STOCKHOLM SCHOOL OF ECONOMICS
Department of Economics
5350 Master's thesis in economics
Academic year 2021–2022

Fear the Walking Dead?

Zombie Firms in the Euro Area and Their Effect on Healthy Firms' Credit Conditions

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Abstract. The extensive monetary and fiscal support measures related to the Covid-19 pandemic have reinvigorated the policy and academic debate around zombie firms. These are firms that are no longer profitable but still operate. This thesis attempts to shed light on the questions of whether zombie firms exist in the euro area, and whether spillovers occur from zombie firms to healthy firms' credit conditions. The ESCB's novel AnaCredit dataset which includes loan-by-loan data from 2018 to 2021, matched with the Orbis dataset on firms' accounting data, allows the analysis of a broader set of countries and firms than in the existing zombie literature, on a new level of granularity. It is found that around 2% of all firms in the euro area economy are zombie firms. Then, to identify the relationship between zombie prevalence and healthy firms' interest rates and access to new credit, a panel regression with fixed effects is employed. The results indicate that zombie firms pay higher interest rates and receive less new credit than healthy firms. The spillover effect of the existence of zombie firms on healthy firms' new credit is not significant. For interest rates, an adverse spillover effect cannot be confirmed, rather, the total effect of the existence of zombie firms significantly lowers healthy firms' interest rates. Thus, zombie firms do exist in the euro area, but they do not seem to pose significant negative externalities on the credit conditions of healthy firms in the economy.

Keywords: *zombie firms, financial spillovers, interest rates, new credit, financial stability*
JEL: E44, G21, G32

Supervisor: Kelly Ragan
Date submitted: 16 May 2022
Date examined: 25 May 2022
Discussant: Jessica Geraghty
Examiner: Magnus Johannesson

Acknowledgements

Above all, I would like to thank the team of the European Systemic Risk Board Secretariat for giving me the opportunity to explore the topic of zombie firms using such a novel, granular and interesting dataset for this thesis. In particular, I am deeply grateful to Tuomas Peltonen for his support for this project; Andreas Westphal for his indispensable advice and guidance; Kristian Horn for taking the time to meet with me and discuss specific ideas, and for giving me invaluable feedback and support on this project; Manuela Storz for providing instrumental insights into the world of zombie firms; and Christoph Seitz, Panagiotis Papadopoulus and Giorgio Pisaroni for their continuous support, encouragement and help. Moreover, I greatly appreciate the advice, encouragement and patience of my advisor, Kelly Ragan.

Contents

1 Introduction

In the quarterly monetary dialogue of the EU's Committee on Economic and Monetary Affairs on 28 September 2020, Christine Lagarde, President of the European Central Bank (ECB) was asked how the ECB plans to mitigate the risk that its measures in response to the Covid-19 pandemic give rise to zombie firms (Committee on Economic and Monetary Affairs, 2020). This illustrates that the Covid-19 monetary and fiscal support measures revived discussion around so-called zombie firms, that is, firms that are no longer profitable but still operating (Helmersson et al., 2021).

Zombie firms have been of policy and academic interest for over a decade. It first arose in the 1990s in the context of the stagnating Japanese economy, where a key paper by Caballero et al. (2008) coined the zombie term. In Europe, zombie firms became an important issue in the aftermath of the global financial crisis (GFC) 2008 and the subsequent European sovereign debt crisis. This discussion has been reinvigorated in the context of the Covid-19 pandemic, with critics raising the concern that monetary and fiscal policies not only support healthy firms facing liquidity constraints due to the pandemic, but also allow zombie firms to avoid bankruptcy. Zombie firms are an issue of policy concern for at least two reasons (The ECB Podcast, 2021). First, zombie firms are kept alive by loans from credit institutions. If many zombie firms start to fail, for instance when pandemic support measures are being phased out, this might endanger their creditors, raising concerns for the financial stability of the banking system. Second, zombie firms withhold resources (e.g., workers) from healthy firms, which could use them more efficiently. Thus, the existence of zombie firms could adversely impact healthy firms through so-called spillover effects.

A large part of the existing zombie literature investigates these spillover effects, with most studies focusing on "real" spillovers from zombies to healthy firms in terms of employment, investment, productivity and profit margins. One channel of transmission for these real spillovers is that zombie firms receive credit at more favourable conditions than healthy firms, assuming that the existence of zombie firms deteriorates credit conditions and access to capital for healthy firms (for instance, Farinha et al. (2018)). Only a handful of these studies attempt to verify this assumption, making financial spillovers an "understudied channel" (Andrews and Petroulakis, 2019, page 3). Therefore, this thesis investigates this "understudied channel" of financial spillovers from zombie firms to healthy firms' interest rates and new credit for the euro area by using the novel "analytical credit dataset" (AnaCredit dataset), which includes granular loan-by-loan data of every loan in the euro area by non-private persons that exceeds €25,000, matched with the Orbis dataset on firm-level financial data.

Before analysing the effects of zombie prevalence on healthy firms, this thesis considers the question if zombie firms exist in the euro area by studying asset-weighted zombie shares across euro area countries and sectors from 2005-2019 using the Orbis dataset. It is found that zombie shares increased for all euro area countries and sectors after the GFC 2008. Since then, zombie shares in the countries hit especially hard by the subsequent sovereign debt crisis (GIIPS countries: Greece, Italy, Ireland, Portugal and Spain) remain higher on average than those in other euro area countries. Moreover, when comparing financial characteristics of the two groups, it is found that zombie firms have much weaker financial fundamentals than healthy firms.

Having established that the prevalence of zombie firms is non-negligible especially in the GIIPS countries, this thesis turns to the question of whether a higher presence of zombie firms in a bank impacts healthy firms' credit conditions. This question is possible to investigate due to the matched dataset of Orbis and AnaCredit, which provides information on firms' credit quality and loan attributes like interest rates. A panel regression with fixed effects is employed to study the effect of an increased share of zombie loans in a bank on healthy firms' interest rates and provision of new credit. In short, I do not find financial spillovers to be a straightforward channel through which zombie firms adversely affect healthy firms. Regarding new credit, healthy firms receive significantly more new credit than zombie firms. Furthermore, the results for the regression with an interaction term do not show a significant negative spillover effect: Healthy firms in banks with a higher zombie share do not receive significantly less new credit than healthy firms in banks with a lower zombie share. For interest rates, zombie firms are found to pay higher interest rates than healthy firms in general, except for firms rated C or worse based on their probability of default. The spillover effect is that an increased presence of zombie firms significantly decreases healthy firms' interest rates, regardless of the firm's credit rating. This finding contrasts with the prevailing view in the literature that the existence of zombie firms adversely affects healthy firms' credit conditions.

The remaining parts of this thesis are structured as follows. Section 2 discusses how to define zombie firms and relates this thesis to the existing literature. Section 3 analyses the prevalence of zombie firms in the euro area countries and sectors from 2005-2019 and compares financial characteristics of zombie firms to healthy firms, thereby "setting the scene". Section 4 then addresses the question of financial spillovers using a panel regression with fixed effects, after discussing characteristics of zombie firms in the Orbis-AnaCredit sample and investigating whether zombie firms have received new credit and state guarantees during the period of study and during especially the Covid-19 crisis. Section 5 concludes.

2 Background

2.1 Identifying weak firms as "zombie" firms

A key question in the zombie literature is how to define "zombies".[1] The challenge is to identify firms that are no longer viable but artificially kept alive as opposed to firms that are only temporarily underperforming or still in the founding or growth phase like start-ups. In the literature, there exist numerous zombie definitions, which can be grouped into two broad categories: (i) definitions building on firm performance measures *and* the receipt of subsidised credit measured by favourable interest rates; and (ii) definitions that *only* rely on firm performance indicators to identify zombie firms.

Key papers like Acharya et al. (2019), Acharya et al. (2020), Acharya et al. (2022), and Caballero et al. (2008) advocate the first approach by insisting that a zombie definition needs (i) a measure of performance *and* (ii) a measure of subsidised credit. Since the existence of zombie firms crucially relies on banks giving them cheap credit, these authors argue that a firm can only be classified as a zombie if it does receive subsidised credit. Acharya et al. (2022) measure subsidized credit as the difference between the firm's interest expense and the median interest expense by AA-rated firms in their sample. If this interest rate gap is negative, then firms are seen to receive subsidized credit.

However, this approach has three important drawbacks:

a. It might be difficult to distinguish between subsidised zombie credit and favourable financing conditions to support viable firms during economic crises like the global financial crisis (GFC) or the Covid-19 crisis (Schivardi et al., 2020). This in part reflects the low-interest rate environment prevailing since the ECB deposit facility rate declined to 0.00% in 2012 (European Central Bank, 2022c). Furthermore, in this low-rate environment, lower-than-average interest rates given to zombie firms would have to be close to zero or negative. It is questionable, though not impossible, that banks would accept negative credit rates just to avoid realising losses from zombie insolvencies in their balance sheets. Similarly, government support in many euro area countries during the Covid-19 crisis makes it difficult to differentiate zombie credit and credit at favourable conditions to support healthy firms throughout the pandemic. The most relevant forms of government support were state-backed guarantees and debt service moratoria, thus influencing healthy firms' credit conditions.

[1] This question is raised in almost every study on zombie firms, irrespective of which thematic strand of the literature it belongs to. While the four thematic strands of the literature are further discussed in section 2.3, it is worth discussing the more methodological question of the zombie definition used already here.

b. Subsidised credit rates might have reasons other than preventing a firm from becoming insolvent, namely long-standing bank-client relations (Banerjee and Hofmann, 2018) or high-quality collateral.

c. Using the subsidised interest rate criterion requires information on interest rates, firm ratings and interest payments. Whilst these data are readily available for large, listed firms, which made up the sample of most papers using this criterion, this information is only rarely available for SMEs, which account for the largest share of the euro area economy.

Therefore, this thesis will, as a baseline definition, follow the approach of using only performance-based zombie identification. More specifically, it follows the definition by Storz et al. (2017). Accordingly, firms are identified as zombies when, for two consecutive years,

i. their return on assets, measured as the ratio of net income to total assets, is negative,

ii. their net investments, measured as the net total change in fixed assets year-on-year, is negative, and

iii. their debt servicing capacity, measured as EBITDA divided by total financial debt (long-term debt plus loans), is lower than 5%.

Criterion (i) is a measure of firm profitability, such that a negative return on assets signals that the firm is not profitable anymore. Criterion (ii) ensures that young, growing firms are not classified as zombies (Storz et al., 2017). If the definition were to rely only on criterion (i), firms like Tesla would have been classified as zombies due to negative returns on their assets during the years in their growth period. Criterion (iii) identifies highly indebted companies[2].

The definition by Storz et al. (2017), which is also used by Andrews and Petroulakis (2019) and Helmersson et al. (2021), will be used throughout this thesis. All three criteria need to hold at the same time and at least for two consecutive years. Nevertheless, the importance of cross-checking the results using alternative zombie definitions is acknowledged and treated in the robustness section 4.3.4. Overall, the zombie shares calculated and interpreted in section 3 do not change much when applying different zombie definitions. Similarly, the regression results for the dependent variable of interest rates remain unchanged in magnitude, size and significance except for the spillover effect. Nevertheless, the total effect and the resulting conclusions stay the same. For new credit, the individual effects all turn insignificant with

[2]The 5%-threshold of criterion (iii) is chosen because the median interest rate that firms pay on their debt is 5%, such that a debt servicing capacity of 5% implies an interest coverage ratio of 1 (ibid).

alternative zombie definitions. Nevertheless, since the individual effects balance each other such that the total effect is not significant in the baseline definition, the main conclusions remain the same.

2.2 Zombie lending and macroeconomic growth theory

Standard macroeconomic growth theory is based on the existence of an aggregate production function, which usually relies on the assumption of optimal resource allocation within an economy (Banerjee and Duflo, 2005). In reality, however, this assumption fails due to various reasons including capital constraints (ibid). This failure of optimal resource allocation points to factor misallocation, where more (less) human and capital resources are allocated to firms than appropriate given their level of productivity (Saborowski and Misch, 2018). One form of factor misallocation is credit misallocation. In the macro literature on factor misallocation, this inefficient distribution of resources between firms within a country is seen as the primary explanation for different productivity and growth levels between countries (Andrews and Petroulakis, 2019; Hsieh and Klenow, 2009). According to this view, if inefficient firms exit the market, within-sector reallocation of resources will boost productivity of that sector within a country, and, thus, that country's growth. However, the recent empirical literature on factor misallocation and productivity has observed three trends in European countries (Andrews and Petroulakis, 2019). First, the productivity gap between more and less productive firms has increased, yet not because of an increase in productivity of very efficient firms. This implies that less productive firms manage to stay in the market for longer. Second, the positive impact of resource reallocation on aggregate productivity growth has decreased. Third, firm entry in several European economies has declined, whilst the persistence of firms that would have usually exited the market has increased (Andrews et al., 2016). This depresses aggregate productivity growth and reduces growth opportunities for more efficient firms.

One possible explanation for these three trends is zombie lending. Zombie lending prevents inefficient firms from exiting the market and thus hinders entry of new, more productive firms. In their seminal paper, Peek and Rosengren (2005) define this bank practice of extending extra credit to weak firms so that they can avoid or delay bankruptcy as "evergreening". In Spain, Adalet McGowan et al. (2018) find that more than half of the declining efficiency of capital reallocation can be attributed to the rise in zombie lending. Thus, from the point of view of economic growth theory and in the context of declining productivity and growth prospects in Europe, especially in the South (Gopinath et al., 2017), a closer investigation of zombie lending seems worthwhile.

2.3 First strand of the literature: Motives for zombie lending

The literature on zombie firms can be grouped into four strands.[3]

The theoretical literature derives three main motives for banks to "evergreen" their loans:

1. Extending credit to non-viable firms prevents banks from realizing losses when these firms would default on their loans in the banks' balance sheets.

2. Banking regulations meant to support undercapitalized banks can incentivize banks to evergreen their loans through two main channels identified by Acharya et al. (2021b). One channel is that in response to financial crises the conventional monetary policy response is to lower interest rates, thereby lowering the return on most bank assets and rendering lending more attractive for banks (ibid). Another channel is that forbearance measures such as credit guarantees by governments incentivize risk shifting. When public authorities bear a larger share of credit risk, banks might shift lending to riskier loans, including to zombie firms (ibid). In their theoretical model, the authors find that this "implicit subsidy" from policymakers is greater for highly leveraged banks holding riskier assets, thereby incentivizing zombie lending especially by weak banks.

3. A third explanation for evergreening, although not as straightforward, is that banks could extend cheap credit to non-viable firms so as not to ruin the firms' reputation by liquidating their loans. Since banks are considered as being better informed about a firm's finances than market-based lenders, firms without bank loans would hardly be able to obtain market-based financing.

The empirical literature mainly focuses on the bank characteristics that favour zombie lending and find that undercapitalized banks have higher proportions of zombie loans (for instance, Storz et al. (2017), Acharya et al. (2021a), Bittner et al. (2021), Schivardi et al. (2021)). Methodologically, the approach of this thesis is very similar to these papers. For example, Storz et al. (2017) use a panel regression with firm-, bank-, and country-sector-year fixed effects to investigate whether the relationship with a stressed bank increases a zombie firm's leverage. They find that in the euro area periphery[4], an increase in bank stress increases zombie firms' leverage. As will be further described in section 4.2, my baseline model adopts the same fixed effects structure as Storz et al. (2017). Nonetheless, while the

[3] Acharya et al. (2022) group the empirical literature in these four groups, their structure is adopted here. Additionally, this thesis assigns the theoretical literature to these groups (see my own overview in the appendix, section A). Note that the debate on zombie definitions elaborated in section 2.1 does not constitute a strand of the literature itself. Rather, it is discussed in almost every study across the four thematic strands, mostly in the form of robustness checks.

[4] Euro area periphery is defined as Greece, Ireland, Portugal, Spain and Slovenia in Storz et al. (2017).

methodological approach of this thesis to gauge financial spillovers is very similar, it seeks to answer a different question: Instead of analysing which bank characteristics favour zombie lending and thus help *create* or *sustain* zombie firms, this paper examines the *consequence* of zombie lending for *healthy* firms in terms of credit conditions.

2.4 Second strand of the literature: Implications of zombie lending for zombie firms

The second question in the zombie literature is whether cheap loans help zombie firms recover. These primarily empirical studies investigate various aspects of firm health. With limited effects on zombies' employment growth, zombie debt and defaults increasing, and lower zombie profitability, zombie lending does not improve firm health (for instance, Acharya et al. (2019, 2021a); Nurmi et al. (2020)). Although this thesis does not track how zombie firm characteristics evolve over time, it finds that zombies perform significantly worse than healthy firms (section 3.3).

2.5 Third strand of the literature: Policies to reduce zombie lending

The third area of the literature investigates policy instruments to address issues related to zombie lending. In Portugal and Italy, stricter banking supervision including bank inspections, bank stress testing and bank recapitalisations are found to effectively reduce zombie lending (for instance, Passalacqua et al. (2021); Farinha et al. (2018)). For the reform of bankruptcy processes and more efficient restructuring policies, there is mixed evidence that it reduces zombie lending (Acharya et al., 2022).

2.6 Fourth strand of the literature: Spillovers of zombie existence to healthy firms

The majority of papers in the fourth and for this paper most relevant strand of the literature does find negative effects of the existence of zombie firms on healthy firms. Backed by the theoretical literature on factor misallocation and models developed to explain zombie spillovers (for instance, Caballero et al. (2008); Acharya et al. (2021b)), the empirical studies focus mainly on Europe and can be grouped by their main variable of interest.

2.6.1 Real spillovers. Most studies focus on real spillovers in the form of employment growth, investment, or productivity, finding that healthy firms in sectors with higher zombie prevalence have lower employment growth, investment and productivity than healthy firms in

sectors with fewer zombies (Acharya et al., 2019, 2022; Adalet McGowan et al., 2018; Banerjee and Hofmann, 2018, 2020; Farinha et al., 2018; Caballero et al., 2008; Schivardi et al., 2021). This thesis relates closely to these studies because the research question and methodological approach are very similar, using the interaction between a non-zombie dummy and the asset-weighted zombie share as the main independent variable. However, as discussed in section 2.7, it differs from existing studies by analysing the euro area as a whole rather than selected countries, by investigating spillovers in the recent time period 2018 to 2021 instead of the immediate aftermath of the GFC and the European sovereign debt crisis, by looking at the firm-bank level rather than the firm-sector level and by using the firm database Orbis (which is usually used by existing studies) *matched with* the novel AnaCredit dataset.

