence intervals of a regression of changes in leverage between year t and $t + h$ on credit shocks between year $t - 1$ and year t, based on regression equation (25). Sample restricted to only credit loosening shocks that are 1.5 times any other credit loosening shock that follows in years $t + 1$ to $t + h$. Coefficients and confidence intervals are reported on the y axis, while horizon h on the x axis. Panel A presents estimation results of coefficient β_{2h}, i.e. the average effect of changes in credit constraints on leverage. Panel B presents the average coefficient of Intangible Intensity β_{3h}, averaged between years $t - 2$ and t. Panel C presents coefficient β_{1h}, on the interaction term between Intangible Intensity and changes in credit constraints. Intangible Intensity in equation (25) is defined as SG&A over Sales, as described in Section 5.

Internet Appendix for “A Structural Break in EU Corporate Leverage Trends”

A. Derivations for Equilibrium

Static equilibrium to the firm level problem (**??**) is solved in the following way.

First, we assume that cost functions take the explicit form:

$$c_H(H, \phi) = \frac{\omega_H H^{c_H}}{\phi c_H},\ c_K(K, \phi) = \frac{\omega_K K^{c_K}}{c_K} \tag{26}$$

with $\omega_m > 1, c_m > 1, \phi > 1$ for $m \in \{K, H\}$.

Moreover, the spillover function $\lambda(H)$ takes the form:

$$\lambda(H) = \frac{\lambda_0 H^{1+\lambda_1}}{1 + \lambda_1} \tag{27}$$

with $\lambda_0 > 0, \lambda_1 > 0$.

Given these functions forms, we start by retrieving equilibrium $X^*_{it} = \{H, K, h, l\}^*_{it}$ by solving a cost minimization problem with $F(X^*_{it}) = y_{it}$:

$$\begin{aligned} \underset{H_{it}, K_{it}, h_{it}, l_{it}}{min} \quad & q_t h_{it} + w_t l_{it} + \mathcal{C}(H_{it}, K_{it}, \phi_i) \\ \text{s.t.} \quad & A_t F(E(H_{it}), K_{it}, h_{it}, l_{it}) = y_{it} \end{aligned} \tag{28}$$

Firms internalize the expected risk of capital depletion so take into account the marginal cash accumulation required for each additional unit of capital they build.

Taking first order conditions with respect to K_{it} and l_{it} and then dividing the first with the second leads to finding equilibrium l_{it} as a function of K_{it}, $l_{it} = l(K_{it})$:

$$l = \frac{1-\zeta}{\zeta w}\left[\omega_K K^{c_K} + (1 - e^{-\delta})K\right] \tag{29}$$

Taking first order conditions with respect to H_{it} and h_{it} and then dividing the first with the second leads to finding equilibrium h_{it} as a function of H_{it}, $h_{it} = h(H_{it}, \phi_i)$:

$$h = \frac{1-\gamma}{q\gamma}\left[\frac{\omega_H H^{c_H - 1}}{\phi_i} + HQ'(H)\right] \tag{30}$$

We can then plug in the solutions for h and l into the cost minimization problem and take first order conditions with respect to K and H. Taking their ratio we can find an implicit solution for K_{it} as a function of H_{it}, $K_{it} = K(H_{it}, \phi_i)$:

$$\frac{\alpha}{1-\alpha} \cdot \frac{\left[K^{\zeta} l(K)^{1-\zeta}\right]^{\rho-1} \cdot \frac{\partial}{\partial K}\left\{K^{\zeta} l(K)^{1-\zeta}\right\}}{\left[H^{\gamma} h(H,\phi)^{1-\gamma}\right]^{\rho-1} \cdot \frac{\partial}{\partial H}\left\{H^{\gamma} h(H,\phi)^{1-\gamma}\right\}} = \frac{\omega_K K^{c_K-1} + (1-e^{-\delta})}{\phi_i^{-1}\omega_H H^{c_H-1} + Q'(H)} \tag{31}$$

This solution is then plugged back in the first order condition for H, to derive an equilibrium solution for H as a function of y and ϕ, $H_{it} = H(y, \phi)$:

$$\frac{y}{\mathcal{Y}}(1-\alpha)\left[H^{\gamma} h(H,\phi)^{1-\gamma}\right]^{\rho-1} \cdot \frac{\partial}{\partial H}\left\{H^{\gamma} h(H,\phi)^{1-\gamma}\right\} = \phi_i^{-1}\omega_H H^{c_H-1} + Q'(H) \tag{32}$$

where:

$$\mathcal{Y} = \left[\alpha\left(K(H,\phi)^{\zeta} l(K)^{1-\zeta}\right)^{\rho} + (1-\alpha)\left(H^{\gamma} h(H,\phi)^{1-\gamma}\right)^{\rho}\right]^{\frac{1}{\rho}} \tag{33}$$

This implicitly defines all inputs of the production function as well as equilibrium cash as a function of y and can be solved for numerically given y, ϕ and the other parameters of the production function and the cost function.

