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The Rise of the Walking Dead: Zombie Firms Around the World*

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ABSTRACT: We build a new dataset of listed and private nonfinancial zombie firms for a large set of Advanced Economies and Emerging Markets over the last two decades. We find that the share of these unproductive and unviable firms has been rising worldwide, especially since the GFC and the Covid-19 pandemic. We show that, perhaps surprisingly, the incidence of zombification is lower among private firms. Lower average survival rates of private firms may explain this phenomenon. We find important negative macrofinancial spillovers from zombie firms: nonzombies' financial performance is persistently reduced in industries populated with a greater number of zombies. To mitigate these effects, we document that countries with stronger banks, and tighter macroprudential policies tend to have fewer zombies and stronger nonzombies. Strengthening the banking sector may, however, not be sufficient if insolvency frameworks are not well-prepared to deal with the restructuring or insolvency of firms.

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1 Introduction

The macroeconomic implications of unproductive and unviable—zombie—firms have come back to the forefront of the public debate during the Covid-19 pandemic, amid the unprecedented public support provided to firms to help them withstand the severe loss in earnings.[1] While this initial (mostly) untargeted support was essential to mitigating the negative shock on the economy, it may have helped zombie firms stay afloat, thus avoiding or delaying a necessary creative destruction process. At the same time, concerns emerged that lenders would fail to properly recognize loans to zombie firms as nonperforming, so as to preserve capital. Lenders would then have incentives to extend credit to zombie firms to keep them alive, creating congestion effects on healthy firms competing with zombie firms, and reducing overall productivity, investment and employment in the economy. Against this background, it is key to tracking the number of zombie firms and its macrofinancial implications to the rest of the economy.

In this paper we contribute to the literature on corporate zombies by computing a new dataset on nonfinancial zombie firms worldwide since 1997 for private firms and since 2000 for listed firms. To the best of our knowledge, we are the first to assess and compare the incidence of zombification between listed and private firms for a large set of Advanced Economies (AEs) and Emerging Markets (EMs). First, the related literature tends to focus on: (i) listed firms, given better data quality and wider coverage (Caballero et al., 2008; Altman et al., 2022; Banerjee and Hofmann, 2022); or (ii) private and listed firms pooled together for several countries, not allowing for a comparison of the prevalence of zombification between the two groups (McGowan et al., 2018; Acharya et al., 2019; Andrews and Petroulakis, 2019; Schivardi et al., 2022).[2] Our analysis of private firms has the advantage of covering an important part of the economy, typically disregarded due to data constraints. Second, we cover a large panel of EMs to complement existing work that focuses exclusively on AEs (McGowan et al., 2018; Banerjee and Hofmann, 2022).[3] This allows us to discern patterns across countries along different dimensions.

[1] The rise in zombie firms and its economic implications were first documented in extensive research dating back to Japan's lost decade, particularly that zombie lending played a key role in the economic stagnation of the 1980s and 1990s by misallocating capital away from the most productive firms and by creating congestion effects for healthy firms competing with zombies (Peek and Rosengren, 2005; Caballero et al., 2008; Giannetti and Simonov, 2013). Similar findings have recently been extended to the 2010s European sovereign debt crisis, when weak banks 'kicked the can down the road' by evergreening zombie loans (Storz et al., 2017; Acharya et al., 2021; Schivardi et al., 2022; Blattner et al., 2023).

[2] The exception is Favara et al. (2022), who look into both private and listed nonfinancial zombie firms for the United States using detailed supervisory data from the Federal Reserve Y-14Q dataset.

[3] During the writing of this paper, we have become aware of recent work by Altman et al. (2022) who use firm-level data from Compustat and Worldscope to assess the incidence of zombification for the largest 20 world countries over 1990-2021. Although their sample covers eight large EMs, our country coverage is much larger, while we also analyze private firms.

Using firm-level data from S&P Compustat and Bureau van Dijk ORBIS over the last two decades, we define zombie firms as firms that are likely both in financial distress and unprofitable, similar to Favara et al. (2022). Specifically, we select firms that have for at least two consecutive years: (i) an ICR below one, (ii) a leverage ratio above the median firm in the same industry, and (iii) negative real sales growth. While the first two indicators are somewhat standard in the literature to capture financial distress, the third indicator is essential to ensure we only select firms that are also persistently unprofitable. The two-year horizon minimizes misclassification from cyclical fluctuations. Our definition departs from the original one proposed by Caballero et al. (2008), who focus on a concept of subsidized interest rates for Japanese firms during the 1980s and early-1990s. While their definition may have been applicable in the Japanese context, recent literature has, however, argued that it may be challenging to identify zombies based on financing conditions more favorable than high-rated firms, especially in an environment of low interest rates (Kulkarni et al., 2021; Banerjee and Hofmann, 2022; Faria-e-Castro et al., 2022).