To exemplify the general approach of these studies on real spillovers, which, except for the zombie definition adopted, is very similar across these papers, consider Banerjee and Hofmann (2018, 2020). In a sample of listed firms in 14 advanced economies, they implement a panel regression with sector-year and country-year fixed effects with employment growth, capex, or TFP growth as the dependent variables. The coefficient of interest on the interaction between the non-zombie dummy and the asset-weighted zombie share denotes the difference in the dependent variable between healthy firms in sectors with many versus sectors with few zombies. They find that increasing the zombie share by one percentage point (p.p.) using a narrow zombie definition significantly decreases non-zombies' employment growth by 0.26p.p. (Banerjee and Hofmann, 2018).

Importantly, Schivardi et al. (2020, 2021) criticise this widely used panel regression approach as the zombie share in a sector might be correlated with unobserved industry-level shocks. If these shocks then affect the performance of healthy, but not zombie firms, this might mechanically lower their employment, investment, or productivity growth, without zombie spillovers being the reason. Whilst most of the mentioned studies note, but do not act on this critique[5], Banerjee and Hofmann (2018, 2020) re-run their regression using an instrumental variable to verify their results, which remain unchanged overall. They use a Bartik shift-share instrument which measures a country's exposure to the global zombie share, computed as $\sum(capital\_share\_sector_{sct} * avg\_zombie\_share\_sector_{st})$.

Thus, the average zombie share in that specific sector across all 14 countries in their sample is computed, and then multiplied by the share of total assets of that sector s in the specific country c at time t, which functions as a weight for that sector. To calculate country c's exposure to the global zombie share, these sector-weighted zombie shares are summed up. This instrument hence fulfils the exclusion restriction since the exposure to

[5] Acharya et al. (2020) and Farinha et al. (2018) also employ instrumental variables in addition to the usual panel regressions.

the global zombie share is not correlated with employment, investment or productivity other than through the zombie share in that country. Moreover, the relevance restriction holds as a country's exposure to the global zombie share is closely related to the zombie share in that country. Due to the aforementioned differences of my regression set-up, including examining at the bank, not the sector level, Schivardi et al.'s critique is less relevant here.

In summary, the literature on real spillovers finds significant negative effects from zombies on healthy firms' employment, investment, or productivity growth. It thereby provides evidence for zombie firms crowding out growth opportunities for more efficient firms, thereby depressing productivity growth as described in section 2.2.

2.6.2 Financial spillovers. The zombie literature on real spillovers pays less attention to the channels through which these real spillovers operate. Acharya et al. (2019) name two main avenues of transmission for real spillovers. The first channel is non-financial: Competition on the sector level is distorted as zombie firms survive economic shocks that would have usually led to their exit. Thus, they deter entry of more productive firms into the market, leading to negative real spillovers for healthy firms via distorted competition. This is theoretically backed by the model by Caballero et al. (2008) for employment, investment, and productivity. The second channel of transmission is financial, namely credit misallocation by banks, where "due to a **loan supply shift to zombie firms**, nonzombie firms had to pay higher interest rates if the zombie prevalence in their industry was particularly high, irrespective of the industry's competitiveness" (Acharya et al., 2019, page 3406, emphasis added). Thus, one channel of transmission for real spillovers are financial spillovers from zombie firms to healthy firms' credit conditions. Surprisingly, papers on real spillovers rely on this channel as an assumption, but rarely test it. Four papers examine such financial spillovers, two of them only in short sub-sections, which are described below. Hence, there is a need for closer investigation of financial spillovers, which this thesis contributes to.

Two recent studies analyse financial spillovers on the province and sector level in China. They are the only existing studies *primarily* focusing on financial variables, as this thesis does too, and thus relevant to mention here. Yu et al. (2021), employing a panel regression with non-interacted fixed effects and just the zombie dummy as the independent variable (no interaction term) and an instrumental variable approach, find that the existence of zombie firms increases the debt financing cost for healthy firms. In their regression, they find that increasing the zombie share in an industry by one percentage point increases healthy firms' debt financing cost by 0.051p.p. Using an instrumental variable, the impact on debt financing cost increases to 14.8%. Similarly, Wang and Zhu (2021) find that zombie firms crowd out financing opportunities for healthy firms and increase healthy firms' financial constraints, as

measured by cash-cash flow sensitivity.

For Europe, as a sub-section of their analysis, Acharya et al. (2019) run their regression with interest rates as the dependent variable for five euro area countries 2009-2015. They find that a one percentage point increase in the industry zombie share increases interest rates of healthy firms in this industry by 2.4p.p., which is significant at the 1%-level (ibid). This thesis is strongly connected to this subsection since it also employs interest rates paid by firms on their bank loans as one dependent variable. However, the regression here is run on bank, not sector level, leading to a different fixed effects structure, which is closer to that mentioned for the first strand of the literature.

Finally, Andrews and Petroulakis (2019) investigate zombie firms crowding out credit from healthy firms in four euro area countries in 2009-2013. With credit availability as their dependent variable, they find that healthy firms in sectors with more zombies report worse access to credit. The authors use a survey-based measure of credit availability from the SAFE survey, asking firms whether they have more difficulties to obtain loans or credit lines from banks compared to the previous six months. A one one percentage point increase in the zombie share decreases their measure of credit availability with its maximum at 3 by -0.0053, significant at the 1%-level. The authors argue that this might be because healthy firms in industries with more zombies have lower returns, thus reducing banks' willingness to lend in these sectors. Despite, or perhaps due to, their small sample size and modest magnitude of this effect, this finding can be seen to justify investigating financial spillovers further, as is done in this thesis.

2.7 Contribution of this thesis

This thesis contributes to the literature on financial spillovers[6] in three main respects. First, to the best of my knowledge, it is the first comprehensive study to include all euro area countries, substantially increasing the sample size compared to the aforementioned studies. In the first part, which investigates zombie prevalence in the euro area, the time frame covered is 2005-2019. It thus includes many of the shorter time periods studied in previous papers. The dataset used here is the Orbis database. Due to the data availability of the AnaCredit dataset used for the second main part (see next paragraph), the analysis of financial spillovers starts in 2018. To sum up, the sample used in this thesis is thus comprehensive and very recent.

Second, this thesis utilises the new AnaCredit dataset[7] , which introduces a new level of

[6]To the best of my knowledge, these four studies are the only ones I could find that deal with financial spillovers.

[7]For more information on AnaCredit, see section 4.1.1 and European Central Bank (2022a)

granularity in information on lending to the sector of non-financial corporations in the euro area. With over 90 loan attributes reported on a quarterly basis, it allows to analyse credit conditions in a more detailed way than was previously possible for the euro area.

Finally, whilst the baseline model is very much in line with those used in the literature and described above, the model employed here differs in two important respects: (i) Regressions are run on bank, not sector level, which seems more plausible when considering financial spillovers as explained below. (ii) Most of the dependent variables analysed here have not been employed before, potentially due to data availability constraints. Thus, this thesis explores spillovers from the existence of zombie firms to healthy firms from a novel perspective.

3 Do zombie firms exist in the euro area?

This section analyses the prevalence and features of zombie firms in the 19 euro area countries from 2005 to 2019, to establish whether the existence of zombie firms is a sizeable problem in the euro area. After all, if zombie firms were found to constitute only a very small fraction of firms, spillover effects would be negligible.

3.1 Data

Data for this section is taken from Bureau van Dijk's Orbis global database, henceforth Orbis. Orbis is the largest existing firm database and includes information from financial accounts and firm's real activity for firms of all sizes in the euro area and other countries (Kalemli-Ozcan et al., 2015, revised 2022). With over 400 million firms in 100 countries, Orbis comprises a sub-sample of the population of all firms in the world. Reporting requirements and firm coverage differ by country. For some countries, only large firms are required to report financial statement information, leading to less coverage of small firms (ibid). Nevertheless, as research by (Kalemli-Ozcan et al., 2015, revised 2022) shows, the Orbis sample for European firms covers a large part of, and is representative for, the whole European economy in terms of output and employment.

This thesis focuses on the 19 euro area countries. The time frame for this section comprises 2005-2019, since there exist far less observations across countries before 2005, and financial accounts data for 2020 onwards is not yet available for all firms due to the reporting time lag. To avoid duplicates, an observation is uniquely identified by the primary key of the firm identifier, the balance sheet reporting date, the consolidation code stating whether the firm is a subsidiary of another reported parent firm, whether the information was filed

in a local registry filing or via annual reports, and the accounting practice. Observations where key financial variables needed for analysis are missing are excluded from the sample. To ensure that only plausible information is included, further sample restrictions along the lines of Storz et al. (2017) are employed: Firms without financial debt, inactive firms, and those with inconsistent balance sheets (zero or negative total assets, negative debt, sum of equity and liabilities not between 99% and 101% of total assets) are excluded. Moreover, as is common practice in the zombie literature, firms in the sectors A and B (primary sector), K (financial sector), O (public administration, defence, and social security) and U (extraterritorial organisations) are excluded. In contrast to Storz et al. (2017), this sample includes large and listed firms to ensure representativeness. Furthermore, all firms with negative equity are excluded[8]. The resulting sample includes over 18 million observations.

Different measures of firm profitability and viability are constructed from the Orbis dataset. These include real indicators such as the number of employees, the age of the firm, country and sector. Financial indicators include

- Measures for firm profitability:
  - EBITDA: the company's earnings before interest, taxes, depreciation and amortization and a measure for a firm's revenues
  - Turnover
  - Sales
  - Return on assets as measured by EBITDA over total assets: indicates how efficiently a firm uses its assets for profit generation
  - Tangibility measured as tangible assets over total assets
- Measure of a company's overall worth: total assets as the sum of a firm's debt and equity
- Equity-related indicators:
  - Return on equity: ratio of net income to equity held by shareholders
  - Equity ratio as equity divided by total assets: Since total assets are the sum of debt and equity, this ratio should not be greater than 1. Companies with an equity ratio below 0.5 are considered leveraged, companies with an equity ratio above 0.5 hold are primarily financed by equity rather than debt.
- Debt-related indicators:

[8]Negative equity arises when a firm's total debt exceeds total assets. When not applying this restriction, the descriptive statistics become very unreasonable also for healthy firms. Considering that my sample size is already very large, the amount of observations lost through this restriction is not substantial.

– Leverage as total financial debt divided by total assets to measure a firm's level of indebtedness: Since total assets are the sum of debt and equity, the leverage ratio should not exceed 1. If it is greater than 1, this would imply that a firm has negative equity, which means that it is bankrupt.
– Debt servicing capacity computed as EBITDA divided by total financial debt: measures whether a firm's profits can service its financial obligations on time
– Liquidity ratio measuring whether a company can meet its short-term debt obligations using its liquid assets: The higher the liquidity ratio, the better, as it indicates that a firm can cover its short-term debt obligations.
– Solvency ratio indicating whether a firm can meet its long-term debt obligations without becoming insolvent: Like the liquidity ratio, the higher the solvency ratio is, the better.

Table 1. Descriptive statistics of the Orbis sample

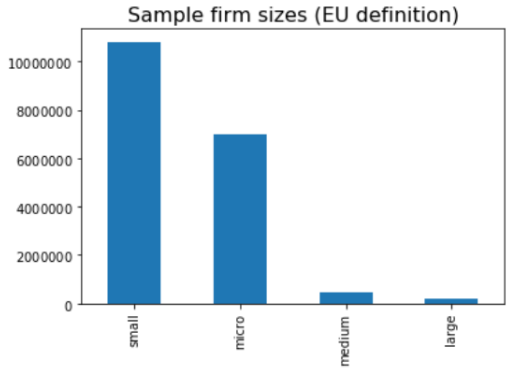
	count	mean	std. deviation	min	10th percentile	50th pctl.	90th pctl.	max
number of employees	11200549	69.44	2236.44	0	1.00	5.00	45.00	709720
firm age	18451141	24.51	13.87	1	11.00	22.00	40.00	1022
is_zombie	18456628	0.02	0.13	0	0.00	0.00	0.00	1
EBITDA	18456628	1273303.25	67487378.03	-15197000000	-2198.00	41549.00	473870.00	50572754892
total assets	18456628	15590673.21	749046058.97	1	83600.00	553178.00	6529501.20	488071000000
return on assets	18456628	0.04	0.47	-1157	-0.04	0.02	0.16	1014.91
net investments	17141410	510625.61	118947802.69	-94901000000	-71764.00	-2136.00	144200.00	123955233000
tangibility	18346323	0.29	0.29	-27.87	0.01	0.19	0.78	79.48
leverage ratio	18456628	0.28	25.56	0	0.01	0.20	0.61	70707.60
EBITDA over total assets	18456628	0.11	3.51	-8700.43	-0.01	0.09	0.27	6140.91
sales	15802108	13080108.08	468106498.05	-690904299	54403.00	487267.00	6234000.00	252632000000
turnover	16142900	13557548.47	477584013.68	-419367539	57215.00	494000.00	6424256.90	259859000000
liquidity ratio	18261877	2.28	5.92	0	0.24	1.07	3.78	100
solvency ratio	18455784	35.91	24.69	0	6.15	31.92	72.38	100
return on equity	18339279	9.52	77.30	-1000	-17.59	8.69	53.60	1000
equity ratio	18456628	0.36	0.96	0	0.06	0.32	0.72	3864.26
debt servicing capacity	18456628	288.42	66096.11	-20233871	-0.02	0.40	6.98	118338000

Notes: EBITDA, total assets, net investments, sales and turnover are reported in Euro. Return on assets, tangibility, the leverage ratio, EBITDA over total assets, and the equity ratio are reported as decimals, to be multiplied by 100 to get percentages. Return on equity is reported in percent.

The majority of the firms in this sample are small and micro firms (Figure 1), following the classifications by the European Commission (2020)[9]. Table 1 shows that the average firm in this sample is 25 years old and financially well-performing. This is underlined by

[9]The definitions by the European Commission are as follows: A micro firm has less than 10 employees

Figure 1. Distribution of firm sizes in the Orbis sample



an average return on assets of 4%, an average leverage ratio of 28%, liquidity and solvency ratios exceeding 1 by far, and positive mean sales, turnover, net investments, EBITDA and total assets. The average zombie share across the whole sample is at 1.7%.

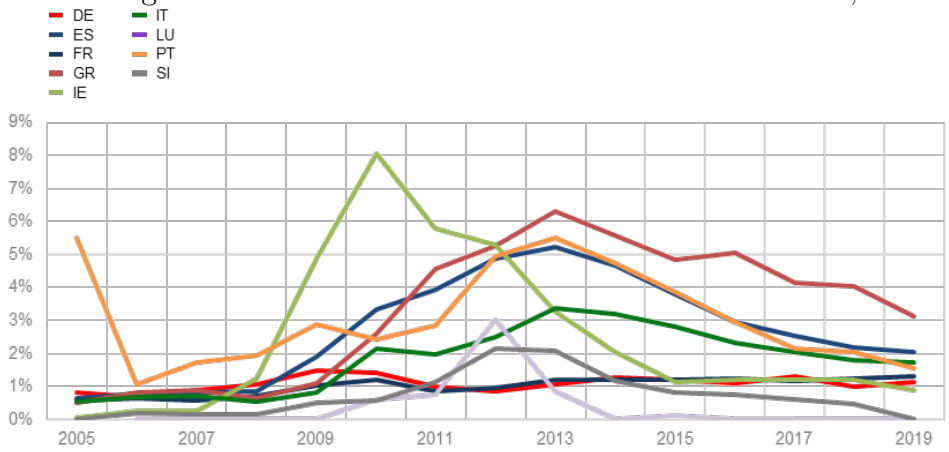
3.2 Zombie prevalence

The following section examines the question of zombie prevalence in the euro area by plotting zombie shares per country and sector. To examine the existence of zombie firms in the euro area, zombie shares are calculated in two steps. First, each firm in each year of observation is classified as either healthy *(is_zombie = 0)* or as a zombie *(is_zombie = 1)*, namely when, for the current and the previous period, (i) returns on assets were negative, (ii) net investments were negative, and (iii) the debt-servicing capacity was below 5%. Second, the share of these zombie firms of total firms in the sample (after applying above restrictions) weighted by their assets is computed for each country or sector. Most empirical studies in the zombie literature use such asset-weighted shares to gauge the economic significance of zombie firms (for instance, Acharya et al. (2019, 2020, 2022); Andrews and Petroulakis (2019); Banerjee and Hofmann (2018, 2020); Caballero et al. (2008)). The remaining studies use the number of zombie firms divided by the number of total firms in the sample (Storz et al., 2017) or employment-weighted shares (Nurmi et al., 2020). Having computed shares both in terms of "pure" numbers and total assets, the difference between them is marginal (see Appendix B). Thus, this thesis uses asset-weighted shares, as they better represent the economic weight of zombie firms.

and either up to €2 million in annual turnover or up to €2 million in balance sheet total. A small firm has between 10 and 50 employees, and either up to €10 million in annual turnover or up to €10 million in total assets. A medium-sized firm has between 50 and 250 employees, and either up €50 million in turnover or €43 million in total assets. Any firm larger than this is classified as a large firm.

Figure 2 plots asset-weighted zombie shares for selected euro area countries from 2005 to 2019. [10]. For all countries except Portugal, the prevalence of zombie firms was small before the global financial crisis, with shares below 2% overall. Starting with the global financial crisis 2008, however, more firms are classified as zombie firms, driving shares up. Interestingly, zombie firms arose in Ireland earlier (peak in 2010) than in other euro area states (e.g. peaks of Portugal and Greece in 2013). This illustrates the course of the global financial crisis, with Greece and Ireland hit early and hard, whilst other countries were more adversely affected by the subsequent European sovereign debt crisis (Godby and Anderson, 2016). Overall, Figure 2 shows that the so-called "GIIPS countries" (Greece, Ireland, Italy, Portugal and Spain) that suffered disproportionately from these two crises exhibit higher zombie shares than the remaining countries. For example, short after the height of the European debt crisis in 2013 the euro area average zombie share (19 countries) was 2.2%, whilst the GIIPS countries' average was 4.7%. Figure 3 plots the average asset-weighted zombie share for each country from 2008 to 2019. With close to 5%, Lithuania and Greece have the highest average zombie share, followed by Spain, Portugal and Ireland. This finding confirms those of the existing literature (for instance, Acharya et al. (2019); Storz et al. (2017). Note that the rise in zombie shares is not due to a decrease in the total number of firms, which for most countries stays rather stable.