B. Supplemental Figures

Figure B.1: Net Leverage Trends Across EU Countries

Net leverage is defined as Debt Securities plus Loans minus Currency and Deposits, divided by the sum of Financial Assets and Fixed Assets. Data for each country is from the OECD's Financial Balance Sheets and Balance Sheets for Non-Financial Assets. All data is measured on a consolidated basis. Fixed Assets are not available for some countries for the entire period of 1995 through 2020.

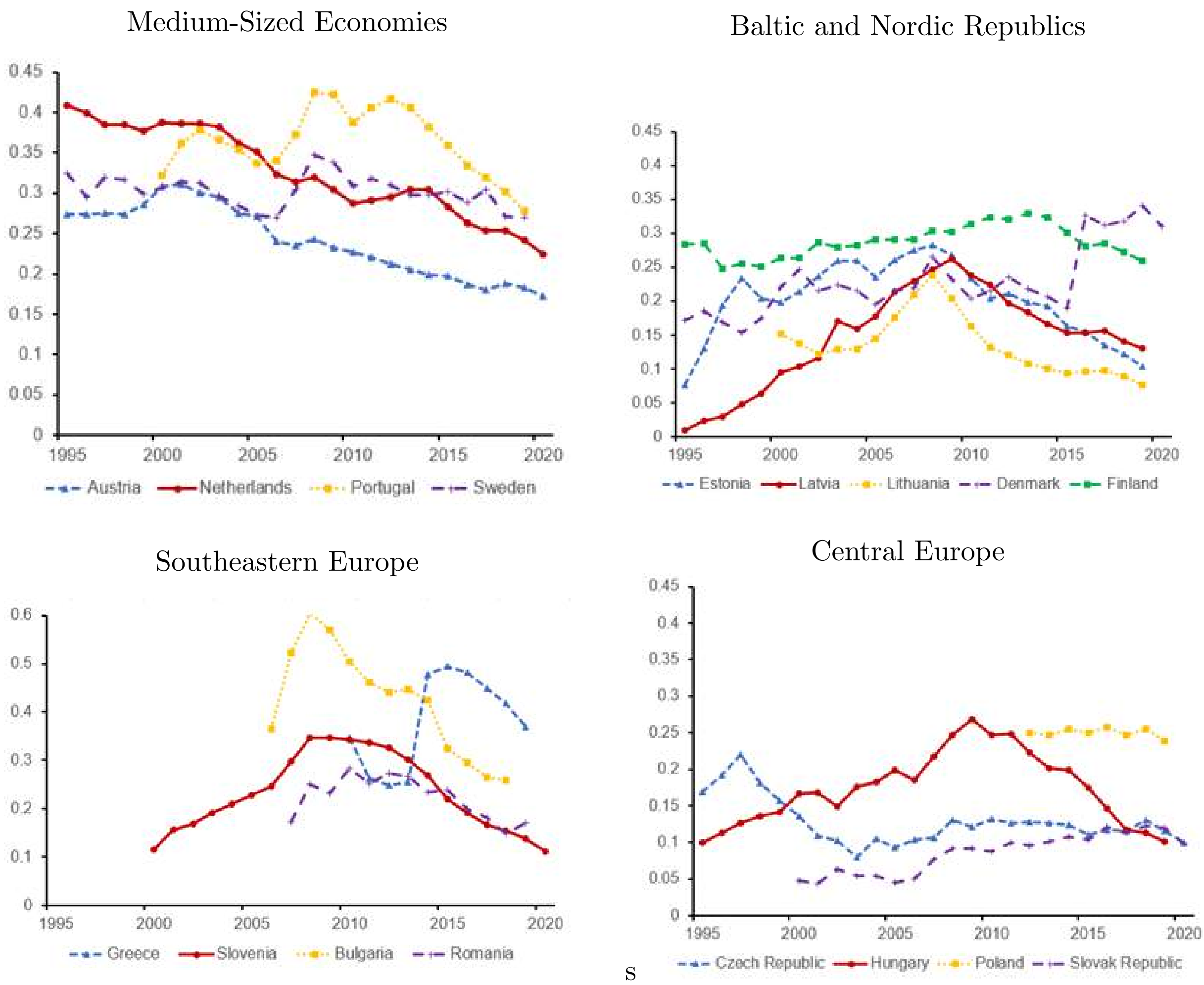
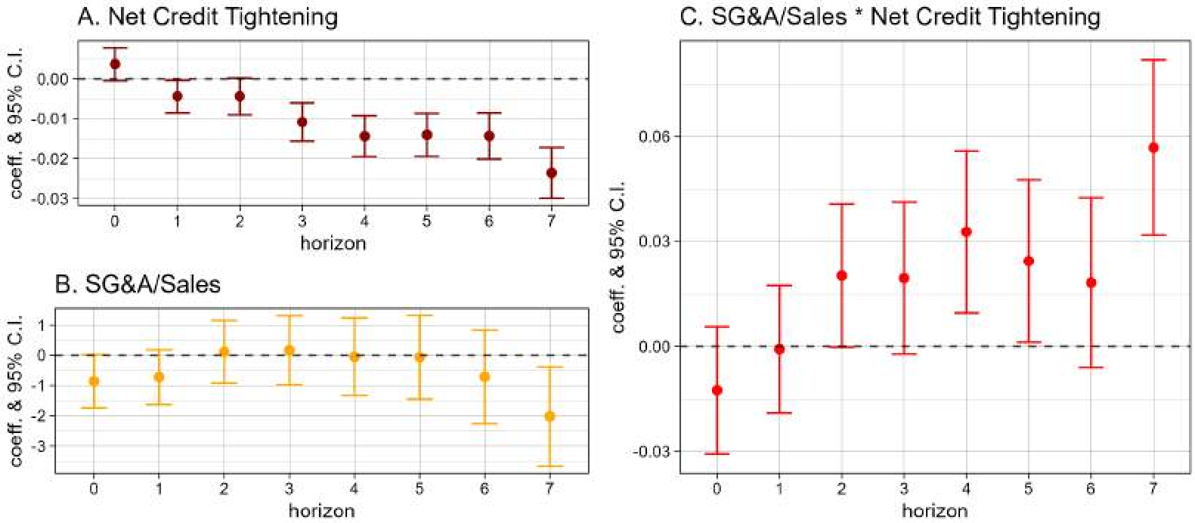
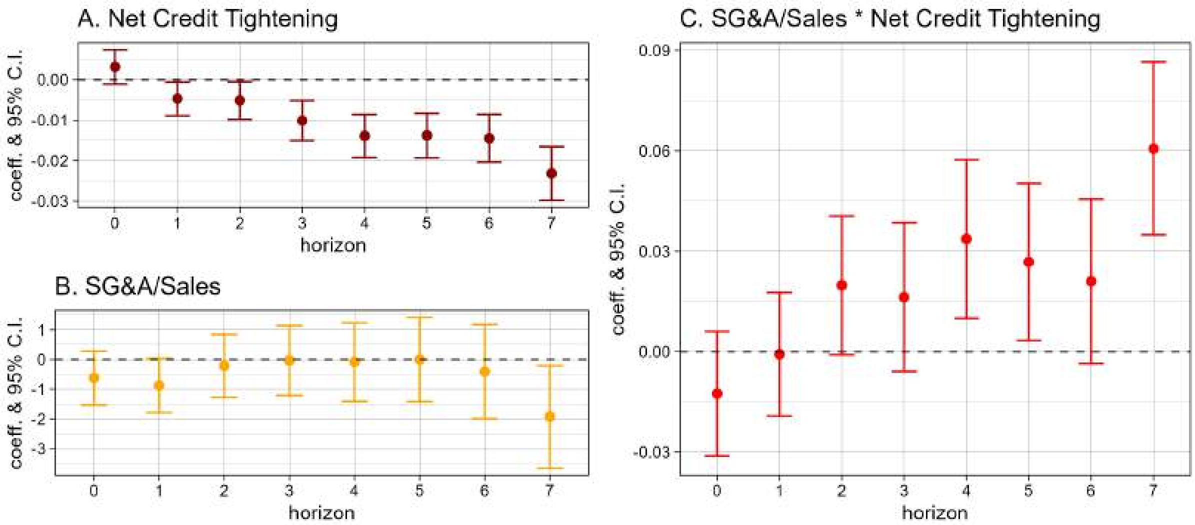