Our zombie definition departs further from most of the literature by only allowing firms to exit the zombie status when at least one of the three indicators or conditions is reversed for two consecutive years after a firm is classified as zombie: either an ICR above one, leverage below the median industry, or positive real sales growth. This approach—also followed by Banerjee and Hofmann (2022)—is key to minimizing type two errors in defining zombie firms: a firm classified previously as zombie may become nonzombie simply because of a temporary improvement in overall economic conditions.

Armed with our definition of zombie firms, we first explore the dynamics of zombification across time for listed and private firms, while zooming in on cross-country and cross-industry differences. We then move on to assessing the zombie transition matrix, particularly the persistence of the zombie status, and the probability of a firm becoming zombie. Furthermore, we explore the characteristics of a typical zombie firm relative to a nonzombie, while also studying the life cycle of zombies, in the spirit of Banerjee and Hofmann (2022). Tracking the evolution of several balance sheet indicators before and after a firm is classified as zombie allows us to shed more light on what makes a firm become zombie firm, and how they typically evolve afterwards.

Finally, we move to the analysis of the macrofinancial spillovers, or congestion effects, from zombie firms to nonzombies, as typically done in the related literature (Caballero et al., 2008; McGowan et al., 2018; Banerjee and Hofmann, 2022). Our contribution is threefold. First, after analyzing how zombies weigh on investment, productivity, and employment of nonzombies

that operate in the same industry, we extend the analysis to the effect on nonzombies' credit conditions. Second, we study congestion effects through the extensive margin, i.e. how the presence of zombie firms may weigh on the probability of a firm exiting the market, or discourage new entrants. Third, we investigate how higher banks' capital buffers, a tighter macroprudential stance, and more-prepared corporate insolvency frameworks can alleviate these negative spillover effects.

Our main findings are as follows. First, the share of zombie firms for listed and private firms has been steadily increasing over the last 20 years, especially after the GFC, in line with recent evidence (Altman et al., 2022; Banerjee and Hofmann, 2022). After the temporary downward trend from 2016 to 2019, the share of zombie firms resumed its upward trend since the Covid-19 pandemic, presumably reflecting the unprecedented policy support and easy financing conditions. Overall, we find a sharper increase in zombification over the last two decades for listed firms, with zombie firms accounting for over 10 percent of all listed firms in 2021, up from 6 percent in 2000. For private firms the rise has been from 1 percent in 1997 to over 5 percent in 2020. A lower incidence of zombification among private firms is surprising at face value. One would expect private firms, which tend to be smaller and more vulnerable, to be more susceptible to becoming zombie firms, as hinted by Banerjee and Hofmann (2022). We show, however, that lower zombie shares among private firms are most likely explained by the lower survival rates of private firms compared to those of listed firms. This suggests that vulnerable private firms prone to becoming zombies may be more likely to exit the market than vulnerable listed firms, thus bringing down the zombie shares. Moreover, private zombie firms also tend to exit the market at a faster pace than listed zombies. Nevertheless, we acknowledge that the comparison between listed and private firms is subject to important caveats; the sample of private firms may be less representative of the whole population, especially for small and micro enterprises. In fact, many private firms in some jurisdictions are not required to disclose their balance sheet information.

Second, we show that zombie shares differ widely across countries and industries, but without any discernible difference between AEs and EMs. Zooming in on industry differences, we document greater zombification among industries that produce durable goods, and are more subject to boom-busts in asset prices and large swings in demand, such as real estate, energy, and consumer discretionary. These (mostly) nontradable industries have been found to be more financially vulnerable, less productive, and face weaker growth opportunities (Albuquerque,

2023; Müller and Verner, 2023). We also assess the zombie status to be quite persistent for both listed and private firms, with roughly 60 to 80 percent of zombie firms remaining zombies in the following year. The average number of years a firm remains zombie has been gradually increasing over time, standing at roughly four years after a firm is first classified as zombie.