Figure 2. Asset-weighted zombie shares for selected euro area countries, 2005-2019

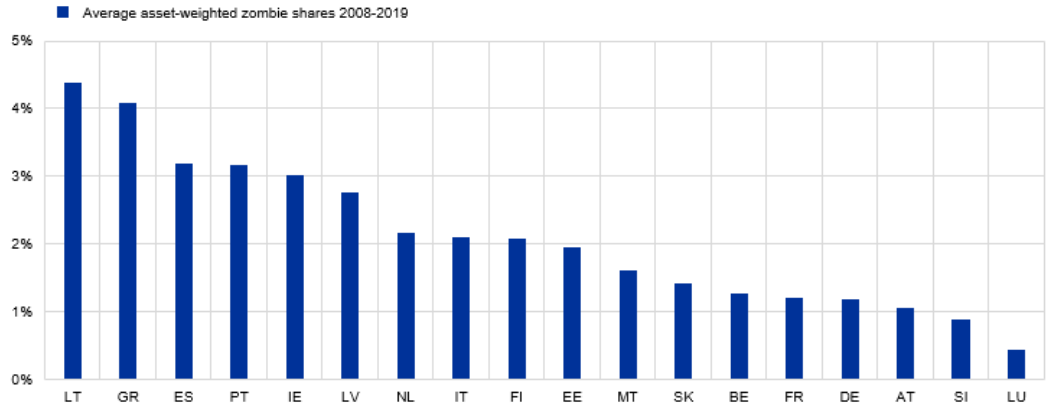


The zombie shares in all countries remained elevated after the global financial crisis, marking 2008 as a potential structural break. This observation is confirmed by the literature,

[10] Countries shown are selected for illustrative purposes. Note that the country-share plot in Figure 2 excludes large firms from the sample. This is because large and listed firms are less likely to be zombie firms as they usually have better financial fundamentals and equity. The zombie shares when including large and listed firms are lower.

finding that economic crises favour the creation of zombies in three ways (Acharya et al., 2021b): They increase the probability of firms' defaults or deteriorate firm credit quality; banks experience a higher economic fallout from more non-performing loans; and policy measures like government credit guarantees taken to combat such crises can favour banks' evergreening by incentivising risk shifting (see section 2.3). Acharya et al. (2021b) find evidence for the European monetary and fiscal policy mix following the global financial crisis 2008 and the European sovereign debt crisis to have incentivised zombie lending. This coincides with the peaks in zombie shares following these crises. The observation that zombie country shares remained persistently on a higher level after the GFC than before is confirmed by Banerjee and Hofmann (2020), who compare the increase in zombie shares after a "normal" recession to that following the global financial crisis. They argue that this increased zombie persistence is due to the depth of the GFC recession and the unprecedented policy response. These findings can hence be seen as one explanation for the rising zombie numbers in Figure 2 in response to these two economic crises, observing that time trends in zombie shares match these policy trends.

Figure 3. Average asset-weighted zombie shares for 17 euro area countries, 2008-2019

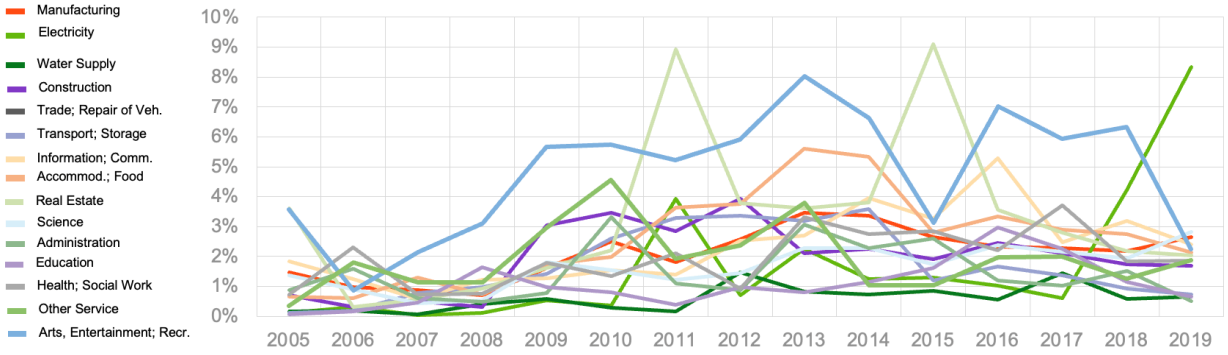


The zombie shares found here are in line with the levels reported by Helmersson et al. (2021), the OECD (Adalet McGowan et al., 2018) and Storz et al. (2017). For instance, Helmersson et al. (2021), who also use the zombie definition by Storz et al. (2017), find an average zombie share of 3.4% for the euro area from 2004-2019, with peaks of up to 6% following the euro area sovereign debt crisis. Yet, they are below the zombie shares of 10-20% that for instance Banerjee and Hofmann (2020), Acharya et al. (2019) or Schivardi et al. (2020) find. Two factors may account for the lower zombie shares in the present sample. First, this thesis uses the same zombie definition as Storz et al. (2017) and Helmersson et al. (2021), but a different one than the other papers. As shown in the robustness checks (section

4.3.4), this can explain some of the difference, but not all of it. Second, my sample is larger and consists of different firm types. For instance, Banerjee and Hofmann (2018) only include listed firms, while my sample also includes unlisted firms. Together, these two factors may partly explain the lower level of zombie shares found with the present sample. Still, with levels reaching up to 8% in 2013 for Ireland, this indicates that the existence of zombie firms in the euro area is not negligible, and thus an important topic of analysis.

A factor influencing country-specific zombie shares could be that countries specialize in different sectors of economic activity and zombie shares vary across sectors. This is also flagged in Banerjee and Hofmann (2020). Thus, zombie shares on the sectoral level are presented in Figure 4. Sectors are defined in line with the European Commission's sector definitions (European Communities - Eurostat, 2008).

Figure 4. Asset-weighted zombie shares for first-level NACE sectors, 2005-2019



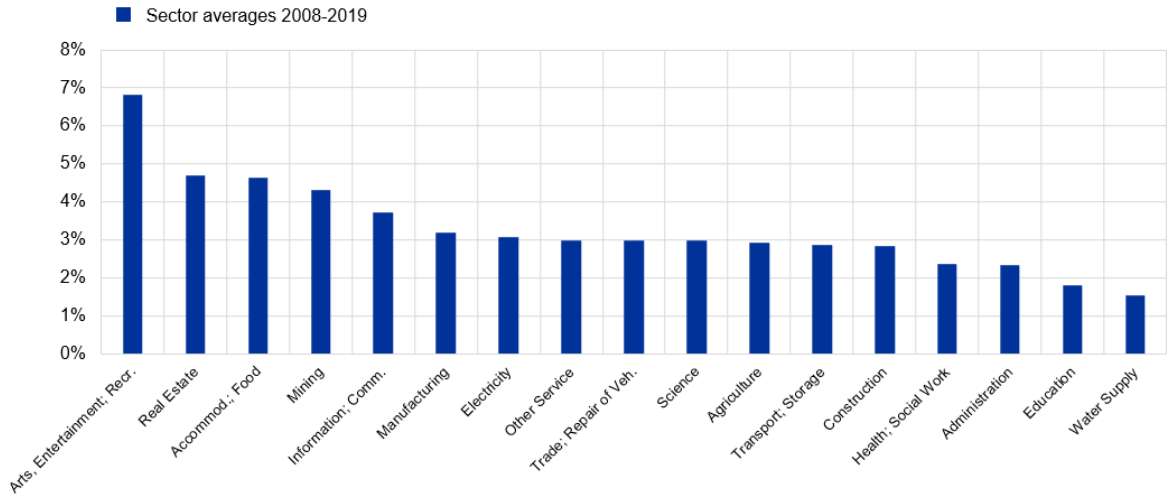
The time series in Figure 4 shows that zombie shares have increased for most sectors after the GFC 2008[11].

Figure 5 plots the average zombie share of the one-digit level NACE sectors from 2008 to 2019. Interestingly, sector R, "Arts, Entertainment and Recreation", exhibits the highest average zombie share around 7%. The Arts, Entertainment and Recreation sector also scores high in the sector breakdown by Banerjee and Hofmann (2020). The zombie share in this sector peaks in 2013, but remains elevated compared to the remaining sectors thereafter. This might be influenced by the GFC and the following recession, which made consumers worse off. Consequently, it seems plausible that most consumers cut back first on cultural activities, travelling and eating out. In fact, these sectors like "Arts, Entertainment and Recreation" and "Accommodation and Food" have average zombie shares higher than 4%. This explanation can also shed light on the real estate sector exhibiting an average zombie

[11]Sector T includes private households, possibly making the data on zombie characteristics less reliable (for instance, households should not have any assets owned by shareholders). Thus, Figures 4 and 5 exclude this sector.

share of over 4%, peaking in 2011 and 2015. Sectors in leisure and real estate are more pro-cyclical, making it more likely that firms in these sectors fulfil the zombie criteria for two consecutive years (Solimano, 2019; Wachter and Orlando, 2017).

Figure 5. Average asset-weighted zombie shares for first-level NACE sectors, 2008-2019



Finally, it is interesting to investigate whether zombie firms stay zombies or become healthy again during the period of analysis. The definition by Storz et al. (2017) allows zombies to recover. The probability of remaining a zombie[12] averages at 35.1%, reaching a peak at 42.3% in 2011 (Figure 6). This is in line with the above findings, underlining that the global financial crisis not only created more zombies, but also increased the probability of remaining a zombie firm. Despite recent decreases since the European sovereign debt crisis, zombie persistence has risen over period of study as illustrated by the dotted trend line. This is also in line with Banerjee and Hofmann (2020).

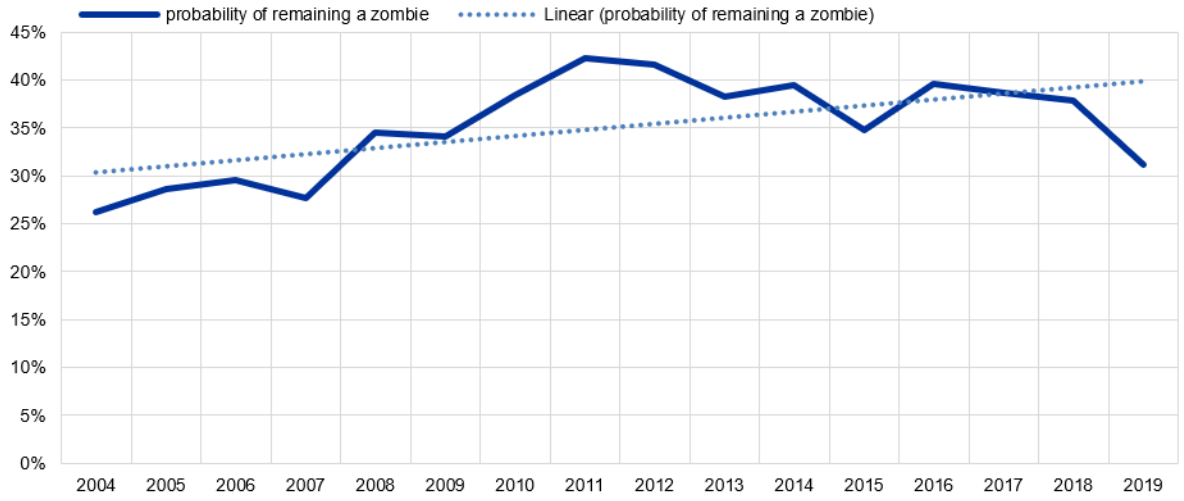
3.3 Zombie characteristics

As the previous section has shown, zombie firms do exist in the euro area, and especially in the GIIPS countries, to a non-negligible extent. This part presents the characteristics of these non-viable firms and compares them to healthy firms, indicating whether the definition chosen correctly identifies zombie firms.

Table 2 shows the mean, median, standard deviation, and number of observations for each variable. The main take-away from this comparison of financial characteristics between

[12]Following Banerjee and Hofmann (2020), the probability of remaining a zombie firm is calculated as the number of zombies in the current period which will stay zombies in the subsequent period, divided by the total number of zombie firms in the current period.

Figure 6. Probability of remaining a zombie, 2005-2019



zombies and non-zombies is that the definition does identify firms as zombies that perform significantly worse than the remaining firms in all financial variables included here.

The average zombie firm, with a mean of 26 employees, is smaller than the average healthy firm, which has 69 employees on average. This seems plausible, assuming larger firms are not as dependent on external financing as smaller firms. This finding is in line with Helmersson et al. (2021). In fact, several studies either a priori exclude large firms from their sample (for instance, Storz et al. (2017)), or run their analysis again in a sub-sample of only small firms (for instance, Andrews and Petroulakis (2019)). The mean and median zombie firm is older than 25 years. This confirms that the zombie definition employed does not mistakenly capture young firms like start-ups that are still in the growth phase and thus temporarily experience weaker fundamentals. The fact that zombie firms identified using this definition are older appears plausible since older firms tend to accumulate more debt and invest less than young firms.

Table 2. Financial characteristcis of zombie firms vs. healthy firms

	healthy_mean	zombie_mean	healthy_median	zombie_median	healthy_std	zombie_std	healthy_count	zombie_count
number of employees	70.15	26.61	6.00	4.00	2254.45	339.91	11018054	182495
firm age	24.46	27.42	22.00	25.00	13.87	13.56	18135048	316093
EBITDA	1299623.86	-236660.09	42900.00	-9882.00	68065489.29	7523183.08	18140417	316211
total assets	15720457.94	8145172.70	550972.00	722544.00	755201231.73	172766662.13	18140417	316211
return on assets	0.04	-0.10	0.02	-0.05	0.47	0.59	18140417	316211
net investments	530851.94	-565592.57	-2000.00	-10600.00	120013341.80	24479681.84	16825199	316211
tangibility	0.29	0.32	0.19	0.17	0.29	0.34	18032044	314279
leverage ratio	0.27	0.33	0.20	0.28	25.79	0.27	18140417	316211
EBITDA over total assets	0.11	-0.07	0.09	-0.02	3.54	0.57	18140417	316211
sales	13228257.75	4312280.58	495000.00	159746.00	471834622.63	107973005.31	15539537	262571
turnover	13724536.37	4265119.37	502514.00	150629.00	481639974.09	107231520.00	15857928	284972
liquidity ratio	2.26	3.05	1.08	0.78	5.85	8.93	17953956	307921
solvency ratio	35.92	34.89	31.97	28.19	24.63	27.93	18139591	316193
return on equity	10.81	-65.79	9.07	-20.16	75.55	125.51	18030135	309144
equity ratio	0.36	0.35	0.32	0.28	0.97	0.28	18140417	316211
debt servicing capacity	295.30	-106.32	0.42	-0.10	66661.04	8124.59	18140417	316211

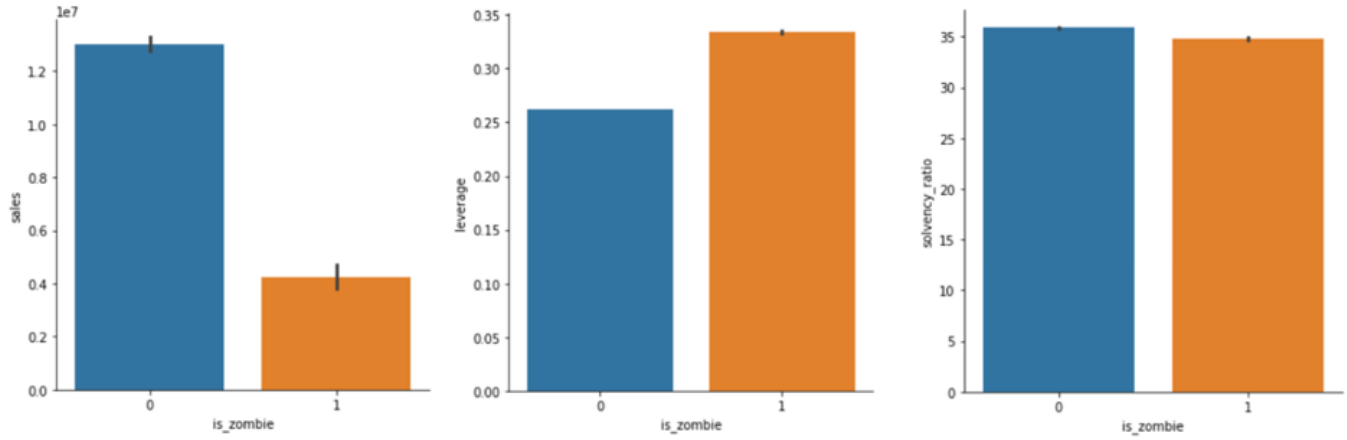
Notes: EBITDA, total assets, net investments, sales and turnover are reported in Euro. Return on assets, EBITDA over total assets,and the equity ratio are reported as decimals, to be multiplied by 100 to get percentages. Return on equity is reported in percent.

Zombie firms are less profitable than healthy firms. In stark contrast to healthy firms, both the mean and median EBITDA of zombie firms are negative, meaning that zombie firms have negative earnings. Moreover, mean and median sales of healthy firms are more than three times those of zombie firms, as illustrated in Figure 7. Note that the standard deviation for zombie firms is very high. This implies that, although mean and median sales are positive, some zombie firms have substantial negative sales. By definition, zombie firms have a negative return on assets, with a mean of -10%. Similarly, the ratio of EBITDA over total assets is negative, with a mean of -7%. This contrasts healthy firms with an average of 11%. Furthermore, healthy firms have significantly higher total assets than zombie firms.

Regarding equity indicators, the median equity ratio of 28% for zombie firms is lower than that for healthy firms with 32% for healthy firms. Furthermore, mean and median returns on equity are strongly negative for zombie firms, whilst positive for healthy firms, indicating the worse financial performance of zombie firms.

Finally, zombie firms are more indebted than healthy firms in this sample, as illustrated in Figure 7 for mean leverage and the average solvency ratio. Their median leverage ratio, calculated as financial debt over total assets, is with 28% a third higher than that of healthy firms. For a firm to be able to pay off its short-term debt obligations, its liquidity ratio needs to be greater than 1. Whilst the median liquidity ratio for healthy firms is 1.08, it is only

Figure 7. Mean sales, leverage, and solvency ratios with 95% confidence intervals for healthy firms (is zombie =0) and zombie firms (is zombie = 1)



0.78 for zombie firms. This implies that the median zombie firm does not have enough liquid assets to cover its short-term liabilities. Similarly, the solvency ratio indicates whether firms are able to meet their long-term debt obligations. In this sample, the mean and median solvency ratios for zombie firms are positive, but lower than for healthy firms. Finally, the debt servicing capacity for zombie firms is negative, implying that the average and median zombie firm has negative cash flows, which is in line with observations from the previous variables.

To sum up, financial fundamentals of zombie firms are much weaker than those of healthy firms. This is in line with descriptive statistics of related empirical papers, which also find significant differences between the two groups (for instance, Acharya et al. (2019); Banerjee and Hofmann (2020)).

This finding also holds when observing these financial characteristics over time and for individual countries, as plotted in Figures 8 and 9 for EBITDA over total assets and leverage. There are two main insights from these figures. First, zombies perform worse than healthy firms over the whole time span; the levels for a given country are fairly constant. Thus, it is not a specific event (for instance the GFC) that is driving the difference between the two groups. Second, firm performance differs according to country. For example, leverage ratios tend to be higher for both groups of firms in Spain, Portugal and Greece, which belong to the GIIPS countries. As leverage is used to calculate the debt servicing capacity for the zombie definition, this supports the above finding of higher zombie shares in these countries.