Figure B.2: Regression Results of Leverage Growth on changes in Credit Constraints due to Collateral Requirements



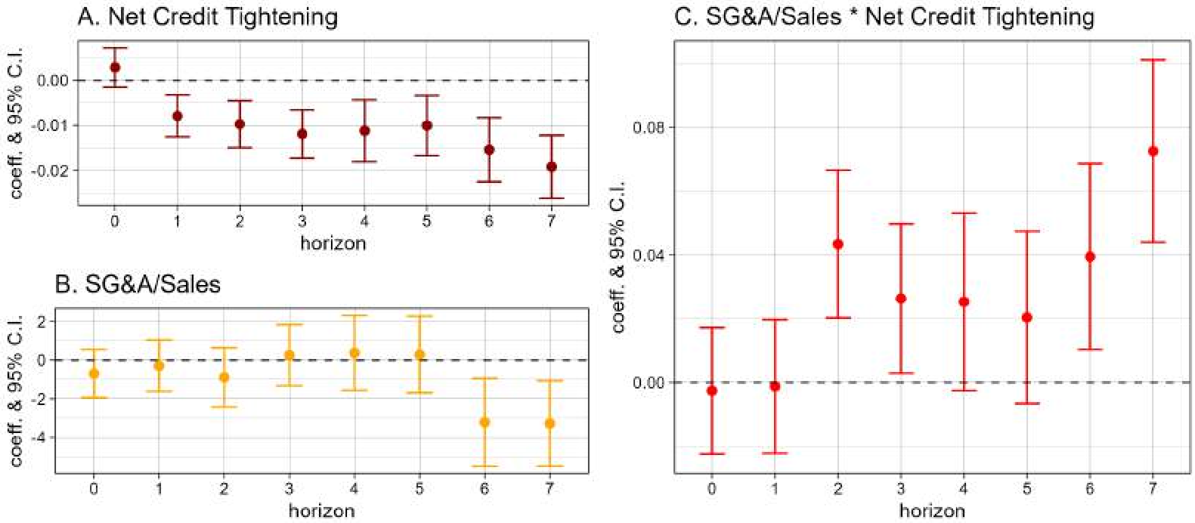
The Figure reports coefficients and 95% confidence intervals of a regression of changes in leverage between year t and $t+h$ on credit shocks between year $t-1$ and year t, based on regression equation (25). Coefficients and confidence intervals are reported on the y axis, while horizon h on the x axis. Panel A presents estimation results of coefficient β_{2h}, i.e. the average effect of changes in credit constraints on leverage. Panel B presents the average coefficient of Intangible Intensity β_{3h}, averaged between years $t-1$ and t. Panel C presents coefficient β_{1h}, on the interaction term between Intangible Intensity and changes in credit constraints. Intangible Intensity in equation (25) is defined as SG&A over Sales, as described in Section 5.

Figure B.3: Regression Results of Leverage Growth on changes in Credit Constraints due to Collateral Requirements