Third, we document that zombie firms are typically characterized by substantially weaker balance sheets than nonzombies within the same industry and country, broadly in line with the literature (McGowan et al., 2018; Banerjee and Hofmann, 2022; Favara et al., 2022). Zombie firms have lower TFP levels, are less profitable, invest less, hold limited liquid assets, tend to be smaller, and are at a higher risk of default. We also find that listed zombies—but not private firms—face a higher cost of debt than the nonzombie peers. This reinforces the view that it may be challenging to empirically identify zombie firms based on a concept of subsidized interest rates. Furthermore, when studying the evolution of new zombies' balance sheets, we document that the performance of a new zombie firm starts deteriorating considerably several quarters before it is classified as zombie. This suggests that it may be possible to anticipate to some degree the future incidence of zombification. After a firm becomes zombie, we only find some tentative evidence for a very gradual recovery in their financial performance.

Fourth, we document important negative macrofinancial spillovers along the intensive and extensive margins from zombies to nonzombies operating in the same industry and country. We find that the presence of zombie firms dampens investment, productivity, and employment of nonzombies (Caballero et al., 2008; McGowan et al., 2018; Banerjee and Hofmann, 2022). But we also show novel results pointing to reduced credit supply to nonzombies that compete with zombie firms. We rationalize this finding with evergreening motives from lenders, who face incentives to extend credit to zombies to avoid recognizing the losses in their balance sheets, creating a misallocation of credit away from the most productive and healthy firms. Along the extensive margin, we find evidence that nonzombies in industries populated with a higher number of zombies tend to exit the market at a faster rate, and firm entry rates are lower. These congestion effects are quite persistent, indicating that zombie firms may cast a long shadow on the economy.

Finally, we find that policies that limit banks' incentives to engage in zombie lending can potentially mitigate the negative spillovers effects from zombie firms (Giannetti and Simonov, 2013; Storz et al., 2017; Andrews and Petroulakis, 2019; Kulkarni et al., 2021; Blattner et al., 2023; Bonfim et al., 2023). These policies are particularly important to mitigate zombification

risks in the current scenario of tighter financing conditions (Albuquerque and Mao, 2023). We find that in countries with higher regulatory capital buffers or lower NPLs, investment and debt growth of nonzombies tend to be statistically significantly higher than nonzombies in countries with weaker banks. Moreover, we also find that nonzombies' performance tends to be higher in countries with tighter macroprudential policies. But we also find that improving regulatory capital buffers may not be a sufficient condition for tackling zombification if the insolvency frameworks are not well-prepared or are costly to deal with the restructuring or insolvency of firms. This chimes well with recent findings pointing to the role of reforms to bankruptcy laws or insolvency regimes in reducing the number of zombie firms (Andrews and Petroulakis, 2019; Kulkarni et al., 2021; Altman et al., 2022; Becker and Ivashina, 2022; Favara et al., 2022). In particular, an efficient resolution of financial distress in the US bankruptcy code may explain the results in Favara et al. (2022), who find that zombie lending is not a prominent feature of the US economy, as zombie firms exit the market through bankruptcy.

Our paper relates to the growing literature on corporate zombification and its macrofinancial implications (Peek and Rosengren, 2005; Caballero et al., 2008; Giannetti and Simonov, 2013; McGowan et al., 2018; Acharya et al., 2019; Banerjee and Hofmann, 2022; Favara et al., 2022) The closest papers to ours are perhaps McGowan et al. (2018), and Banerjee and Hofmann (2022). While both papers also analyze zombification for several countries and the economic implications from the rise of zombie firms, our paper differs from theirs along several dimensions, apart from differences in the zombie definition. First, we cover both AEs and EMs, while McGowan et al. (2018)—also using ORBIS— only focus on nine advanced European countries over 2003-13, while Banerjee and Hofmann (2022) use Worldscope on 14 OECD countries over 1980-2017. Second, extending our analysis to the universe of private firms allows us to compare zombie firms between listed and private firms, while McGowan et al. (2018) pool them together, and Banerjee and Hofmann (2022) only cover listed firms. Third, our analysis of the congestion effects from zombie firms on healthy firms is much broader; while the negative spillovers to investment, employment and productivity of healthy firms is well-documented, we also study the impact on healthy firms' credit conditions and on the probability of exiting the market. And, finally, we investigate the extent to which regulatory capital buffers, macroprudential measures, and insolvency regimes can mitigate congestion effects.