Since the given dataset is panel data, it is inappropriate to use the usual t-tests to test for a difference in means between the two groups. Instead, one needs to account for the

Figure 8. EBITDA over total assets for healthy vs. zombie firms, 2005-2019

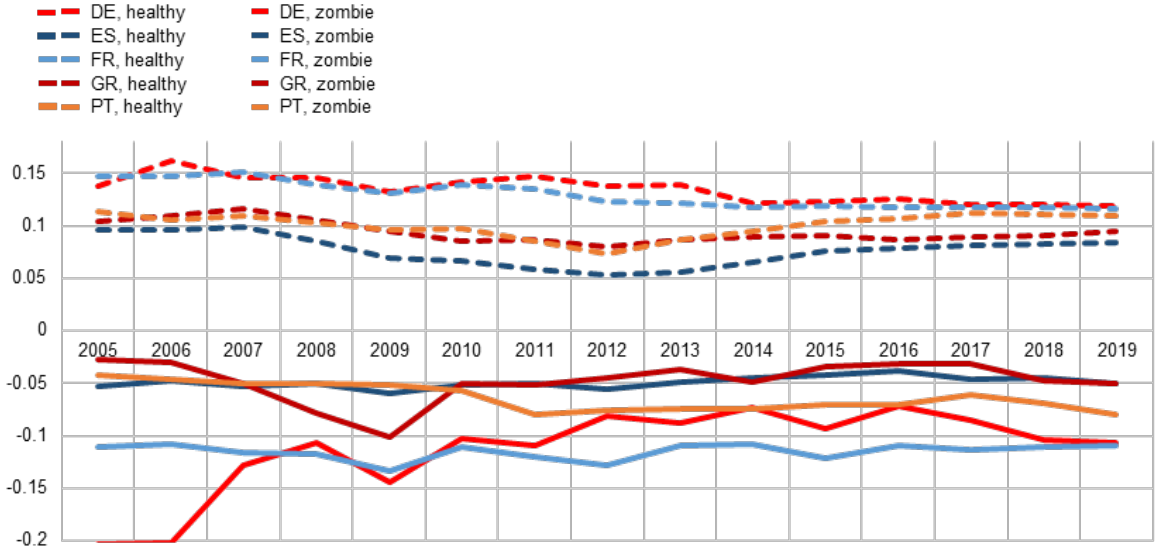
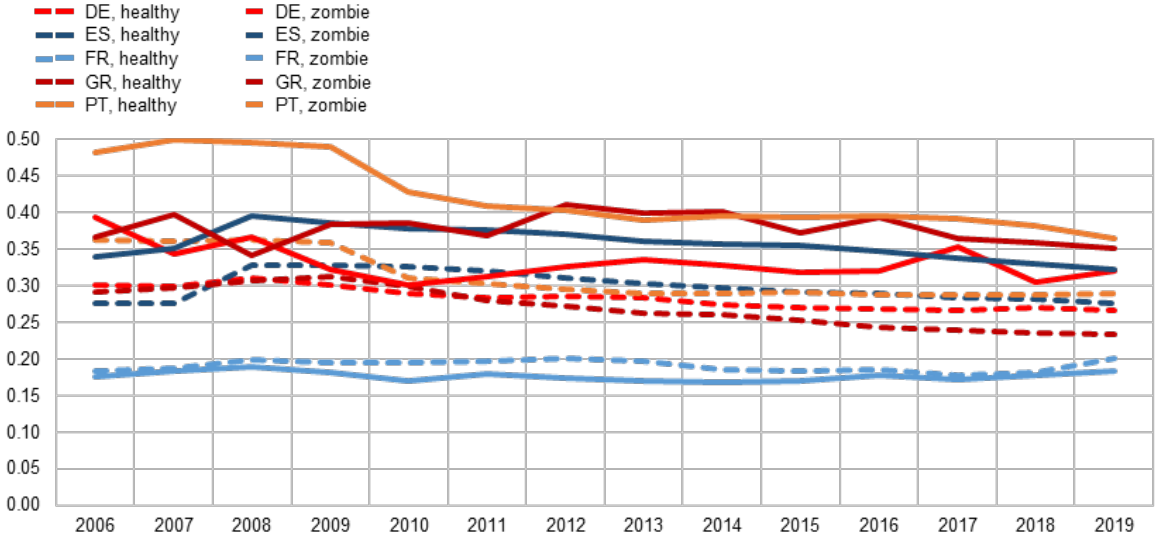


Figure 9. Leverage ratios for healthy vs. zombie firms, 2005-2019



clustering of observations, because one firm, over the period of study, can be classified as a zombie in some years and as healthy in others. Thus, simple panel regressions with sector, country, country-sector, and time fixed effects are run, as shown in equation 1. The financial characteristic where the difference in means is to be tested is the dependent variable, for instance total assets. The independent variable is the *is_zombie* dummy, which equals 1 if the firm is identified as a zombie firm, and 0 otherwise. If the coefficient on the zombie dummy is significant, there is a difference between the two groups.

$$Characteristic_{i,t} = \beta_1 * is\_zombie_{i,t} + \gamma_t + sectorFE_t \quad (1)$$

The differences between zombies and healthy firms are significant at the 1% level for all variables (table 3). These findings support the baseline zombie definition adopted here as identifying significantly weaker firms in this sample.

Table 3. Testing the difference in means between healthy firms and zombie firms

	healthy_mean	zombie_mean	healthy_med	zombie_med	healthy_std	zombie_std	healthy_count	zombie_count	t-stat	p-value
number of employees	70.15	26.61	6.00	4.00	2254.45	339.91	11018054	182495	-6.437	0.000
firm age	24.46	27.42	22.00	25.00	13.87	13.56	18135048	316093	7.695	0.000
total assets	15720457.94	8145172.70	550972.00	722544.00	755201231.73	172766662.13	18140417	316211	-4.973	0.000
EBITDA over total assets	0.11	-0.07	0.09	-0.02	3.54	0.57	18140417	316211	-11.940	0.000
return on assets	0.04	-0.10	0.02	-0.05	0.47	0.59	18140417	316211	-12.649	0.000
net investments	530851.94	-565592.57	-2000.00	-10600.00	120013341.80	24479681.84	16825199	316211	-7.018	0.000
leverage ratio	0.27	0.33	0.20	0.28	25.79	0.27	18140417	316211	12.632	0.000
debt servicing capacity	295.30	-106.32	0.42	-0.10	66661.04	8124.59	18140417	316211	-7.984	0.000

4 Does the presence of zombie firms impact the credit conditions of healthy firms?

Having established in section 3 that zombie firms exist in the euro area, and especially in the GIIPS countries, to a non-negligible extent, and that they differ in financial characteristics to healthy firms, the question arises whether this is a more far-reaching economic problem. This would be the case, for instance, if the existence of zombie firms affected healthy firms. As described in section 2.6, the zombie literature addresses this question of spillover effects primarily with regard to "real" effects in terms of investment, employment or productivity. Most studies rely on the assumption that such real effects are transmitted either via the competition channel or via the financial spillover channel, where zombie firms are assumed to receive credit at more favourable financing conditions than healthy firms (see section 2.6 for a detailed explanation). This raises the question if the presence of zombie firms in a bank really does impact credit conditions for healthy firms. The ESCB's AnaCredit dataset makes it possible to study this question for a wide range of firms and from different angles.

4.1 Data and descriptive statistics

4.1.1 A novel dataset. The dataset used here in section 4 to analyse credit conditions is a joint dataset of the Orbis data used in section 3 and the AnaCredit dataset. The joined Orbis-AnaCredit table used here has been created by the European Systemic Risk Board Secretariat (ESRB Secretariat). Initiated in 2011 by the European Central Bank, the

AnaCredit project collects granular data on all loans exceeding €25,000 in the euro area, except loans by private persons which are not included (European Central Bank, 2022a). Data collection by most financial institutions in the euro area member states started in September 2018, which is also the first date of the data record in this sample. The purpose of AnaCredit is to monitor the performance of the whole euro area credit market, allowing the detection of risky credit exposures on a loan-by-loan basis.

Over 90 credit attributes for each loan in the sample are reported on a monthly basis, whilst financial account variables are reported quarterly. Therefore, the dataset used in this section includes quarterly data from Q3 2018 to Q4 2021. The same sample restrictions as in section 3 are applied. In addition, observations with interest rates below -100% or above 100% are excluded, because these reflect mostly reporting errors. Furthermore, observations with missing values in the key variables of interest (total assets, fixed assets, leverage, EBITDA, number of employees, and firm age) are eliminated. Finally, healthy firms with a return on assets below -10 are excluded. This very negative ratio is mostly due to a low amount of total assets reported and affects 450 firms. The sample restrictions yield a sample of 24.998 million observations. The granularity of the dataset used here is such that one observation uniquely identifies the aggregated amount of loans (and credit attributes for these loans) that a specific firm holds at a specific bank in a specific quarter. A debtor can have loans at multiple banks.

Since Orbis financial account data are only available until including the financial year 2019 for most firms, it is not possible to identify zombie firms for 2020 onwards. Therefore, all firms that are identified as zombie firms in 2019 are assumed to stay zombies over the period of study, yielding a fixed sample of 15658 zombie firms. Since the matched sample includes around 1.16 million distinct firms, this yields an overall zombie share of 1.4%. This average share is slightly lower than in the Orbis sample because not all zombie firms from Orbis might be reported in AnaCredit. Recall that all firms included in AnaCredit must have loans exceeding €25,000. Therefore, the matched sample used here only includes firms that use credit instruments, on top of the aforementioned filters. Nevertheless, with a zombie share of 6.3% in the matched sample, Greece illustrates that zombie existence is a non-negligible issue also when using the matched Orbis-AnaCredit dataset (Figure 10).

Table 4 shows that the firms in this matched sample are similar to those in section 3, except for a higher average number of employees and higher average total assets. Table 4 also includes variables from the AnaCredit dataset, such as the outstanding nominal amount (ONA) of a loan, which is around €808,000, and the average interest rate paid on a loan, which is 3% with a standard deviation of 4%.

Figure 10. Top five countries with highest zombie shares in Orbis-AnaCredit matched sample

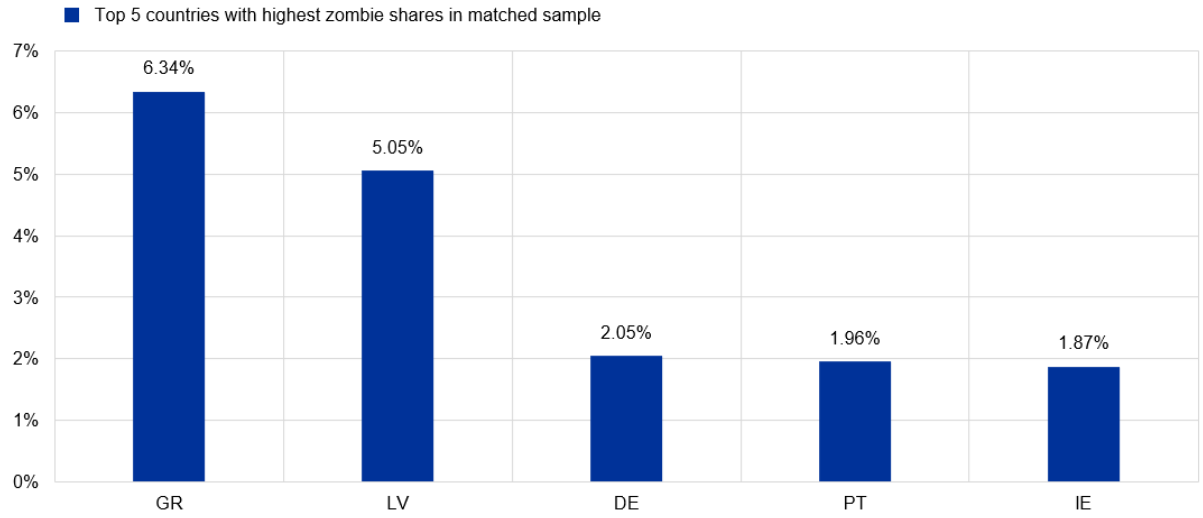


Table 4. Descriptive statistics for the matched Orbis-AnaCredit sample

	count	mean	standard deviation	min	10th percentile	50th pctl.	90th pctl.	max
firm age	24997815	24.54	17.76	1	7.00	21.00	44.00	905
number of employees	24997815	280.72	4992.43	0	2.00	11.00	109.00	709720
is_zombie	24997815	0.01	0.12	0	0.00	0.00	0.00	1
total assets	24997815	98495739.16	2318039234.41	166	229773.00	1736296.00	26684047.00	305891000000
EBIT	24997815	3502973.51	104758806.25	-10821000000	-38165.00	54139.00	1149116.00	15153704154
leverage ratio	24997815	0.27	0.43	-4.67	0.00	0.24	0.58	332.68
interest rate	24997815	0.03	0.04	-0.82	0.01	0.03	0.07	1
outstanding nominal amount	24918677	807966.62	12766563.90	-113352232.51	2238.94	91596.91	1032920.60	11438286426.65
zombie share bank	24585257	0.02	0.02	0	0.01	0.02	0.03	1

Furthermore, the average share of zombie loans held by a bank in this sample is 1.89%, with a standard deviation of 1.78%.

4.1.2 Credit conditions and zombie characteristics. The matched sample allows to compare not only financial characteristics of healthy and zombie firms, but also information on credit risk and credit conditions. Table 5 shows that zombies and healthy firms in this matched sample are similar to the respective group in section 3. However, zombie firms have higher leverage in the mean with 47%. Both groups in this sample have higher total assets and EBIT, but the relation between the two groups is broadly unchanged. For instance, total assets of healthy firms are about double those of zombies, on average.

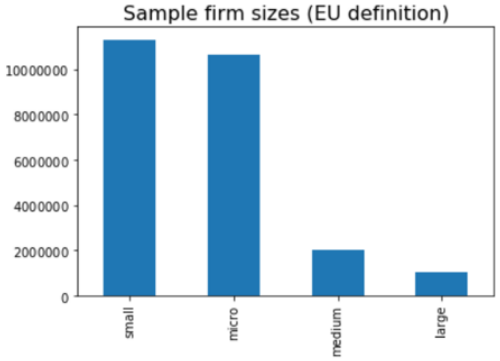
Table 5. Financial characteristcis of zombie firms vs. healthy firms

	healthy_mean	zombie_mean	healthy_median	zombie_median	healthy_std	zombie_std	healthy_count	zombie_count
firm age	24.50	27.12	21.00	24.00	17.76	17.61	24659231	338584
number of employees	282.80	129.15	11.00	8.00	5025.00	1066.21	24659231	338584
total assets	99208642.84	46574630.83	1732557.00	2082361.00	2333285971.41	453449970.68	24659231	338584
EBIT	3580584.95	-2149504.09	55854.00	-68941.00	105414628.74	30055402.58	24659231	338584
leverage ratio	0.27	0.47	0.23	0.36	0.37	1.87	24659231	338584
interest rate	0.03	0.04	0.03	0.03	0.04	0.04	24659231	338584
outstanding nominal amount	805200.10	1009166.33	91217.00	119523.00	12828557.29	6895411.68	24580690	337987
probability of default	0.05	0.19	0.01	0.02	0.16	0.34	14961520	200502

The average outstanding nominal amount (ONA) for a zombie firm is higher than for a healthy firm, meaning that zombie firms have higher loans on average and in the median. At first glance, this might seem counter-intuitive: large firms should have higher loans than smaller firms, and, as mentioned before, large firms are less likely to be zombies. Thus, one could expect healthy firms to have higher average ONAs. However, Figure 11 shows that zombie firms have higher average ONAs among micro, small and medium firms, whereas among large firms, healthy firms have more outstanding credit. As this sample consists mostly of micro and small firms (see Figure 11), the mean ONA across all firm sizes is higher for zombie firms.

Figure 11. Distribution of outstanding nominal amount (LHS) and distribution of firm size in the matched sample (RHS)

Sum of outstanding nominal amount		
EU firm size	healthy firms	zombie firms
large	7845996	6429586.63
medium	1234628.72	1724805.17
small	693894.02	1122360.49
micro	145859.43	371532.2

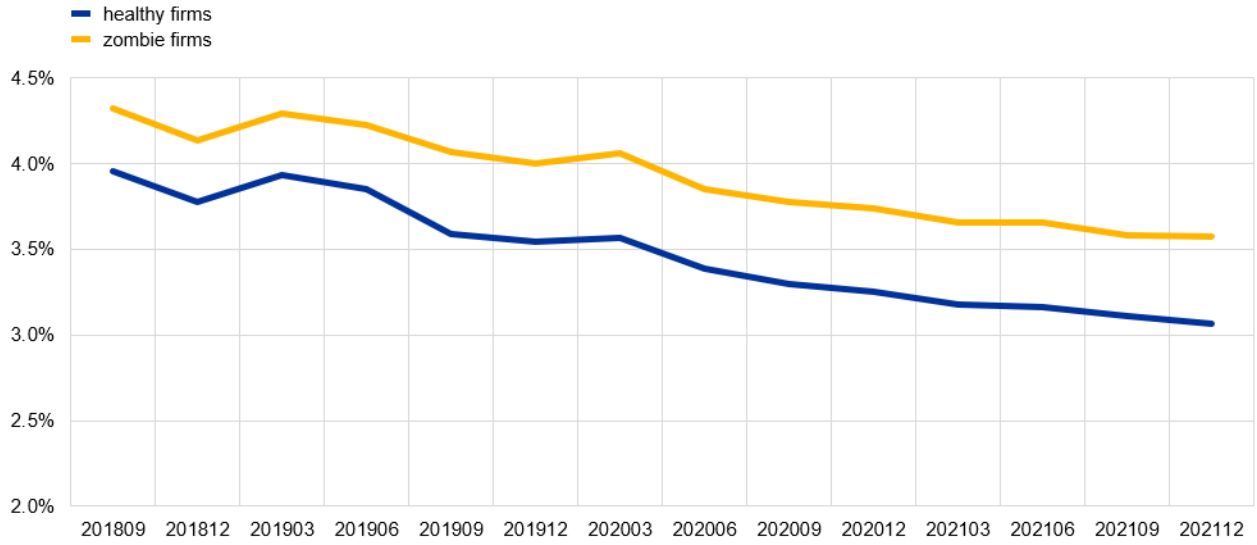


Average interest rates are one percentage point higher for zombie firms (4%) than for healthy firms (3%). Meanwhile, median values for both groups are at 3%, with the same standard deviation of 4%. In the context of the existing literature, this is a very interesting finding. As mentioned in section 2.1, many papers argue that zombie firms receive credit at subsidised interest rates, stating that zombie lending gives rise to credit misallocation (for instance, Acharya et al. (2019), page 3372). Furthermore, Acharya et al. (2019) find that an increase in the proportion of zombie firms by one percentage point in a sector

increases interest rates paid by healthy firms by 2.4p.p. This way to identify zombies through subsidised credit and the findings discussed in section 2.6 would foster the expectation that zombie firms pay *lower* interest rates than healthy firms.