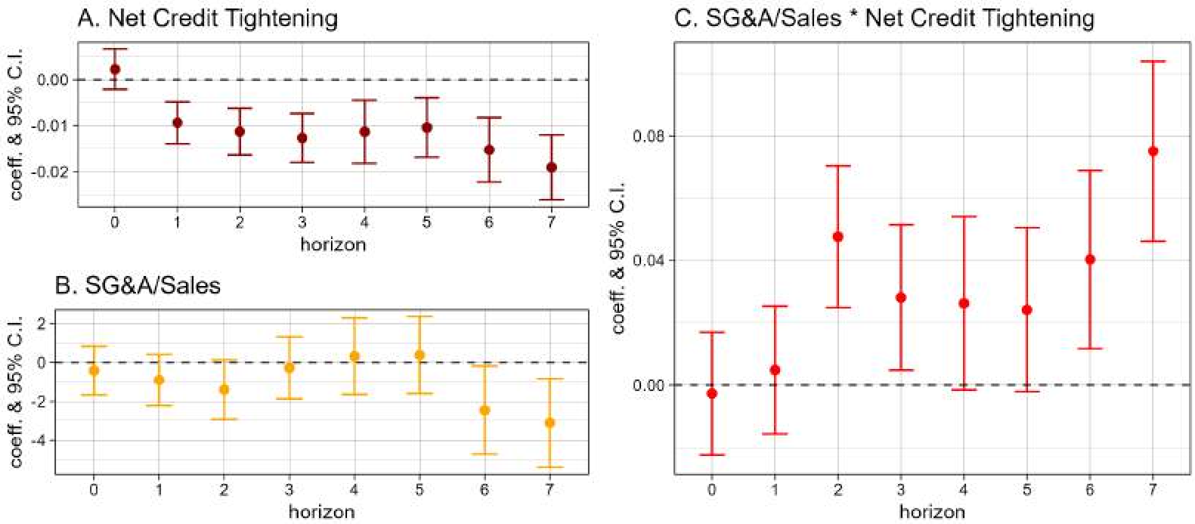
The Figure reports coefficients and 95% confidence intervals of a regression of changes in leverage between year t and $t+h$ on credit shocks between year $t-1$ and year t, based on regression equation (25). Coefficients and confidence intervals are reported on the y axis, while horizon h on the x axis. Panel A presents estimation results of coefficient β_{2h}, i.e. the average effect of changes in credit constraints on leverage. Panel B presents the average coefficient of Intangible Intensity β_{3h}, averaged between years $t-3$ and t. Panel C presents coefficient β_{1h}, on the interaction term between Intangible Intensity and changes in credit constraints. Intangible Intensity in equation (25) is defined as SG&A over Sales, as described in Section 5.

Figure B.4: Regression Results of Leverage Growth on changes in Credit Constraints due to Collateral Requirements - Tightening only



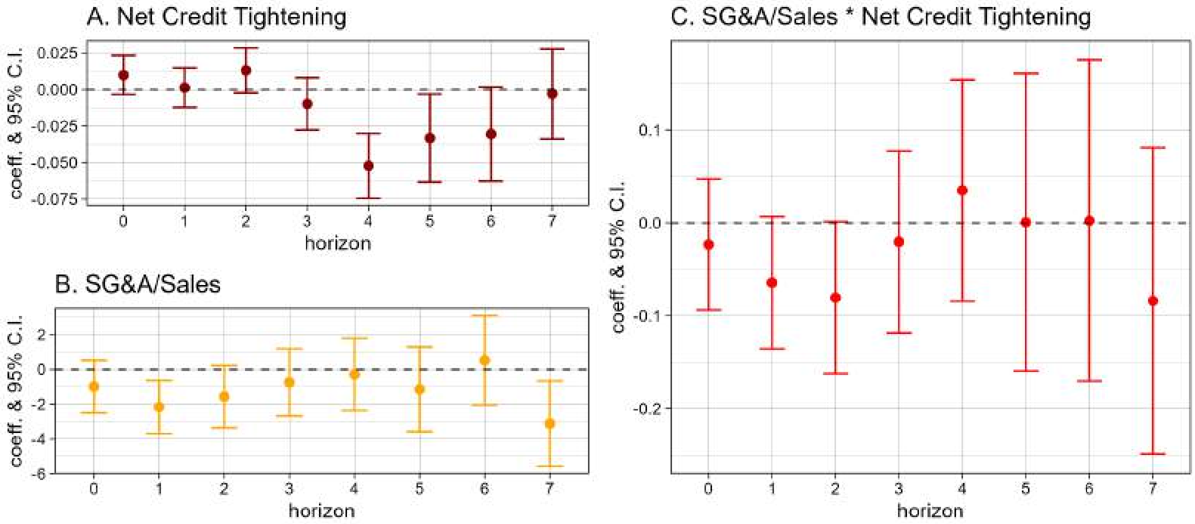
The Figure reports coefficients and 95% confidence intervals of a regression of changes in leverage between year t and $t+h$ on credit shocks between year $t-1$ and year t, based on regression equation (25). Sample restricted to only credit tightening episodes. Coefficients and confidence intervals are reported on the y axis, while horizon h on the x axis. Panel A presents estimation results of coefficient β_{2h}, i.e. the average effect of changes in credit constraints on leverage. Panel B presents the average coefficient of Intangible Intensity β_{3h}, averaged between years $t-1$ and t. Panel C presents coefficient β_{1h}, on the interaction term between Intangible Intensity and changes in credit constraints. Intangible Intensity in equation (25) is defined as SG&A over Sales, as described in Section 5.