2 Data

Listed firms

We use quarterly balance sheet data from S&P Compustat North America, and Compustat Global on nonfinancial listed firms for 63 countries, 32 EMs and 31 AEs, over 2000-2021.[4] We use quarterly data in all of our empirical results, but we identify zombie firms in the annual dataset, as detailed in the next section. We exclude financial firms (banks, diversified financials, and insurance firms) from our analysis, as these are highly regulated industries. Table A.2 in Appendix A shows the industry breakdown, aggregated at the two-digit code: a large share of the firms are concentrated in the industrial sector, consumer discretionary, information technology, and materials.

Following standard practice in the literature, we clean the data and make other adjustments to minimize measurement errors, and ensure the representativeness of the data. For instance, we drop firms with missing assets, liabilities, debt, or the capital stock. We also drop firms with fewer than three years of data on the leverage ratio, the investment rate, the interest coverage ratio (ICR), and sales, to minimize biasing our data from picking up firms that do not report consistently comprehensive balance sheet data. In addition, we restrict the sample to firms whose total debt does not exceed 100 percent of their total assets, as in Almeida et al. (2004).

At the country level, we drop observations for countries with fewer than five firms for each quarter. We then winsorize key variables at the 2.5/97.5 percentiles at the country level to minimize the impact of extreme outliers. Finally, we deflate nominal variables with the respective country CPI deflator. Appendix A lists the full data cleaning assumptions, including summary statistics (Table A.3). Our final sample covers an unbalanced panel of 42,760 nonfinancial firms over 2000q1-2021q4, resulting in 1,770,521 firm-quarter observations.

Figure A.1 in Appendix A shows a steady increase in the number of firms and countries since 2000. We have, on average, twice as many listed firms in AEs than in EMs, reflecting greater financial market depth in AEs, but the gap has been shrinking over time.

Private firms

Compustat dataset has the advantage of relying on high-quality balance sheet data for listed firms. Nevertheless, it comes with the downside of not covering an important part of the

[4] We also match Compustat with Capital IQ to extract the year of foundation to compute the age of the firm. When the year of foundation is missing, we compute age from Compustat's Initial Public Offering date (*ipodate*).

economy as represented by private firms. With a few exceptions the literature tends to focus on listed firms in light of better data quality and wider coverage (Caballero et al., 2008; Altman et al., 2022; Banerjee and Hofmann, 2022). We fill the gap in the literature by covering private firms from the Bureau van Dijk ORBIS dataset. But we note that ORBIS comes with its own caveats. First, ORBIS covers a smaller set of countries relative to Compustat. In particular, data on EMs is sparse, which practically means that the analysis falls mostly on AEs. Second, while some European countries are well-represented, such as Spain, France, Italy, and Portugal, other large economies outside of Europe are not (e.g. the US, UK, Japan, and Canada). This means that the analysis is biased toward European countries. Third, ORBIS comes with important data lags, while only covering annual data, which limits the study of the implications of zombie firms to low-frequency data. Fourth, there are significant cross-country differences in disclosure regulations, as many private firms in some jurisdictions are not required to disclose their balance sheet information. This introduces an important selection bias, as the sample of private firms may be less representative of the whole population than the sample of listed firms.

With these caveats in mind, we clean the ORBIS dataset following standard practice in the literature (Kalemli-Özcan et al., 2015), and also Díez et al. (2021). Moreover, since ORBIS includes both listed and private firms, we select only private firms by keeping those that are 'Unlisted' or 'Delisted'. To avoid firm-year duplicates, from the same firm reporting under different consolidation codes, we first prioritize consolidated accounts, and only take unconsolidated accounts for firms that consistently report under unconsolidated accounts. Appendix B contains a detailed list of cleaning assumptions and data definitions. Our final sample covers 43 countries (26 AEs and 17 EMs) in an unbalanced panel of 4,394,313 nonfinancial firms over 1997-2020. Although we cover several EMs, firms in EMs only account for roughly 6 percent of the total sample, representing 269,667 firms (Figure B.1), a caveat to bear in mind when comparing private with listed firms.

Although the industry classification in ORBIS is different from Compustat—NACE2 versus GICS—the distribution of firms across sectors is similar. Table B.2 in Appendix B shows that almost half of the sample is concentrated in the manufacturing industry, and in wholesale and retail trade, followed by real estate and professional activities.