In contrast, using the novel AnaCredit dataset, this thesis finds higher interest rates for zombies than for healthy firms, on average. Figure 12 plots the average interest rate for zombies and healthy firms over time, confirming a higher rate for zombie firms in the whole period of study. A possible explanation for the discrepancy with the literature could be that existing studies often rely on samples of large firms because interest rate data is hardly available for unlisted, small firms. As shown above, AnaCredit is the first dataset for the euro area to include detailed data on loan conditions also for micro, small and medium-sized firms. The finding of higher average rates for zombie firms suggests more efficient credit allocation than found in the literature, indicating that banks lend more in line with fundamentals than previously thought.

Figure 12. Average interest rate paid by healthy vs. zombie firms



Indicators of credit quality confirm this impression as zombie firms have a much higher average probability of default[13] (19%) than healthy firms (5%), with higher median values as well (2% for zombies vs. 1% for healthy firms). Following S&P's 2020 global report on ratings, firms with probabilities of default between 0.39%-1.02% (i.e. the median healthy firm) are considered BBB-rated, whereas firms with PDs between 1.02%-4.24% (the median

[13]Note that the number of observations is slightly lower for the probability of default variable because not all banks report this variable.

zombie firm) are BB-rated (Kraemer et al., 2021).

Similarly, zombie firms are more often declared to be in default (12.01% of all zombies), whereas only 1.76% of all healthy firms are in default (see Table 6). Moreover, zombie firms have a higher proportion of non-performing loans (15.29%) than healthy firms (2.27%). These differences are statistically significant at the 1%-level, employing the same t-tests as described in section 3.3. Finally, a much lower proportion of zombie loans is classified as IFRS stage 1, meaning that the credit risk attached to the loan has not significantly increased since initial recognition (BIS, 2022). Instead, 18.9% of zombie loans are classified as stage 2 (significant increase of credit risk) and 17.59% as stage 3 (credit risk increased so much to be considered credit-impaired) in contrast to 9.75% and 3.09% for healthy firms, respectively.

Table 6. Credit quality indicators of zombie firms vs. healthy firms

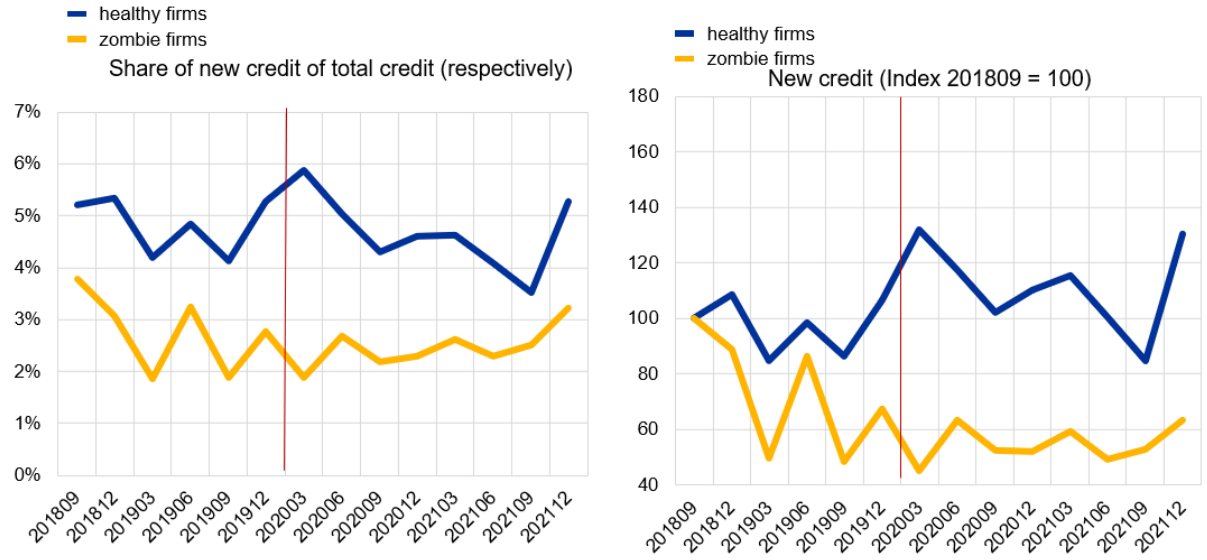
	Not in default	In default	Performing loans	Non-performing loans	IFRS stage 1	IFRS stage 2	IFRS stage 3	GAAP unimpaired	GAAP impaired
Healthy firm	98.24%	1.76%	97.73%	2.27%	80.10%	9.75%	3.09%	5.97%	1.12&
Zombie firm	87.99%	12.01%	84.71%	15.29%	55.99%	18.94%	17.59%	6.43%	1.05%

Thus, the previous finding from section 3 that zombie firms perform worse financially is reflected in their credit quality, which is inferior to that of healthy firms. In addition, they pay higher interest rates on average, pointing to tighter credit conditions for zombie firms. Nevertheless, they have a higher mean amount of loans, raising the question of whether these are legacy loans or whether banks still give out new credit to zombie firms during the period of study.

As shown in Figure 13, zombie firms did receive new credit between Q3 2018 and Q4 2021. As a share of the total credit stock held by zombie firms, they received 2-3% new credit each quarter (Figure 13, LHS). This is only 2p.p. lower than for healthy firms, which received 4-6% new credit as a share of total "healthy" credit. Healthy firms see an increase in new credit in March 2020, which is when the Covid-19 pandemic first hit Europe. This is not the case for zombie firms. Figure 13 (RHS) further illustrates the time trends of new credit, indexed here at 100 in Q3 2018 for both groups. Figure 13 (RHS) shows that for zombie firms, new credit decreases over time to 60, while for healthy firms it increases to 130. The difference between these groups seems to start increasing at the onset of the pandemic (end 2019, beginning of 2020). Then, apart from the final increase towards the end of 2021, new credit seems to stabilise on these levels. There are several possible reasons for the uptick in new credit for both groups towards the end of 2021, for instance the move towards "normalisation" of Covid-19 with the planned reduction of state aid programmes, or the prospect of a possible rise in interest rates favoured by the strong increase in inflation

end-2021, which would make new credit more expensive. Nevertheless, apart from the peak in March 2020 for healthy firms and a rise in December 2021, no "clear" pattern in response to the Covid-19 pandemic is discernible.

Figure 13. Sum of new credit for healthy vs. zombie firms

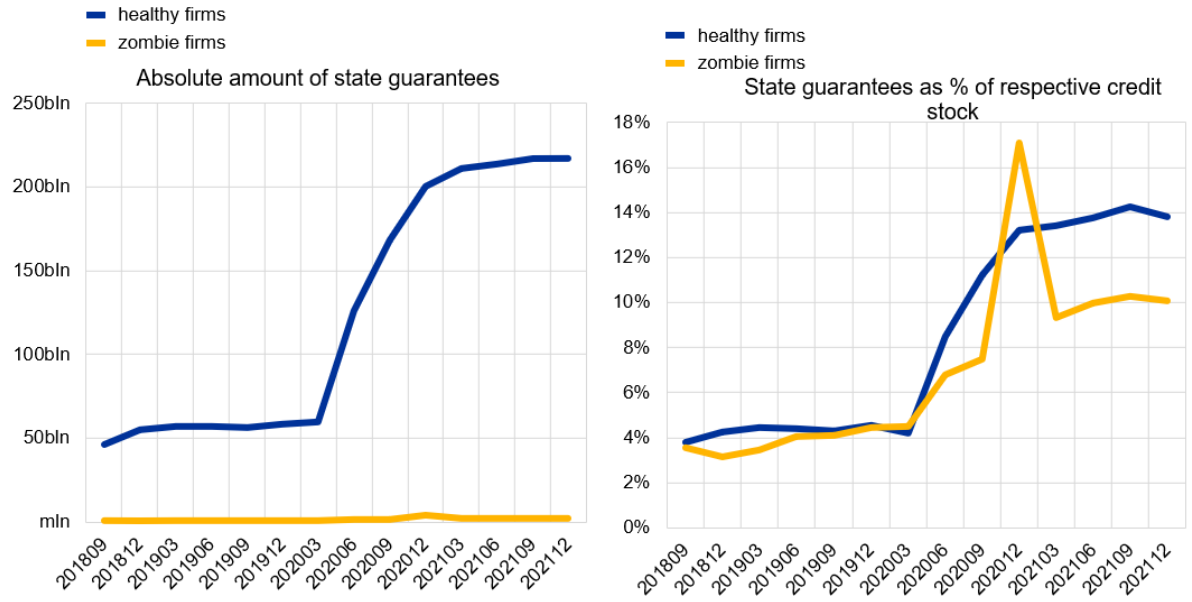


New lending during the Covid-19 pandemic has been supported by liquidity measures like guarantees or moratoria. On average, a guarantee will ease credit conditions, reduce interest, and increase credit volume of the credit contract that it is to support. Using AnaCredit data on the protections backing the individual loans, it is possible to identify the amount of financial guarantees provided by entities belonging to the state sector received by zombie and healthy firms. As can be seen in Figure 14 (LHS) the amount of state guarantees has increased substantially for healthy firms since March 2020. This is most likely due to Covid-19 fiscal support measures including state guarantees for credit. For healthy firms, the amount of state guarantees has increased steeply over the course of 2020 to a relatively stable level of €200 billion thereafter. This trend is confirmed for state-backed protections as a share of the respective credit stock (Figure 14, RHS). For healthy firms, this share increased from a steady average pre-pandemic level of 4.3% to 13.8% in the last quarter of 2021. This is in line with the expectation that healthy firms hit by the pandemic, or healthy firms that seized the opportunity of cheap credit for investment, made use of state aid measures including guarantees. This confirms existing findings on public guarantees related to the Covid-19 pandemic, as for instance discussed in detail in the ECB Economic Bulletin 06/2020 (Falagiarda et al., 2021).

For zombie firms, the absolute amount of state-backed guarantees was around €1 billion

before the pandemic. This corresponds to an average of 3.8% of total "zombie" credit, which is at a similar level as for healthy firms. Zombie firms also see an increase in state guarantees from March 2020[14], then stabilising around €1.7 billion in 2021. This could suggest that zombie firms also profited from Covid-19 related support measures, although these should have targeted firms that were healthy before the pandemic. This trend seems to be driven by the number of firms receiving state guarantees (rather than the amount of state guarantees increasing for specific loans), which increases from an average of 67,400 healthy firms (646 zombie firms) before March 2020 to around 500,000 healthy firms (roughly 4000 zombies) in each quarter of 2021.

Figure 14. State-guaranteed protections to healthy vs. zombie firms



Summing up, zombie firms did receive new credit and financial guarantees during the period of study, although the descriptive statistics clearly show that the credit quality of zombie firms is inferior to that of healthy firms. Whilst this finding is concerning in itself, it raises the question whether such a misallocation of resources has adverse implications for healthy firms and thus for the broader economy.

[14]The peak in December 2020 for zombie firms at €4 billion is due to one firm receiving a financial guarantee over €1.9 billion, it is thus an outlier in the zombie trend.

4.2 Methodology and variables

To examine the question of whether the existence of zombie firms in a bank causes financial spillovers to the credit conditions of healthy firms, a panel regression with fixed effects is used.

In the literature on real spillovers, the standard approach is to run a panel regression with fixed effects, measuring zombie shares on the sectoral level. This is reasonable because one channel of transmission for spillovers on employment growth, investment or productivity is through distorted competition between healthy firms and zombie firms in a specific industry and a certain country (Acharya et al., 2019). However, this thesis focuses on financial spillovers, which more likely happen on the bank-, rather than sector, level. Therefore, the dependent variable is measured on the firm-bank-time level, which is more granular than analysis on the firm-time level, and the explanatory variable is the share of loans held by zombies in a bank, not in a sector. To avoid concerns of reverse causality, all independent variables including controls are lagged by one period.

The baseline panel regression in equation 2 is run first without an interaction term. This allows to compare healthy firms to zombie firms (β_1), and firms in banks with a higher zombie share to firms in banks with a lower zombie share (β_2):

$$CreditCondition_{ib,t} = \beta_1 is\_not\_zombie_i + \beta_2 zombie\_share\_bank_{b,t-1} + Controls_{i,t-1} + Time\_FE_t + Bank\_FE_b + Sector\_FE_s * Country\_FE_c * Time\_FE_t + \epsilon_t \quad (2)$$

Including the interaction term then allows to capture the spillover effect from zombies to healthy firms (β_2+β_3). In this specification, β_1 is the difference in the credit condition between zombie and healthy firms when the zombie share in a bank is zero, which becomes thus meaningless to interpret. β_2 shows the effect of a one percentage point increase in the bank's zombie share on zombie firms' credit conditions. Finally, β_2+β_3 is the effect of a higher bank zombie share on healthy firms' credit conditions, so the difference between healthy firms in banks with a higher zombie share to healthy firms in a bank with a lower zombie share. It is specified as follows (Equation 3):

$$CreditCondition_{ib,t} = \beta_1 is\_not\_zombie_i + \beta_2 zombie\_share\_bank_{b,t-1} + \beta_3 is\_not\_zombie_i * zombie\_share\_bank_{b,t-1} + Controls_{i,t-1} + Time\_FE_t + Bank\_FE_b + Sector\_FE_s * Country\_FE_c * Time\_FE_t + \epsilon_t \quad (3)$$

where

- $CreditCondition_{ib,t}$: Dependent variable in time t, measured for firm i, which has at least one loan at bank b.
- $is\_not\_zombie_i$: Dummy variable equal to 1 if a firm does not identify as a zombie, equal to 0 if a firm is classified as a zombie. This is used instead of the previous *is_zombie* dummy to identify the spillover effect on *healthy* firms in the interaction term. Thus, β_1 describes the difference in the dependent variable between healthy firms and zombie firms when the zombie share is zero, which becomes pointless to interpret.
- $zombie\_share\_bank_{b,t-1}$: Share of zombie loans held by bank b, calculated as the outstanding nominal amount that is held by zombie firms from the point of view of the creditor, divided by the total outstanding nominal amount issued by the creditor to all its debtors included in the sample. β_2 hence states the effect of holding a loan at a bank with a higher zombie share compared to a bank with less zombie loans for zombie firms.
- $is\_not\_zombie_i * zombie\_share\_bank_{b,t-1}$ Interaction term between the non-zombie dummy and the share of zombie loans at a bank. β_3 is the difference in the effect of banks with a higher zombie share between healthy firms and zombie firms.
- $Controls_{i,t-1}$: Control variables on firm level, including firm size, firm age, leverage and EBITDA over total assets.
- $Time\_FE_t$, $Bank\_FE_b$: Capture unobserved time-invariant heterogeneity on the firm and bank level (for instance firm- or bank-specific characteristics like location)
- $Sector\_FE_s * Country\_FE_c * Time\_FE_t$ Country-sector-year fixed effects as commonly employed in the literature (for instance, Storz et al. (2017)). These fixed effects are meant to capture shocks affecting all firms in a specific sector s in country c, at time t.

Different dependent variables can be employed to proxy credit characteristics of firms. As argued by Acharya et al. (2019), "due to a **loan supply shift to zombie firms**, nonzombie firms had to pay higher interest rates if the zombie prevalence in their industry was particularly high" (page 3406, emphasis added). Hence, this thesis first investigates the amount

of new credit received by firm i from bank b in time t to examine whether a higher share of zombie loans in a bank really does lead to changes in loan supply for healthy firms. The hypothesis based on the above quote would be that banks give more credit to their zombie clients, so healthy firms in banks with a high zombie share have lower credit volumes than healthy firms in banks with lower zombie shares. Apart from Andrews and Petroulakis (2019), who use a survey-based measure of a firm's subjective access to credit, this is the first study to analyse actual amounts of credit, made available via the AnaCredit dataset.

This thesis examines as a second dependent variable what Acharya et al. (2019) see as the consequence of a loan supply shift, namely the average interest rate paid across all loans of firm i at bank b in time t. The argument made by Acharya et al. (2019) is that the increased prevalence of zombie firms in a sector shifts loan supply to zombie firms, reducing the loan supply for healthy firms. Assuming that healthy firms' demand for loans remains constant, this would increase the interest rates they need to pay. Based on results of the literature (see section 2.6), the hypothesis would be that healthy firms with loans in banks with higher zombie prevalence pay higher interest rates ($\beta_2+\beta_3>0$). Interest rates have been employed as dependent variables in one empirical study before; however, Acharya et al. (2019) measure the zombie share on the sector level. As argued above, the transmission channel for credit conditions on the sectoral level as opposed to the bank level is far less obvious. Moreover, the regression is run for sub-samples of healthy and zombie firms with the same credit rating, to see if the spillover effect differs across these groups. Thus, based on the existing studies by Andrews and Petroulakis (2019) and Acharya et al. (2019), the two main hypotheses for the spillover analysis are:

- **H1:** Healthy firms in banks with a higher zombie share receive less new credit than healthy firms in banks with a lower zombie share ($\beta_2+\beta_3<0$).
- **H2:** Healthy firms in banks with a higher zombie share pay higher interest rates than healthy firms in banks with a lower zombie share ($\beta_2+\beta_3>0$).

The baseline regression includes several fixed effects. First, a firm-level fixed effect controls for time-invariant differences between firms, such as firm location. Since the zombie sample is fixed over time, the firm-fixed effect eliminates this variable in the regression. Thus, as an alternative specification, the firm-fixed effect is excluded, but firm-level control variables are added. Following the literature (for instance, Acharya et al. (2019); Andrews and Petroulakis (2019); Banerjee and Hofmann (2018)), these controls include firm age, the size of the firm as approximated by the number of employees, a firm's leverage ratio as a debt-related measure and EBITDA over assets as a firm profitability measure[15]. As shown

[15]Since these variables are taken from the Orbis database, firm size, leverage and EBITDA over total assets

in Table 7, these characteristics are significantly different for both groups, as established by a t-test controlling for sector and country. Furthermore, the baseline regression includes a bank-fixed effect to control for bank characteristics. Finally, the country-sector-time-fixed effect controls for shocks affecting firms in the same sector in the same country at the same time. Standard errors are clustered at the firm level, as is standard in the zombie literature (ibid).