Figure B.5: Regression Results of Leverage Growth on changes in Credit Constraints due to Collateral Requirements - Tightening only



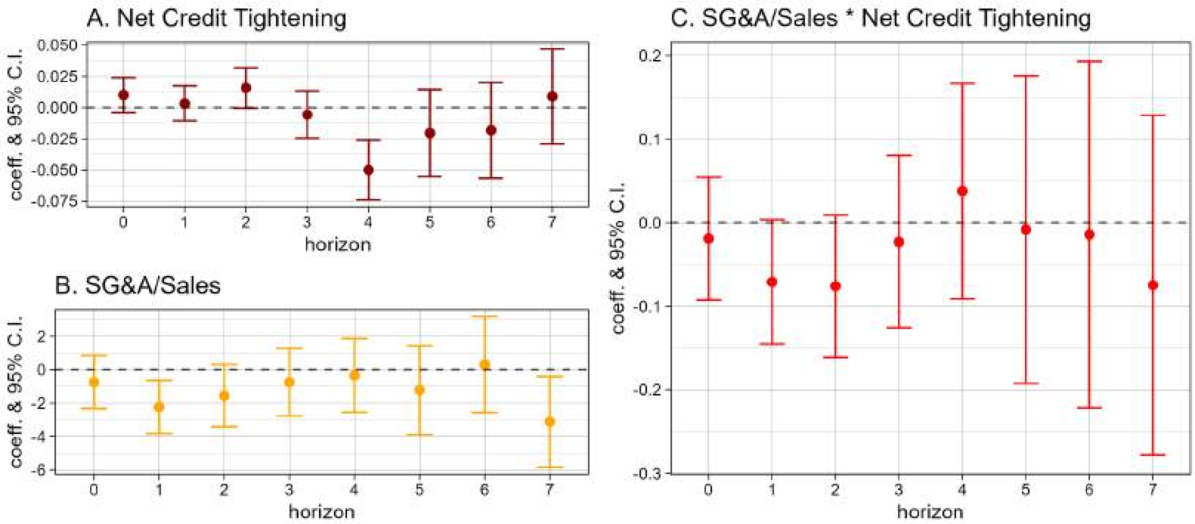
The Figure reports coefficients and 95% confidence intervals of a regression of changes in leverage between year t and $t+h$ on credit shocks between year $t-1$ and year t, based on regression equation (25). Sample restricted to only credit tightening episodes. Coefficients and confidence intervals are reported on the y axis, while horizon h on the x axis. Panel A presents estimation results of coefficient β_{2h}, i.e. the average effect of changes in credit constraints on leverage. Panel B presents the average coefficient of Intangible Intensity β_{3h}, averaged between years $t-3$ and t. Panel C presents coefficient β_{1h}, on the interaction term between Intangible Intensity and changes in credit constraints. Intangible Intensity in equation (25) is defined as SG&A over Sales, as described in Section 5.

Figure B.6: Regression Results of Leverage Growth on changes in Credit Constraints due to Collateral Requirements - Loosening only



The Figure reports coefficients and 95% confidence intervals of a regression of changes in leverage between year t and $t + h$ on credit shocks between year $t - 1$ and year t, based on regression equation (25). Sample restricted to only credit loosening episodes. Coefficients and confidence intervals are reported on the y axis, while horizon h on the x axis. Panel A presents estimation results of coefficient β_{2h}, i.e. the average effect of changes in credit constraints on leverage. Panel B presents the average coefficient of Intangible Intensity β_{3h}, averaged between years $t - 1$ and t. Panel C presents coefficient β_{1h}, on the interaction term between Intangible Intensity and changes in credit constraints. Intangible Intensity in equation (25) is defined as SG&A over Sales, as described in Section 5.

Figure B.7: Regression Results of Leverage Growth on changes in Credit Constraints due to Collateral Requirements - Loosening only



The Figure reports coefficients and 95% confidence intervals of a regression of changes in leverage between year t and $t + h$ on credit shocks between year $t - 1$ and year t, based on regression equation (25). Sample restricted to only credit tightening episodes. Coefficients and confidence intervals are reported on the y axis, while horizon h on the x axis. Panel A presents estimation results of coefficient β_{2h}, i.e. the average effect of changes in credit constraints on leverage. Panel B presents the average coefficient of Intangible Intensity β_{3h}, averaged between years $t - 3$ and t. Panel C presents coefficient β_{1h}, on the interaction term between Intangible Intensity and changes in credit constraints. Intangible Intensity in equation (25) is defined as SG&A over Sales, as described in Section 5.