Country-level data

We use country-level data in Section 5 to study how strengthening banks and tightening macro-

prudential policies can mitigate the negative spillover effects from zombification. We construct our main indicator of the banking sector health—regulatory capital buffers—by subtracting the minimum required risk-based regulatory capital ratio, taken from the World Bank's Bank Regulation and Supervision Survey (available for 55 countries from 2001 to 2019), from the banks' actual regulatory capital to risk-weighted assets (from the IMF's Financial Soundness Indicators). We use the regulatory capital buffers and not capital ratios given that the latter may not be strictly comparable across countries. In addition, capital buffers may provide us with a more accurate picture of the underlying resilience of banks, i.e. the additional capital banks hold above the regulatory limit that can actually be used to mitigate shocks. As an additional indicator, we use nonperforming loans to total gross loans (NPL), available from 2001 to 2021.

To capture macroprudential policies, we use the IMF's integrated Macroprudential Policy (iMaPP) database, a comprehensive historical monthly database that combines information from various sources on 17 macroprudential policy measures in place, and changes in these measures, for 182 jurisdictions over 1990-2020 (Alam et al., 2019). For each one of these measures, it assigns the value of one for tightening actions (the effective date at which the policy enters into force), minus one for loosening actions, and zero for no change.[5] We transform all indices into cumulative terms for each country and quarter to have a better sense of their stringency: we follow Akinci and Olmstead-Rumsey (2018) and sum up the dummy indices for each instrument taking the beginning of the dataset in 1990 as the starting point. Our proxy for the overall macroprudential stance is the sum of all the 17 macroprudential indicators.

To proxy for the quality of insolvency regime frameworks, we use the crisis preparedness indicator of insolvency systems from Araujo et al. (2022). This indicator measures countries' preparedness to handle a large-scale restructuring of corporates. It includes five dimensions of the insolvency and restructuring regime in the corporate sector: out-of-court restructuring, hybrid restructuring, reorganization, liquidation, and the institutional framework. Araujo et al. (2022) find that corporate sector vulnerabilities tend to be more pronounced in countries with shortcomings in crisis preparedness. The indicator is time-invariant, giving us a snapshot of

[5] Following Alam et al. (2019), we group the macroprudential instruments into seven main categories: *Demand* instruments include limits to the loan-to-value (LTV) ratio and to the debt-service-to-income (DSTI) ratio; *Supply – loans* instruments impose limits to credit growth (LCG), loan loss provisions (LLP), loan restrictions (LoanR), limits to the loan-to-deposit ratio, and limits to foreign currency loans; *Loan – targeted* measures refer to the sum of the previous two groups; *Supply – general* instruments refer to reserve requirements, liquidity requirements, and limits to FX positions; *Supply – capital* instruments encompass limits on leverage (LVR), countercyclical buffers (CCB), conservation buffers, and capital requirements; *SIFI* measures include capital and liquidity surcharges that aim at mitigating risks from global and domestic systemically important financial institutions; and *OT* instruments refer to other measures such as stress testing, and restrictions on profit distribution.

the legal and institutional status of each country as of 2021. The original indicator covers 60 countries, although we are only able to match with 43 countries in our firm-level dataset.

In Section 3.5 we use additional country-level variables to shed more light on the country factors that correlate with zombification. In the baseline specification, we add real GDP growth, and the three-month short-term interest rate.[6]

3 The rise of nonfinancial zombie firms

3.1 Identification of zombie firms

What is a zombie firm? While there is no commonly agreed definition of what constitutes a zombie firm, we can broadly define zombie firms as firms that are risky, unproductive and unviable but that manage to avoid immediate default, most likely thanks to lenders' (banks, investors, or governments) continued support, in light of misaligned incentives (Caballero et al., 2008). The literature has used several different definitions to capture these unproductive firms; using a concept of subsidized interest rate from lenders—funding costs below benchmark risk-free rates—which allows zombie firms to remain afloat (Caballero et al., 2008; Acharya et al., 2019), firms that are behind their interest payments but still receive credit from at least one bank (Kulkarni et al., 2021), old firms that do not generate enough operating revenues to meet their interest payment obligations (McGowan et al., 2018), and combined with lack of growth opportunities (Banerjee and Hofmann, 2022), firms with weak profitability and investments (Storz et al., 2017), firms with low profitability and high default risk (Altman et al., 2022; Schivardi et al., 2022), or distressed firms with negative sales growth (Favara et al., 2022).