Table 7. Control variables on firm-level and t-tests for difference in means, controlling for country, sector and year

	healthy mean	zombie mean	healthy median	zombie median	healthy std	zombie std	healthy count	zombie count	t-stat	p-value
number of employees	282.80	129.15	11.00	8.00	5025.00	1066.21	24659231	338584	-4.027	0.000
firm age	24.50	27.12	21.00	24.00	17.76	17.61	24659231	338584	4.099	0.000
EBITDA over total assets	0.08	-0.08	0.07	-0.02	0.27	0.30	24659231	338584	-25.688	0.000
leverage ratio	0.27	0.47	0.23	0.36	0.37	1.87	24659231	338584	18.119	0.000

4.3 Results and discussion

4.3.1 New credit. The descriptive statistics in section 4.1.2 show that healthy firms receive more new credit as a share of their total credit. Thus, it appears plausible that healthy firms receive significantly more new credit than zombie firms in absolute terms, as shown by the positive and significant coefficient on the non-zombie dummy (β_1) in specification (1) in Table 8, which includes firm-level controls and no firm-fixed effects. Accordingly, healthy firms receive €109,538 more new credit in a quarter on average, ceteris paribus. Firms in banks with many zombie firms do not receive significantly more or less new loans than firms in banks with fewer zombies, as reflected in the insignificant coefficient on the lagged bank zombie share (β_2).A firm that is one year older receives €8,734 more new credit, on average, ceteris paribus. Similarly, an additional employee increases new credit by €202. These effects are statistically significant at the 1%-level. Increasing the leverage ratio by 1p.p. increases new credit by €155,577, which is statistically significant on the 5%-level. The profitability measure of EBITDA over assets is not significant.

are only available until 2019 for the majority of firms. Since independent variables are lagged by one period, there are "missing" observations of these variables for 2021. It is assumed here that these three variables remain unchanged for each firm.

Table 8. Regression results for new credit as the dependent variable

	(1) sum_new_credit	(2) sum_new_credit	(3) sum_new_credit
is_not_zombie=1	109537.7***	437127.9***	0
	(2.91)	(2.62)	(.)
zombie_share_bank_lag	−389720.6	14329818.2*	31138966.7**
	(−0.38)	(1.82)	(2.37)
is_not_zombie=1 X zombie_share_bank_lag		−15062585.9*	−31659068.0**
		(−1.86)	(−2.36)
firm_age_lag	8734.895***	8734.288***	
	(1079.303)	(1079.289)	
numberemployees_lag	202.0***	202.0***	
	(7.34)	(7.34)	
leverage_lag	156576.9**	155662.5*	
	(1.97)	(1.96)	
ebitda_over_assets_lag	12367.5	12169.4	
	(0.79)	(0.78)	
Firm-level controls	*Yes*	*Yes*	*No*
Firm FE	*No*	*No*	*Yes*
Bank FE	*Yes*	*Yes*	*Yes*
Country-Sector-Time FE	*Yes*	*Yes*	*Yes*
Observations	1940277	1940277	1814122
Adjusted R^2	0.085	0.085	0.328

t statistics in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Specification (2) shows the same regression, but including the interaction term. As such, β_2 shows that a one percentage point increase in a bank's zombie share increases new credit given to zombie firms, which is significant at the 10%-level. Due to the negative sign of β_3, this balances with the positive direction and almost same absolute size of β_2, such that the effect of a higher zombie bank share on healthy firms becomes very small. Conducting a Wald test with the null hypothesis that H_0 :β_2+β_3=0, with an F-statistic of 0.46 for specification (2) in Table 8, the null hypothesis cannot be rejected. Thus, there is not a statistically or economically significant effect of the presence of zombie firms on healthy firms' receipt of new credit. This is not in line with Andrews and Petroulakis (2019) who find a small, but significant decrease in access to credit for healthy firms in sectors with more zombie firms (see section 2.6). Neither does this finding support the claim by Acharya et al. (2019) of a loan

supply shift from healthy firms to zombie firms in banks with a higher presence of zombie firms. In terms of control variables, the lagged firm age, number of employees and leverage ratio are significant, and very similar in sign, significance and magnitude to specification (1).

Specification (3) in Table 8, which includes firm-fixed effects, confirms these results. The inclusion of firm-level fixed effects increases the adjusted R-squared of the model from 8.45% to 29.74%. The direction of the coefficients' signs remains unchanged. Indeed, the levels of statistical significance of the coefficients, representing the total effect of the lagged bank share of zombie loans on zombie firms'new credit and on the spillover effect increase from 10% to 5%. The F-statistic for the Wald test on the spillover effect is 0.12, thereby confirming the findings in specification (2).

Figure 15. Margin plot for new credit specification (2) as the dependent variable

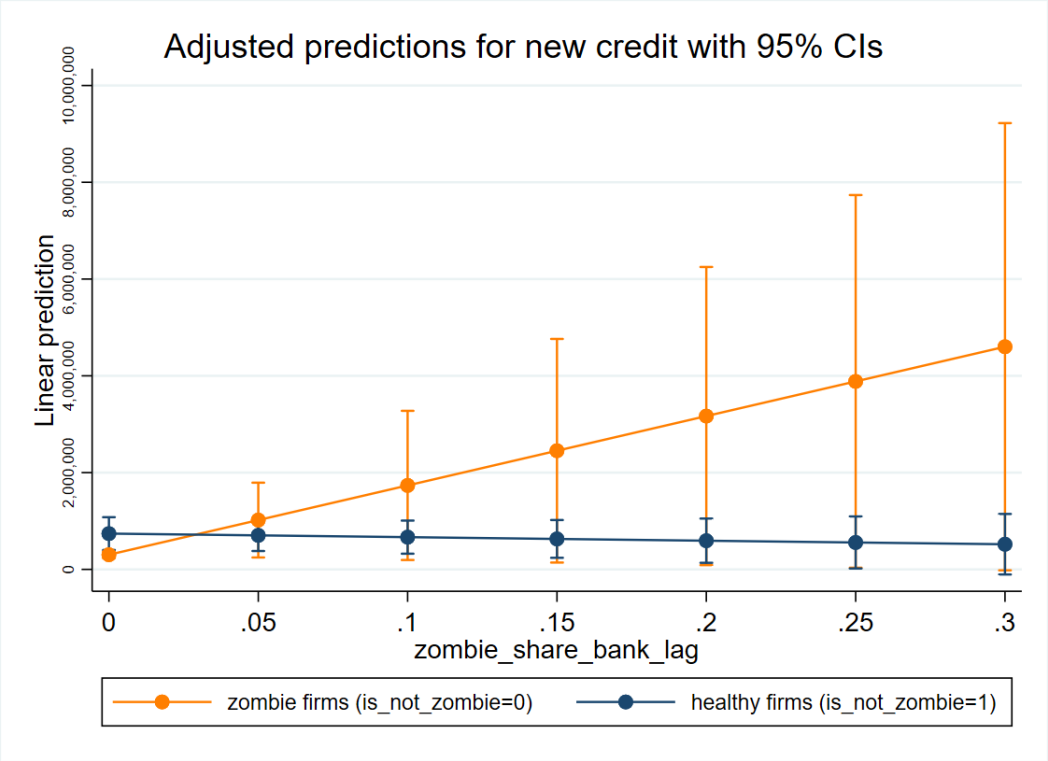


Figure 15 plots the marginal effects for both groups in specification (2), which is the combined effect on zombie firms' and healthy forms' new credit at specific values of a bank's zombie share. In Figure 15, the marginal effect is significant at the 5%-level if the bars that mark the 95% confidence interval in the graph do not include the x-axis (i.e., the horizontal line through zero). The intercept of the line for healthy firms is at 437128 higher than for zombie firms, as this is the positive β_1 coefficient in specification (2). The slope of the respective line is the effect of a being in a bank with a zombie share at the level shown on the

x-axis. Thus, the positive slope (β_2) of the orange line in Figure 15 shows that for zombie firms, a higher share of zombie loans in a bank increases their amount of new credit, which seems reasonable: If a bank has a higher proportion of zombie loans, it might indeed be less hesitant to continue providing these very weak firms with credit, to avoid finally realising the losses from a complete zombie default in their balance sheets. For healthy firms, the effect of a higher zombie share is not significant as the slope ($\beta_2+\beta_3$) is relatively constant. The interaction coefficient β_3, which is also the difference in the slopes for the two groups, is statistically significant from zero. Thus, the difference in the effect of a higher zombie share between zombie and healthy firms is significant. Therefore, the data do not suggest that healthy firms experience an economically significant shift in loan supply due to the presence of zombie firms.

Acharya et al. (2019) phrase it such that because the increased presence of zombie firms in a sector reduces the loan supply for healthy firms, assuming healthy firms' demand for loans remains unchanged, they need to pay higher interest rates. Considering that the analysis so far cannot establish an economically significant decrease in new credit given to healthy firms, the effect on interest rates will be investigated now.

4.3.2 Interest Rates. The coefficient on the non-zombie dummy in specification (1) in Table 9 is statistically significant at the 1%-level. However, as already indicated by the descriptive statistics in section 4.1.2, healthy firms are the ones paying lower interest rates on their loans. More specifically, healthy firms pay 0.329 p.p. lower rates on their loans on average, ceteris paribus. Considering that the average interest rates in this sample are at 4% for zombies and at 3% for healthy firms, this is an economically sizeable difference. Hence, this finding does not confirm the assumption of subsidised credit for zombie firms and is an important difference to the existing literature. A possible explanation could be that the Orbis-AnaCredit sample used here differs from those employed by previous studies; in particular, it also includes unlisted and smaller firms. More specifically, AnaCredit provides direct interest rate data on loans of unlisted firms. By contrast, Acharya et al. (2019), the only other study that investigates interest rates, infers interest rate data by dividing the total interest payments by firm i in year t by its outstanding debt (Acharya et al., 2019, page 3385). Thus, they do not have exact data on interest rates, and their measure is a yearly average interest rates paid by the firm. As explained in section 4.2, my interest rate measure is averaged across all loans a firm holds at a specific bank in a certain quarter, which is a more granular level of aggregation.

Furthermore, specification (1) in Table 9 shows that all firms in banks with a higher share of zombie firms pay lower interest rates than firms in banks with less zombie loans

(β_2). This is statistically significant at the 1%-level. One possible explanation could be that a high share of zombie loans worsens a bank's credit portfolio, which is audited by a country's financial regulators. Thus, to balance their portfolio, banks with a higher zombie share might need to attract better-rated clients. One potential way of achieving this is by offering attractively low interest rates. Another potential explanation might be the relatively recent rule for European capital-oriented credit institutions to report credit risk under the IFRS 9 framework. In contrast to the previous standard which required banks to recognize credit losses only when they became evident, IFRS 9 obliges banks to report and account for expected credit losses (Bundesbank, 2015; BIS, 2022). These new provisions might have implications on the bank's capital as it could reduce a bank's regulatory capital (Rhys et al., 2016). Thus, a high proportion of zombie loans could be costly for banks as it might reduce their profit through these value corrections for risky loans. To make up for this "lost" profit, banks could try to attract more new clients with lower interest rates, which could be one explanation for the significant and negative coefficient on the lagged zombie share in a bank in specification (1).

As concerns the control variables, the lagged firm age, number of employees and EBITDA over assets are statistically significant. In line with expectations, a firm needs to pay lower interest rates when it is older, larger (more employees) and more profitable. The first two effects are statistically significant at the 1%-level, the effect of EBITDA over total assets is significant at the 5%-level.

Table 9. Regression results for interest rates as the dependent variable

	(1) avg_interest_rate	(2) avg_interest_rate	(3) avg_interest_rate
is_not_zombie=1	−0.00329***	−0.00346***	0
	(−14.46)	(−13.93)	(.)
zombie_share_bank_lag	−0.0645***	−0.0710***	−0.0589***
	(−34.75)	(−17.27)	(−12.43)
is_not_zombie=1 X zombie_share_bank_lag		0.00679*	−0.00467
		(1.77)	(−1.02)
firm_age_lag	−.0001024***	−.0001024***	
	(1.69e − 06)	(1.69e − 06)	
numberemployees_lag	−4.74e − 08***	−4.74e − 08***	
	(−4.62)	(−4.62)	
leverage_lag	0.0000517	0.0000522	
	(0.50)	(0.51)	
ebitda_over_assets_lag	−0.00171**	−0.00171**	
	(−2.18)	(−2.18)	
Firm-level controls	*Yes*	*Yes*	*No*
Firm FE	*No*	*No*	*Yes*
Bank FE	*Yes*	*Yes*	*Yes*
Country-Sector-Time FE	*Yes*	*Yes*	*Yes*
Observations	23426188	23426188	24528565
Adjusted R^2	0.228	0.228	0.442

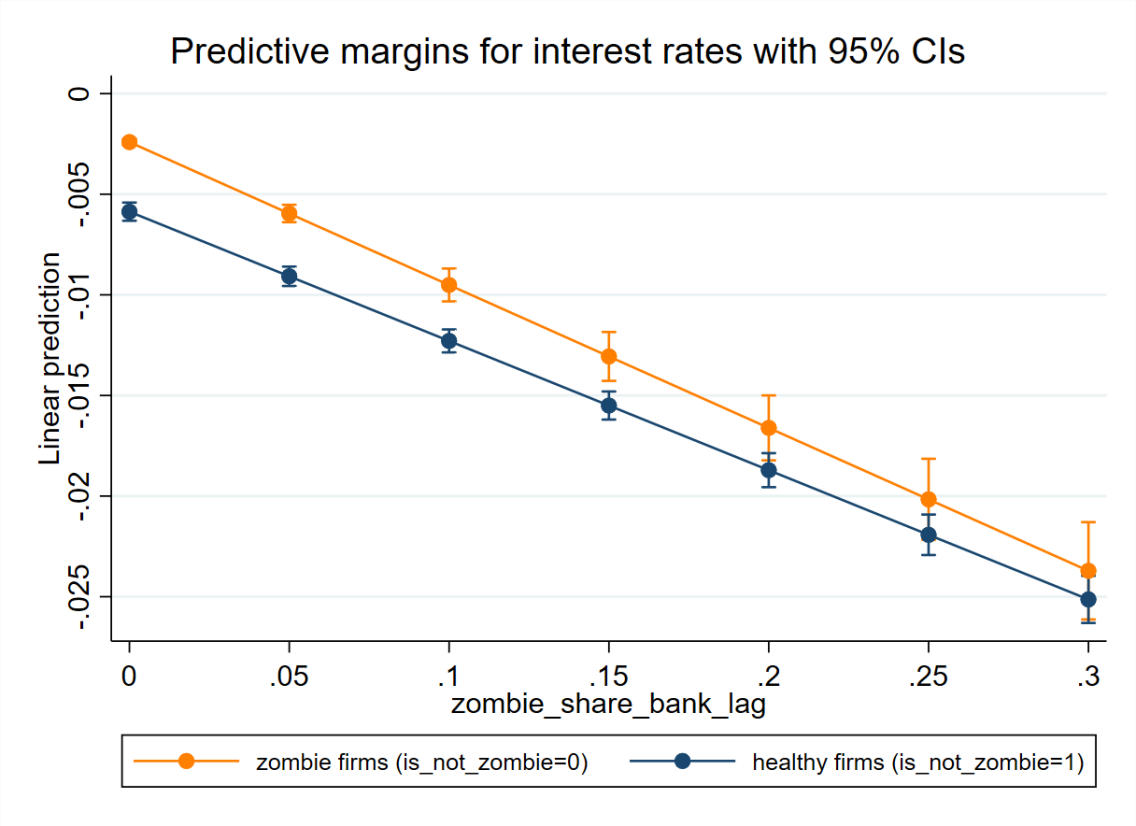
t statistics in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

In specification (2) with the interaction term, a higher zombie bank share decreases the interest rates paid by zombie firms, which is statistically significant on the 1%-level (β_2). In addition, the spillover effect for healthy firms, measured by the sum of β_2 and β_3, is statistically significant at the 1%-level and negative. This finding is not in line with hypothesis H1 that healthy firms in a bank with a higher share of zombie loans pay higher interest rates than healthy firms with loans in bank with a lower zombie share.

The computation of marginal effects at bank shares ranging from 0-30% illustrates this negative overall effect on healthy firms' interest rates. Due to the negative β_1 in specification (2) in Table 9, the intercept for healthy firms is slightly lower. The slope for healthy firms in this case is slightly flatter due to the positive β_3-coefficient, which attenuates the total effect for healthy firms. This combined effect is statistically significant for healthy firms on the 1%-level, with the F-statistic from the Wald test with the null hypothesis $H_0: \beta_2+\beta_3=0$ exceeding 1185. For example, in a bank with a zombie share of 10%, healthy firms pay 1.23 p.p. lower interest rates. While this is an effect of non-negligible economic size, especially

Figure 16. Margin plot for interest rates specification (1) as the dependent variable



in the low-interest rate environment during the period of study, note that the mean share of zombie loans in a bank is at 1.89%, so a 1% increase in the zombie share is quite substantial. As illustrated by the margin plot in Figure 16, this effect increases in absolute size with the share of zombie firms in a bank. The same applies for zombie firms, where a zombie share of 10% in a bank lowers the interest rates paid by zombie firms by 0.24p.p. The difference in the slopes between the two groups, β_3, is not statistically significant. This implies that a higher zombie share lowers interest rates paid by healthy and zombie firms, but the two groups do not react in a significantly different way to such a zombie share increase in their bank.

Results from the regression specification employing firm-fixed effects and not firm-level controls (3) in Table 9 are very similar. The non-zombie dummy is omitted due to firm-fixed effects. The effect of being a firm in a bank with a higher proportion of zombie loans is negative and statistically significant at the 1%-level, as in specification (1) in Table 9. Similarly, the spillover effect for healthy firms decreases healthy firms interest rates, and is statistically significant at all common levels of significance with an F-statistic of 1253. These results suggest that an adverse spillover effect cannot be found. This finding is not in line with

the existing literature. In contrast, Acharya et al. (2019) find that a one percentage point increase in the zombie share in the sector increases healthy firms' interest rates by 2.4p.p. compared to healthy firms in a sector with a lower zombie share. This finding cannot be confirmed using the matched Orbis-AnaCredit dataset. Notice that the circumstances in Acharya et al. (2019) and the present study differ in four key respects: The calculation of interest rates, the period of study (2009-2014 vs. 2018-2021), the sample studied (large firms in Germany, Spain, France, the UK and Italy vs. firms of various sizes in all euro area countries) and the dataset used (firm-level data from Amadeus database by Bureau van Dijk vs. matched Orbis-AnaCredit sample). These differences could well explain the discrepancy with Acharya et al.'s (2019) findings.

4.3.3 Interest rates in sub-samples by credit rating. To further break down the findings on interest rates, debtors are classified into rating groups according to their probability of default[16]. Note, however, that in AnaCredit, only internal ratings-based approach (IRB) banks[17] report probabilities of default. Thus, the sample reduces from around 25 million observations to roughly 15 million observations. Nevertheless, for this sub-sample of firms, it is interesting to see if the results found above also hold when controlling for credit risk as classified by the bank that gives out the loan.