In this paper we use balance sheet indicators to capture firms that are both in financial distress and unprofitable, similar to Favara et al. (2022). These indicators may provide us with a reasonable approximation of the universe of zombie firms relative to just using one indicator or dimension of the firm's balance sheet. To capture financial distress, we select firms for each year that have for at least two consecutive years: (i) an ICR below one, and (ii) a leverage ratio above the median firm in the same two-digit industry. A persistently low ICR, computed as the ratio of EBIT (earnings before interest, and taxes) to interest expenses, typically signals higher default risks as firms do not generate enough internal cash flows to cover their interest

[6] We use additional controls in robustness checks: CPI inflation, the real effective exchange rate (REER), the current account balance as percentage of GDP, the one-year government bond yield, and the Chinn-Ito index, which measures the degree of capital account openness in each country (Chinn and Ito, 2006).

expenses.[7] A high leverage ratio relative to peers, computed as total debt (short-term and long-term) divided by total assets, also capture financial distress as highly leveraged firms typically face tighter constraints in raising additional debt to finance new projects. The third indicator to define zombie firms is negative real sales growth for two consecutive years. We choose this indicator based on research showing that sales growth is a strong predictor of future expected productivity for private and listed firms (Goyal and Yamada, 2004; Whited and Wu, 2006). While the first two indicators of financial distress are relatively standard in the literature, using negative real sales growth ensures that we are defining zombie firms as those that are also persistently unprofitable. We take a two-year horizon for the three indicators to avoid misclassification arising from cyclical fluctuations.[8]

To exit the zombie status, we follow the methodology in Banerjee and Hofmann (2022) to add some degree of persistence to the zombie status. We impose that a zombie firm needs to record for two consecutive years an ICR above one, *or* a leverage ratio below the median firm in the industry, *or* positive sales growth. The assumption is that a zombie firm is not expected to easily recover within a very short period of time, say a year, while at the same time we rule out that a change in zombie status between two years may be simply driven by aggregate cyclical fluctuations. Accordingly, we define zombie firms on the annual Compustat data since zombification should be a slow-moving process.[9] We then merge the zombie classification with the main quarterly dataset to be able to carry out the empirical analysis at a higher frequency.

Our zombie definition differs from those that focus on subsidized interest rates, whereby zombies receive favorable financing conditions relative to other (high-rated) firms in order to survive. (Caballero et al., 2008; Acharya et al., 2019). Recent literature has, however, argued that this identification may problematic. First, banks may grant credit at low interest rates due to long-standing relationships with a firm, irrespective of the firm's viability (Banerjee and Hofmann, 2022). Second, banks may have incentives to capitalize interest payments by

[7] Due to lack of data on EBIT in ORBIS, for private firms we compute the ICR as EBITDA (earnings before interest, taxes, and depreciation) over interest expenses.

[8] Our zombie definition differs from Favara et al. (2022) along three aspects. First, we compare leverage of a given firm to the median leverage ratio of the same industry and country in which the firm operates, and not the whole sample. This is an important distinction given the significant heterogeneity in leverage ratios across industries. Second, we only allow firms to exit the zombie status when at least one of the three conditions is met for two consecutive years after a firm is classified as zombie: an ICR above one, leverage below the median industry, or positive real sales growth. This criterion is key to going beyond cyclical fluctuations that may classify previously zombie firms as nonzombies when economic conditions improve, even in the absence of any structural change in the business model of the zombie firm. Finally, we look at two consecutive years to classify zombie firms, while Favara et al. (2022) take three years. But our results remain qualitatively similar when taking three years.

[9] An alternative way—which practically yields the same results—would be to classify zombies by taking rolling averages of the quarterly balance sheet indicators.

evergreening new loans to cover payments on the old loan, but still charging high interest rates on the new loan (Kulkarni et al., 2021). Third, in a low-interest rate environment, a feature of most of the period over the last 15 years, subsidized interest rates would imply banks charging zero or even negative interest rates to weak firms, which seems unlikely (Kulkarni et al., 2021; Banerjee and Hofmann, 2022). Finally, in most cases the interest rate that firms pay on the loans is not available. Research has thus computed implicit interest rates derived from interest expenses for a given firm relative to a highly rated firm (Caballero et al., 2008; Acharya et al., 2019). But using implicit interest rates come with their own caveats because interest expenses: (i) are backward-looking, (ii) may not predict accurately the marginal cost on new loans, (iii) take time to adjust to new credit conditions, and (iv) ignore the capital structure of firms related to the maturity of debt.

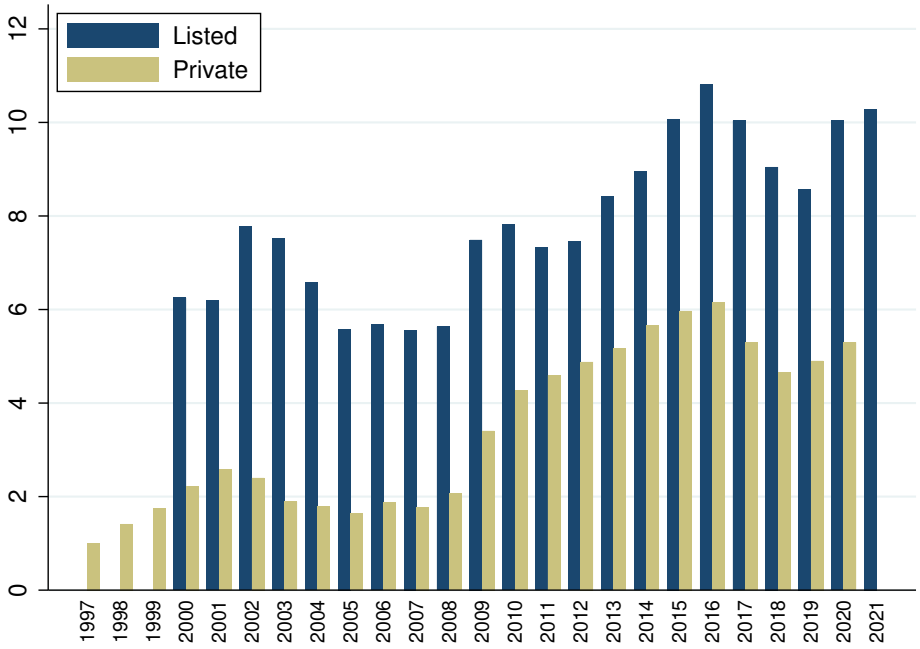
3.2 Zombie shares for listed and private firms

Armed with our definition of zombie firms, Figure 1 shows several interesting patterns. First, the share of zombie firms for both listed and private firms has been steadily increasing over the last 20 years, especially after the GFC. Low interest rates, ample liquidity, and search for yield may have been related to this upward trend (Altman et al., 2022; Banerjee and Hofmann, 2022). This phenomenon is particularly evident for listed firms, with zombie firms accounting for over 10 percent of all listed firms in the sample in 2021, which compares with 6 percent in 2000. For private firms the rise has been from 1 percent in 1997 to 5.3 percent in 2020. We find that upticks in the share of zombie firms tend to occur in the wake of economic downturns, such as in the early-2000s, and after the GFC. Banerjee and Hofmann (2022) document the same phenomenon for selected OECD countries. These trends are also visible when weighting zombie shares by total debt, total assets, or employment (Figure C.1 in Appendix C). While zombie share levels are remarkably similar when weighting by debt (and also by assets for private firms), we find that zombie firms tend to account for a smaller share of employment. But we interpret the latter result with due care as data on employment are significantly more sparse.

Second, after the temporary downward trend from 2016 to 2019, the share of listed zombie firms started to rise again during the Covid-19 pandemic, potentially reflecting the unprecedented policy support and easy financing conditions. This support, which was initially largely untargeted, may have helped unviable firms stay afloat. The share of zombies among private firms has also ticked up slightly since 2018. We speculate that the steeper increase in the share

of private zombie firms after the GFC suggests that this share may have continued to increase in both 2021 and 2022.

Figure 1: Share of zombie firms: listed vs private firms



Notes: The blue (khaki) bars refer to the percentage share of listed (private) zombie firms from Compustat (ORBIS).

Third, we find that the share of zombie firms for private firms is somewhat lower than the one for listed firms. This result seems a bit surprising, as private firms tend to be smaller than listed firms, and potentially more vulnerable, which may make them more susceptible to becoming zombies. This is the conjecture of Banerjee and Hofmann (2022), who suggest that their results on listed zombie firms may be a lower bound of the 'true' number of zombie firms in the economy. We find that differences in country composition between Compustat and ORBIS do not seem to explain this phenomenon: Figure C.2 in Appendix C shows that the zombie share of listed firms is relatively similar when we restrict the Compustat sample to the countries covered in ORBIS.[10]