The distribution of probabilities of default for both zombie and healthy firms is such that most observations are in the "B-all" bucket, with 65.91% for healthy and 63.95% for zombie firms. Unsurprisingly, the share of "A-all"-rated loans is higher for healthy firms (27.7% vs. 11.28% for zombie firms), and the share of "C and worse"-rated loans is higher for zombie firms (24.76% vs. 6.39% for healthy firms). Nevertheless, there is a substantial amount of observations in each category, such that estimation in sub-samples is possible.

[16]The S&P 2020 Global Report classifies firms into AAA, AA, A, BBB, BB, B or CCC/C according to their probability of default (PD). Similarly, the Eurosystem credit assessment framework (ECAF) establishes five credit quality steps, corresponding to SP's categories AAA/AA+/AA/AA-, A+/A/A-, BBB+/BBB/BBB-, BB+ and BB (European Central Bank, 2022b). To simplify the discussion, loans are grouped into the categories "A-all" (including AAA, AA, A which cover PDs from 0%-0.39%), "B-all" (BBB, BB, B which cover PDs from 0.4-13.84%) and "C and worse" (CCC/C and unrated with PDs greater than 13.84%). The results for the individual seven groups following the S&P 2020 Report can be found in the appendix.

[17]There are two approaches to reporting risk-weighted assets under the Basel III revised credit risk framework (BIS, 2018). On the one hand, banks can compute their off-balance-sheet exposures weighted by risk by using a standardised risk weight scheme (standardised approach). On the other hand, banks can use their own internal rating schedules, for instance using probabilities of default as the risk parameters (internal ratings-based approach).

Table 10. Regression results for interest rates as the dependent variable

	(1) interest_rate, A-all	(2) interest_rate, B-all	(3) interest_rate, C& worse	(4) interest_rate, A-all	(5) interest_rate, B-all	(6) interest_rate, C& worse
is_not_zombie=1	−0.00186***	−0.00266***	0.00342***	−0.00174***	−0.000596	0.00307***
	(−4.06)	(−10.44)	(6.00)	(−2.72)	(−1.59)	(4.08)
zombie_share_bank_lag	−0.116***	−0.237***	−0.170***	−0.110***	−0.138***	−0.184***
	(−13.35)	(−29.30)	(−7.41)	(−4.49)	(−8.27)	(−5.88)
is_not_zombie=1 X zombie_share_bank_lag				−0.00607	−0.100***	0.0160
				(−0.26)	(−6.63)	(0.71)
firm_age_lag	−.0000589***	−.0000849***	−.000197	−.0000589***	−.0000849***	−.000197***
	(2.42e − 06)	(1.84e − 06)	(7.36e − 06)	(2.42e − 06)	(1.84e − 06)	(7.36e − 06)
numberemployees_lag	−4.53e − 08***	−0.0000001***	−9.74e − 09	−4.53e − 08***	−0.0000001***	−9.73e − 09
	(−6.10)	(−5.32)	(−0.55)	(−6.10)	(−5.32)	(−0.55)
leverage_lag	−0.00356***	−0.000547*	−0.000626***	−0.00356***	−0.000548*	−0.000625***
	(−5.70)	(−1.93)	(−2.71)	(−5.70)	(−1.92)	(−2.71)
ebitda_over_assets_lag	−0.00479***	−0.00416***	−0.00195***	−0.00479***	−0.00416***	−0.00195***
	(−6.41)	(−21.71)	(−4.35)	(−6.41)	(−21.71)	(−4.34)
Firm-level controls	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*
Bank FE	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*
Country-Sector-Time FE	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*
Observations	3705583	8897678	888028	3705583	8897678	888028
Adjusted R^2	0.185	0.228	0.275	0.185	0.228	0.275

t statistics in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

In the specifications including firm-level control variables, the difference in interest rates between healthy firms and zombie firms is significant for the groups "A-all" (specification (1) in Table 10) with PDs between 0-0.39%, "B-all" with PDs between 0.4%-13.83% (specification (2) in Table 10), and "CCC and worse" (specification (3) in Table 10) with PDs above 13.84%, as is the case for the full sample in the previous section. However, note that the coefficient on the zombie dummy changes sign for firms rated "C or worse": Healthy firms in the worst credit rating category actually pay 0.34p.p. *more* than zombie firms in this category. This finding supports the idea of zombie firms receiving subsidised credit and of negative spillovers to healthy firms. However, this thesis only finds support for this idea for firms that have high probabilities of default. Thus, it seems that the former findings in the literature are only valid with a very strict zombie definition and for healthy firms that are themselves already in bad shape. The coefficient on the lagged bank share of zombie loans is statistically significant at the 1% for all rating groups, which is in line with the finding for the whole sample in specifications (1) in Table 9.

For all credit rating groups, zombie firms pay significantly lower interest rates when the zombie bank share increases ($beta\_2$) negative and statistically significant at the 1%-level in specifications (4)-(6) in Table 10). Similarly to the whole sample, also the effect of a higher zombie bank share on healthy firms' interest rates lowers their rates and is significant at the 1%-level for all rating groups. For firms rated AAA, AA or A, the difference in reaction to a higher bank share is not statistically different between zombies and healthy firms. This

seems reasonable because if such well-rated firms had to pay a premium due to the existence of zombie firms in that bank, they would probably just move to a different bank offering them lower interest rates. The coefficient is negative, indicating that if there were a spillover effect, healthy firms would pay even lower interest rates in banks with higher zombie shares than zombie firms. Only for "B-all" rated firms is the reaction to a higher zombie share statistically different for zombies and healthy firms. This means that healthy firms rated BBB, BB or B in banks with a higher zombie share actually pay lower interest rates than "B-all" rated zombie firms when the zombie bank share increases by one percentage point. This finding could be in line with the idea that banks need to attract better-rated firms to balance the zombie loans in their credit portfolio. Firms rated "C or worse" do not react significantly differently to an increase in the zombie share. This means that the interest rates of healthy firms rated "C or worse" in banks with more zombie firms react in the same way as those of zombie firms rated "C or worse".

The marginal effects confirm that, regardless of the sign or significance of the spillover, healthy firms pay lower interest rates when zombie firms exist in a bank where they have loans. Zombie firms also see a negative marginal effect, paying lower rates as the zombie share in a bank increases. This is the same finding as for the whole sample of 25 million observations.

In summary, the findings here cannot confirm the dominant view in the literature, which is that there exist significant negative spillovers from zombie firms to healthy firms' access to credit (Andrews and Petroulakis, 2019), and that spillovers from zombie firms increase interest rates paid by healthy firms compared to healthy firms in sectors with fewer zombies (Acharya et al., 2019). The present analysis differs from these papers as it uses more direct measures of new credit and interest rates from AnaCredit, investigates a broader set of euro area countries and firms, has a more recent time frame of study, namely from Q3 2018 to Q4 2021, and conducts the panel regression on the bank, not sector, level. There is a significant difference between healthy firms and zombie firms both in new credit received (more new credit for healthy firms) and the average interest rate paid on their loans (healthy firms pay *lower* rates). Zombie firms receive significantly more new credit in banks with higher zombie shares, which seems plausible. There is no significant effect on healthy firms' new credit when the zombie share in a bank increases. Regarding interest rates, the combined effects of the presence of zombie firms lowers zombies' and healthy firms' interest rates for all bank shares up to 30%. Thus, a clear adverse spillover effect on healthy firms' credit rates is not discernible.

4.3.4 Robustness checks. There are three dimensions along which robustness checks are conducted: Alternative zombie definitions, Covid-19 related concerns, and alternative fixed effect structures.

First and foremost, as discussed in section 2.1, the question of the zombie definition is raised in almost every study in the zombie literature. Therefore, three alternative zombie definitions are implemented to cross-check the main results. One simple way to identify zombie firms is to classify all firms with a very high leverage ratio as zombies. Storz et al. (2017), in one of their robustness checks, use the threshold of 85% as Gebauer et al. (2018) show that this is the leverage level in the euro area above which investment would be affected by debt overhang. Employing this definition leads to a share of 1.04% of zombie firms in the matched Orbis-AnaCredit sample. The zombie country shares analysed in section 3 shift, with Ireland becoming the country with the highest zombie share of 4.6% compared 3% for Ireland under the baseline definition.

Instead of debt servicing capacity that is used in my baseline definition, several papers use an interest coverage (IC) ratio below 1 as a criterion to identify weak firms (for instance, Adalet McGowan et al. (2018); Banerjee and Hofmann (2018, 2020); Nurmi et al. (2020)). The IC ratio is defined as EBIT, a measure of firm profit, over interest payments. However, if zombie firms are more prone to receiving credit under subsidized credit conditions as is commonly argued in the literature (for instance, Acharya et al. (2022), their interest payments will be lower, thus increasing the interest coverage ratio. Hence, this criterion might classify zombie firms as healthy, which is why the baseline definition uses debt servicing capacity instead. Nevertheless, given their popularity in the literature, two alternative definitions using the IC ratio are employed as robustness checks. The definition by Adalet McGowan et al. (2018) is often used by other studies, either as the baseline definition or as a robustness check. It defines a firm as a zombie when the IC ratio is smaller than 1 in the last three years and when a firm is older than ten years. With this definition, the share of zombie firms in the matched sample increases to 2.77%. Although the country zombie shares from section 3 are higher than under the baseline definition, the ordering of countries is very similar, with Greece, Italy and Spain being in the top 5 countries with the highest zombie shares for the baseline and for this definition.

Considering that the average firm in both section 3 and section 4 is older than 24 years, it is not surprising that the definition by Adalet McGowan et al. (2018) yields higher zombie shares than the baseline definition. Thus, a third definition from Nurmi et al. (2020) is employed. It also uses the criterion of an IC ratio below 1 for three consecutive years, but replaces the age criterion by no positive average employment growth over the previous two periods. This definition yields a zombie share of 1.36% in the matched sample and is thus

close to the baseline share. This definition has the most overlap with the baseline definition also in the size and ordering of country zombie shares.

Running the regressions for new credit with these alternative definitions, none of the coefficients is significant, which is surprising (specifications (2), (3), (4) in Table 11). However, note that the baseline zombie definition by Storz et al. (2017) is quite strict and poses demands on several financial variables. Thus, it could be the case that for new credit, there only is a significant difference when firm quality is significantly deteriorated, which is the case for the baseline definition as shown in sections 3.3 and 4.1.2. In any case, these findings for new credit support the main conclusion that a clear and economically significant combined effect of an increased zombie presence on healthy firms' new credit is not discernible. Hence, these robustness checks confirm the discrepancy with the assumption of a zombie-induced loan supply shift by Acharya et al. (2019).

For interest rates, the results under the baseline definition as presented in section 4.3.2 are confirmed by all three alternative definitions, which is very reassuring. All definitions find that a higher zombie share significantly lowers interest rates paid by zombie firms. As for the different specifications under the baseline, the spillover effect to healthy firms is statistically significant, such that a higher bank zombie share also lowers the interest rates of healthy firms. The sign and significance of the coefficient on the interaction differ (significant and positive for the leverage>85% definition (specification (2) in Table 12), not significant and negative for the OECD definition (specification (3) in Table 12) and not significant and positive for the definition by Nurmi, Vanhalla and Viren (specification (4) in Table 12)). Together with the negative marginal effects that are statistically significant at the 1%-level for both groups and all bank zombie shares considered, these robustness checks clearly confirm the findings under the baseline definition, deepening the discussed discrepancy with the findings by Acharya et al. (2019).

A second dimension for robustness checks addresses the concern that the inclusion of the pandemic in the period of study might distort the results by running the panel regressions in two sub-samples: a pre-Covid-19 sample from Q3 2018 to Q4 2019 (specifications (5) in Tables 11 and 12), and a Covid-19 sample from Q1 2020 to Q4 2021 (specifications (6) in Tables 11 and 12). The findings for the pre-Covid period are the same as for the whole sample. This shows that the inclusion of the Covid-19 period does not distort the results. During the Covid-19 period, the spillover effect for healthy firms remains insignificant as for the pre-Covid period, but the effect on zombie firms' new credit also turns insignificant. The magnitude and sign of the coefficients remains the same as for the pre-Covid period and the whole sample. This broadly underlines that there is no economically significant effect on new credit for healthy firms.

For interest rates, the Covid-19 sub-sample is the only specification in these robustness checks where the coefficient on the lagged bank share, i.e. the effect of a higher bank zombie share on zombie firms' interest rates, turns insignificant. Again, a possible explanation could be that the way in which state-supported liquidity has been provided during the pandemic reduced banks' freedom in choosing the interest rates they charge. This might have made interest rates charged on zombie loans by banks with many zombie loans more similar to those charged by banks with a lower zombie share. The total effect for healthy firms' interest rates is still significant and negative for both groups, as in the case of the whole and the pre-Covid-19 sample. Therefore, the Covid-19 period does not change the general conclusion that the presence of zombie firms significantly decreases interest rates for healthy firms.

A third dimension to check the robustness of my results is to employ different combinations of fixed effects and control variables. Variations that are explored are: Running the regressions both with firm-level controls and firm-fixed effects (specifications (7) in Tables 11 and 12), adding lagged bank-level control variables like the size of the bank and its turnover of the bank (specifications (8) in Tables 11 and 12), or including only time-fixed effects instead of the more conservative country-sector-time fixed effects (specification (9) in Tables 11 and 12). None of these variations changes the main conclusions. Summing up, the robustness checks using alternative zombie definitions, controlling for Covid-19 and implementing different fixed effect structures confirm the main findings under the baseline regression specification.

Table 11. Robustness checks for new credit

	(1) Baseline, new credit	(2) Leverage def.	(3) Adalet McGowan et al. def.	(4) Nurmi et al. def.	(5) Pre Covid	(6) Covid	(7) Firm Contr. & FE	(8) Bank Contr. & FE	(9) Time FE
is_not_zombie=1	437127.9***				424701.2**	448601.3**	0	421074.7***	443333.7***
	(2.62)				(2.51)	(2.13)	(.)	(3.02)	(2.77)
zombie_share_bank_lag	14329818.2*	731993.7	−1280274.6	6682405.3	15495717.2**	11335205.7	30680911.3**	12584963.5*	13918145.8*
	(1.82)	(0.24)	(−0.25)	(0.64)	(2.27)	(0.93)	(2.28)	(1.94)	(1.85)
is_not_zombie=1 X zombie_share_bank_lag	−15062585.9*				−13851623.6**	−16949275.3	−31428828.1**	−13456907.2**	−14501124.5*
	(−1.86)				(−2.01)	(−1.38)	(−2.29)	(−2.01)	(−1.86)
numberemployees_lag_1	202.0***	202.0***	202.1***	202.0***	175.5***	217.6***	63.03	205.1***	162.8***
	(7.34)	(7.34)	(7.35)	(7.34)	(5.81)	(6.43)	(0.64)	(7.15)	(4.11)
leverage_lag	155662.5*	147499.3*	153941.8*	152625.1*	100539.6	254924.3***	−29073.5	155316.2*	197234.2**
	(1.96)	(1.82)	(1.95)	(1.94)	(1.45)	(2.61)	(−1.16)	(1.81)	(2.44)
ebitda_over_assets_lag	12169.4	14953.9	20979.6	21225.8	−607.8	121218.7	4895.2	12182.8	1337.2
	(0.78)	(0.89)	(1.03)	(1.03)	(−0.14)	(1.59)	(0.94)	(0.78)	(0.10)
is_not_zombie_leverage=1		−88029.1							
		(−0.81)							
is_not_zombie_leverage=1 X zombie_share_bank_lag		−1142654.9							
		(−0.39)							
is_not_zombie_OECD=1			−287574.2						
			(−1.38)						
is_not_zombie_OECD=1 X zombie_share_bank_lag			913153.2						
			(0.18)						
is_not_zombie_icempl=1				−278959.2					
				(−0.70)					
is_not_zombie_icempl=1 X zombie_share_bank_lag				−7180652.6					
				(−0.67)					
turnover_creditor_lag								$4.65e-12$	
								(0.04)	
employees_creditor_lag								−0.00502	
								(−1.10)	
Firm-level controls	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*
Bank-level controls	*No*	*No*	*No*	*No*	*No*	*No*	*No*	*Yes*	*No*
Firm FE	*No*	*No*	*No*	*No*	*No*	*No*	*Yes*	*No*	*No*
Bank FE	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*
Country-Sector-Time FE	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*	*No*
Time FE	*No*	*No*	*No*	*No*	*No*	*No*	*No*	*No*	*Yes*
Observations	1940277	1940277	1940277	1940277	791509	1148677	1716056	1669448	1951384
Adjusted R^2	0.085	0.085	0.085	0.085	0.071	0.096	0.336	0.085	0.038

Notes: t-statistics in parentheses.* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 12. Robustness checks for interest rates

	(1) Baseline, interest rates	(2) Leverage def.	(3) Adalet McGowan def.	(4) Nurmi et al. def.	(5) Pre Covid	(6) Covid	(7) Firm Contr. & FE	(8) Bank Contr. & FE	(9) Time FE
is_not_zombie=1	−0.00346***				−0.00290***	−0.00398***	0	−0.00357***	−0.00348***
	(−13.93)				(−9.10)	(−14.64)	(.)	(−13.62)	(−13.71)
zombie_share_bank_lag	−0.0710***	−0.0853***	−0.0651***	−0.0604***	−0.141***	0.00125	−0.0573***	−0.0348***	−0.0603***
	(−17.27)	(−14.53)	(−15.42)	(−9.45)	(−16.64)	(0.34)	(−11.96)	(−8.65)	(−14.45)
is_not_zombie=1 X zombie_share_bank_lag	0.00679*				0.00301	0.0148***	−0.00495	0.0118***	0.00932**
	(1.77)				(0.47)	(4.01)	(−1.06)	(3.02)	(2.38)
numberemployees_lag_1	$-4.74e-08$***	$-4.79e-08$***	$-4.63e-08$***	$-4.76e-08$***	$-5.27e-08$***	$-4.04e-08$***	$1.07e-08$	$-4.29e-08$***	$-2.98e-08$**
	(−4.62)	(−4.68)	(−4.53)	(−4.63)	(−3.63)	(−4.69)	(0.53)	(−4.27)	(−2.53)
leverage_lag	0.0000522	−0.00000892	0.0000690	0.0000771	−0.000216	0.000168*	−0.000293**	−0.0000636	−0.000195
	(0.51)	(−0.08)	(0.69)	(0.75)	(−0.77)	(1.84)	(−2.48)	(−1.06)	(−1.62)
ebitda_over_assets_lag	−0.00171**	−0.00176**	−0.00166**	−0.00171**	−0.00174*	−0.00168	0.0000526	−0.00177*	−0.00172**
	(−2.18)	(−2.18)	(−2.19)	(−2.19)	(−1.79)	(−1.63)	(1.42)	(−1.95)	(−2.23)
is_not_zombie_leverage=1		−0.00264***							
		(−9.79)							
is_not_zombie_leverage=1 X zombie_share_bank_lag		0.0214***							
		(3.76)							
is_not_zombie_OECD=1			−0.00334***						
			(−18.68)						
is_not_zombie_OECD=1 X zombie_share_bank_lag			0.000696						
			(0.18)						
is_not_zombie_icempl=1				−0.00332***					
				(−13.52)					
is_not_zombie_icempl=1 X zombie_share_bank_lag				−0.00410					
				(−0.65)					
turnover_creditor_lag								$3.60e-18$***	
								(13.08)	
employees_creditor_lag								$-1.15e-11$***	
								(−4.73)	
Firm-level controls	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*
Bank-level controls	*No*	*No*	*No*	*No*	*No*	*No*	*No*	*Yes*	*No*
Firm FE	*No*	*No*	*No*	*No*	*No*	*No*	*Yes*	*No*	*No*
Bank FE	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*
Country-Sector-Time FE	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*	*No*
Time FE	*No*	*No*	*No*	*No*	*No*	*No*	*No*	*No*	*Yes*
Observations	23426188	23426188	23426188	23426188	8575793	14850394	23401152	20172719	23433100
Adjusted R^2	0.228	0.228	0.228	0.228	0.252	0.284	0.448	0.242	0.200

Notes: t-statistics in parentheses.* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

4.3.5 Limitations and avenues for future research. Although the main results of this paper are robust to different specifications and zombie definitions, two drawbacks related to data quality and data availability need to be kept in mind. First, AnaCredit is still a quite novel dataset. It is based on the reporting by euro area banks, which is collected by the national central banks and compiled by the ECB. All institutions try to minimise reporting errors, but of course they cannot be ruled out. An example are the very high interest rates at the beginning of the period of study (Q3 and Q4 2018), which may be due to banks misunderstanding reporting standards or simply typing errors (e.g. confusing a value of "1" with 1% when it actually means 100%). To address such potential shortcomings, additional sample restrictions mentioned in section 4.1 on interest rates (excluding anything below -100% and above 100%) and on return on assets (excluding observations below -10 for healthy firms, which is mostly due to extremely low reported total assets) are imposed.

Second, data availability constrains the analysis in different ways. A main issue is that Orbis data has a time lag of approximately 1.5 to 2 years, counted from the closing date, simply due to accounting policies. Consequently, in this analysis, Orbis financial accounting data is only available up until 2019 for all firms (until 2020 for some exceptions), which is why a fixed zombie sample is used. Moreover, since AnaCredit data only starts in Q3 2018, the analysis cannot go back further in time. As a result, the analysis cannot include firms that became zombies in 2020 and 2021, or zombie firms that recovered to healthy status, or firms that exited the market because they died. Rather, it focuses on firms that were zombies already before the pandemic. It will be very interesting to extend this analysis with a zombie sample allowing for entry and exit of zombies during the pandemic, once the data become available. A related issue is that Orbis data are not only used to identify zombie firms, but also as firm-level control variables. Controls are lagged by one period. This means that the controls leverage, number of employees and EBITDA over assets are assumed to be constant from 2020 onwards, while firm age is constructed as being continuous. To address this issue, the regressions are run with different specifications: including firm-level controls, but without firm-fixed effects; without controls, but with firm-fixed effects; and including both. As it turns out, the results do not differ much comparing these specifications.

Finally, bank-level control variables employed in the robustness checks are taken from AnaCredit. However, the reference date for these variables is not obvious, such that it would be desirable to use official bank balance sheet data to control for bank-specific time-variant characteristics. However, it is not trivial to match the present Orbis-AnaCredit dataset with a third containing bank information. This task is outside the scope of this master thesis. Nonetheless, this idea gives rise to very interesting avenues of future research. It would allow to implement an instrumental variable approach as done on the sector level by Banerjee and

Hofmann (2018). A possible instrument might be the exposure of a bank to the average zombie share across all banks in the sample, which is very similar to what Banerjee and Hofmann (2018) use. This could be an interesting way to cross-check the panel regression results and investigate causal relationships. Furthermore, one could extend the analysis to different types of banks with a higher or lower zombie share.

5 Conclusion

To conclude, zombie firms do exist in the euro area, but they do not pose significant negative externalities on the credit conditions of healthy firms in the economy.

Firms are identified as zombie firms when, for two consecutive years, they report a negative return on assets, negative net investments and a debt servicing capacity below 5%. Under this definition, the asset-weighted zombie share averaged from 2005 to 2019 using the Orbis sample ranges between 0.4% for Luxembourg to 3.5% for Greece. The time series of asset-weighted zombie shares shows that the GIIPS countries (Greece, Italy, Ireland, Portugal and Spain) that were particularly hit by the GFC and the subsequent European sovereign debt crisis have the highest zombie shares, with peaks around 5-8% in times of crisis. Similarly, sectors that are more pro-cyclical like Arts and Entertainment or Real Estate exhibit the highest asset-weighted zombie shares of up to 8%. A closer look at zombie firms shows that these are, on average, smaller, less profitable and more leveraged than healthy firms.

Merging the Orbis dataset with the granular AnaCredit dataset allows us to analyse credit quality indicators and other credit attributes on a loan-by-loan basis for healthy and zombie firms. This matched sample includes 15658 zombie firms among over 1.16 million firms in total and confirms the significantly weaker financial fundamentals of zombie firms. In addition, zombie firms are found to have a higher amount of bank loans (except for among large firms) and perform much worse in terms of credit quality indicators like the probability of default, the share of non-performing loans or the share of loans where credit risk significantly increased since establishing the loan. However, this weaker credit quality does not translate into much lower shares of new credit or Covid-19-related state guarantees in terms of total "zombie" credit. These findings, together with the non-negligible shares of zombie existence especially in euro area peripheral countries, raises the question if the existence of zombie firms adversely impacts healthy firms, which would render the existence of zombie firms a more far-reaching economic problem.

Indeed, the majority of the existing literature finds negative real spillover effects from zombies to healthy firms in terms of employment growth, investment and productivity, which

are transmitted through two main channels according to these papers: competition and credit conditions. Using the matched Orbis-AnaCredit sample from Q3 2018 to Q4 2021 and a panel regression with fixed effects, this thesis cannot confirm the existence of negative financial spillovers. More specifically, while healthy firms do receive significantly more new credit than zombie firms in general, a significant adverse spillover effect on healthy firms' new credit cannot be found. Thus, the overall effect of a higher share of zombie loans in a bank on healthy firms is economically not significant.

Furthermore, interest rates paid by zombie firms are significantly higher than those paid by healthy firms. This applies for all firms except for those rated C or worse based on their probability of default. Here, healthy firms rated C or worse pay higher interest rates than zombie firms rated C or worse, suggesting that the subsidised credit argument applies only within the realm of firms that are already in bad shape. Banks with a higher share of zombie firms charge significantly lower rates for both groups of firms. In contrast to the one existing study examining spillovers on interest rates in the euro area, there there exists a spillover effect to healthy firms, but it is benefiting them. Healthy firms in banks with a higher zombie share pay significantly lower interest rates than firms with loans in banks with a lower zombie share. The spillover effect does not seem to depend on the credit quality of loans, as is examined using sub-samples of similarly rated firms. In any case, the total combined effect of the existence of zombie firms in a bank actually *reduces* the interest rates paid by healthy firms for all bank zombie shares between 0-30%, which is statistically significant at the 1%-level. These main conclusions are robust to using alternative zombie definitions and alternative fixed effect specifications, with slight differences of the individual effects during the Covid-19 period, which is potentially related to pandemic-induced state support measures.

There are several possible explanations for this discrepancy of my findings with the literature as this is the first paper, to the best of my knowledge, that investigates

- financial spillovers from zombie firms in terms of new credit (new) and interest rates (investigated previously by Acharya et al., 2019, which estimate average interest rates based on other variables)
- in the euro area
- in the very recent time period from 2018 to 2021,
- using the AnaCredit dataset which includes a more extensive sample of not only large, but also medium-sized, small and micro firms
- with a panel regression on the bank, not the sector, level.

In terms of policy implications, these findings seem like "good news" for the economy:

Zombie firms are charged higher interest rates according to the elevated credit risk that they pose, and an unambiguous spillover effect is not discernible. Healthy firms receive more new credit than zombie firms and the negative spillover on healthy firms' new credit is outweighed by the positive effect of a bank with more zombies providing more new credit to all firms. Nevertheless, this does not mean that one should disregard the issue of zombie firms altogether. After all, the mere existence of zombie firms suggests misguided lending incentives by banks or policy structures that favour artificially keeping inefficient firms alive. *Although* zombie firms pay higher interest rates than healthy firms, it is not clear if these appropriately reflect these firms' elevated credit risk. *Although* zombie firms receive less new credit than healthy firms, they still receive new credit (and even public guarantees in the Covid-19 context). And *although* financial spillovers might not be as significant as assumed by the literature, real spillovers through the competition channel might still exist, as demonstrated by the existing literature in several contexts. Therefore, the existence of zombie firms in the euro area remains an important issue that should be kept in mind when assessing the health of the economy and possible risks to financial stability, especially in the aftermath of the Covid-19 pandemic. Thus, the answer of President Lagarde to the question by the Committee of Monetary and Economic Affairs in September 2020 seems appropriate: Policymakers should continue to monitor the evolution of zombies and spillovers from zombie companies, but it does not seem that the situation has gotten out of hand (yet).

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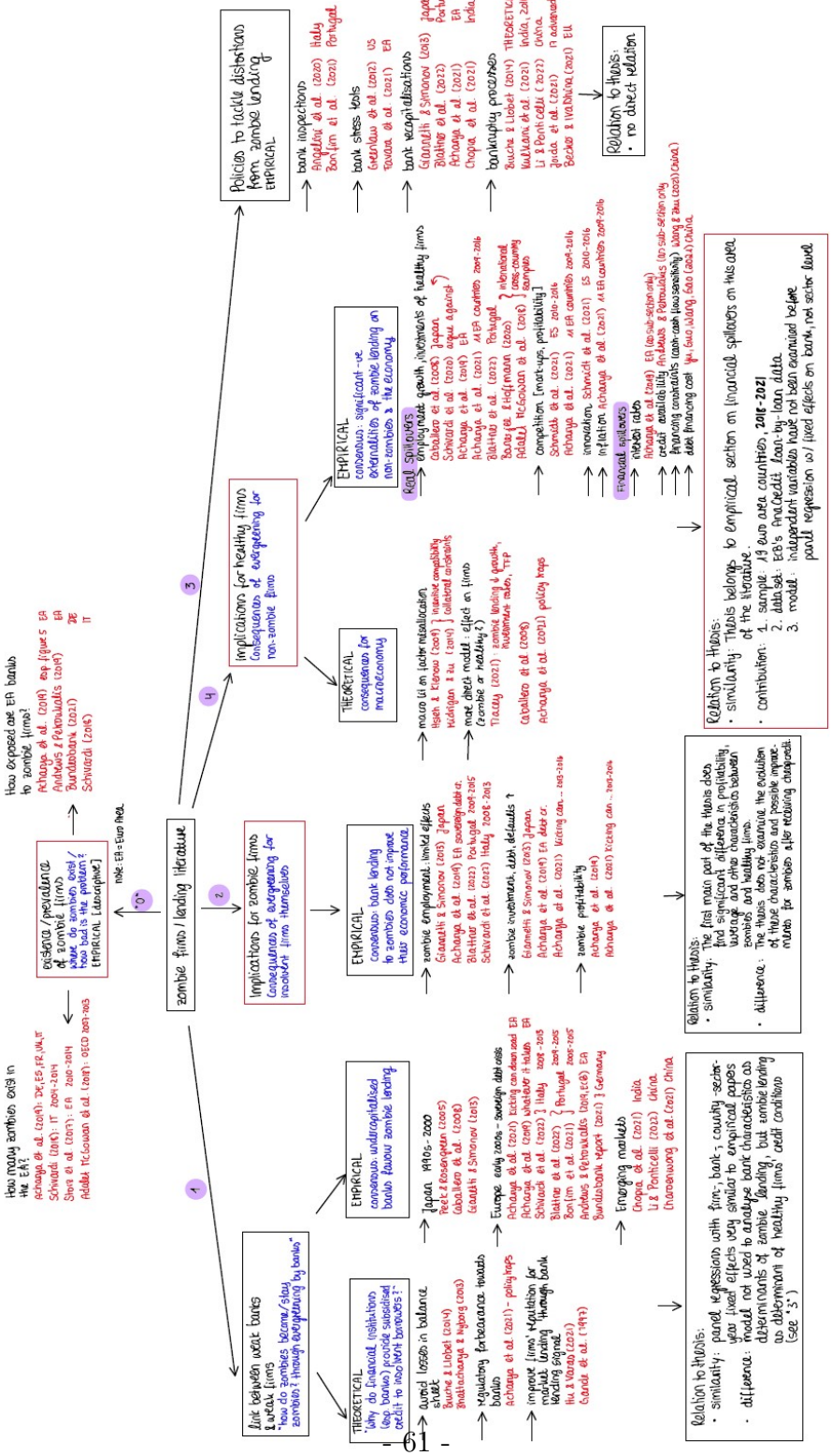
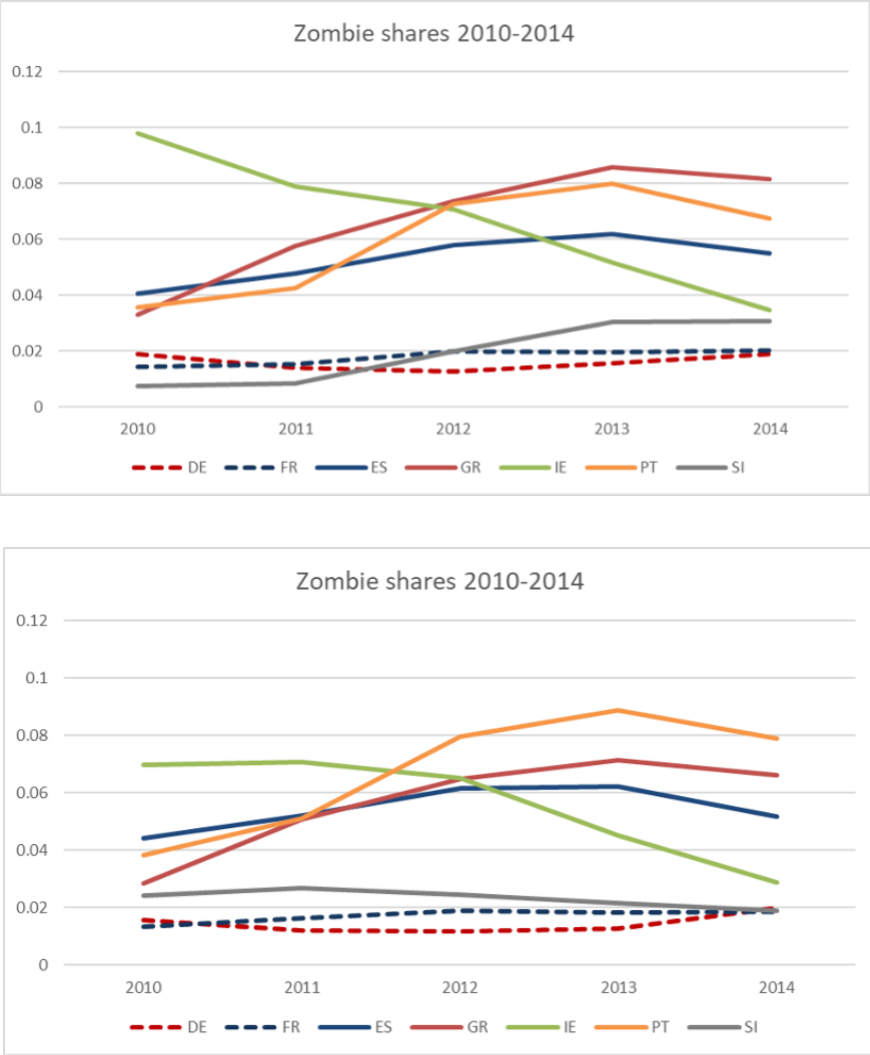
Appendix

A Literature overview and contribution of this study



B Asset-weighted zombie shares vs. the number of zombies divided by the total number of firms



Top: Asset-weighted shares, bottom: number shares. To better compare the measures, the shares here illustrated for a sub-set of countries from 2010 to 2014.

C Regression results for more granular rating categories

Table 13. Regression results for interest rates in granular credit rating buckets

	(1) AAA, PD=0%	(2) AA,0%-0.38%	(3) A, 0.38%-0.39%	(4) BBB: 0.39%-1.02%	(5) BB: 1.021%-4.24%	(6) B: 4.24%-13.84%	(7) CCC/C: 13.84%-49.46%	(8) unrated
is_not_zombie=1	0.00423	−0.00164***	0.0000275	−0.000176	−0.000285	0.000841	0.0000421	−0.00271***
	(0.93)	(−2.60)	(0.01)	(−0.28)	(−0.54)	(1.53)	(0.05)	(−9.10)
zombie_share_bank_lag	−0.636**	−0.0985***	−0.0850	−0.175***	−0.157***	−0.227***	−0.261***	−0.0196***
	(−2.10)	(−4.05)	(−0.79)	(−6.02)	(−6.29)	(−8.07)	(−6.84)	(−5.11)
is_not_zombie=1 X	−0.305	−0.00836	−0.0827	−0.104***	−0.0778***	−0.0535**	0.0102	0.0172***
zombie_share_bank_lag	(−1.02)	(−0.36)	(−0.82)	(−3.92)	(−3.42)	(−2.39)	(0.38)	(4.47)
numberemployees_lag_1	−0.000000181**	$-4.49e-08$***	$-9.12e-08$**	$-9.67e-08$***	−0.000000116***	−0.000000137**	−0.000000121**	$-1.95e-08$*
	(−2.23)	(−6.04)	(−2.42)	(−4.44)	(−4.59)	(−2.27)	(−2.33)	(−1.70)
leverage_lag	−0.000363	−0.00362***	−0.00473***	−0.00461***	−0.00171**	−0.000131*	0.000182	−0.0000348
	(−1.47)	(−5.64)	(−8.34)	(−19.23)	(−2.33)	(−1.66)	(1.12)	(−0.25)
ebitda_over_assets_lag	−0.000231	−0.00488***	−0.00229***	−0.00439***	−0.00164***	−0.000835***	−0.00224***	−0.000831*
	(−1.03)	(−6.25)	(−2.60)	(−16.56)	(−4.22)	(−3.10)	(−5.30)	(−1.81)
Firm-level controls	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*
Bank FE	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*
Country-Sector-Time FE	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*
Observations	848018	3578241	120408	3065088	4466284	1343331	466533	9469756
Adjusted R^2	0.486	0.182	0.352	0.200	0.254	0.238	0.267	0.344

Notes: t-statistics in parentheses.* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. Standard errors are clustered on the firm level.