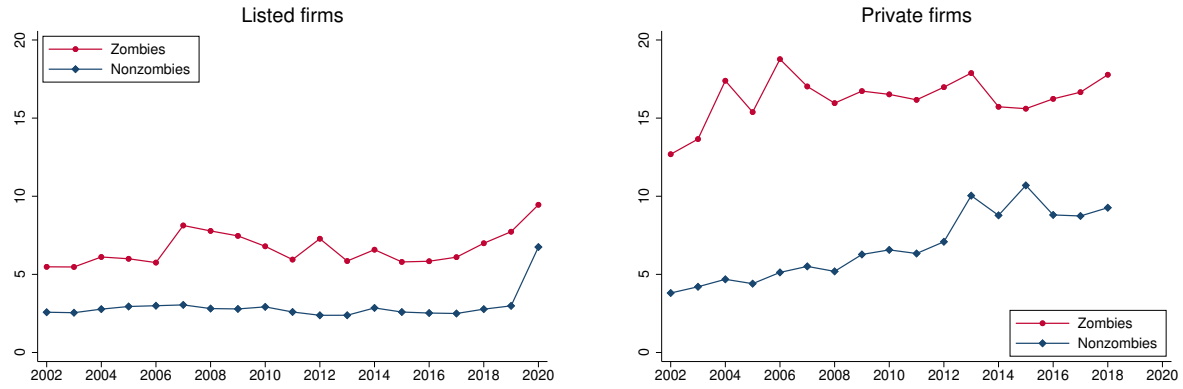
We speculate that a lower share of zombies among private firms may be related to different factors. First, larger firms may be more likely to become zombies because they are also the ones more likely to receive government subsidies that keep them alive (McGowan et al., 2018). Small private firms may find it more difficult to get a bank to evergreen their loan, leaving them with no other option than to default. We show in Section 3.3 that zombie firms, however, tend

[10]We also do not find that our results are meaningfully distorted by the fact that we compute the ICR for listed firms as EBIT over interest expenses, while for private firms we use the EBITDA in the numerator of the ICR, due to lack of data on EBIT in ORBIS.

to be smaller, suggesting that other factors may be at play. Second, large firms, given their prominent role in the economy, tend to have better political connections, creating incentives for investors and governments to bail them out (Faccio et al., 2006). While we do not have the data on politically-connected firms, we can focus on the extreme form of political connections: state-owned enterprises (SOEs).[11] The ORBIS dataset contains information on the firm ownership, which allows us to identify SOEs.[12] This hypothesis also lacks strong support in our data as the zombification incidence among unlisted SOE is very similar to other firms (Figure C.3 in Appendix C).

Finally, we show that the lower incidence of zombification among private firms may most likely be explained by the substantially higher exit rates of private firms compared to those of listed firms. This is true for both zombies and nonzombies (Figure 2). Our conjecture is that (i) 'weak' private firms prone to becoming zombies may be more likely to exit the market than weak listed firms; and (ii) private zombie firms tend to exit the market at a faster pace than listed zombies. These two forces lead to an overall lower zombification rate among private firms. Nevertheless, we acknowledge that this conclusion is not definitive as the sample of private firms is less representative of the whole population than the sample of listed firms.

Figure 2: Exit rates of zombies and nonzombies



Notes: Exit rates refer to the number of firms that exit the Compustat (ORBIS) dataset in each quarter (year) divided by the total number of firms. For more details, see Section 4.2.

[11] Research has found that politically connected firms—which tend to be financially weaker—are more likely to be bailed out than similar non-connected firms (Faccio et al., 2006). This creates an incentive for markets to continue providing credit—often at lower rates—to these firms (Bussolo et al., 2022). But it may as well be the case that investors are less willing to lend to these firms with a strong connection to the government since they may be afraid of too much state intervention that may affect the profitability of the firm (Borisova et al., 2015).

[12] To capture SOEs, we first select government shareholders from the entity type. Second, we keep ownership data in the following order: single shareholder of first level (SHH), first level shareholder identified via the Calculated Total Percentage (CTP), and shareholder at first level who is the immediate shareholder (ISH). When the target company is a branch or foreign company, we consider the single shareholder to be its headquarters. Third, we sum up the direct ownership shares of government entities to get the total government ownership of each firm. Finally, we define SOEs as those firms with the government ownership of at least 20 percent. In total, we have 16,939 SOEs (12,988 firms in AEs and 3,951 firms in EMs) for 26 countries (18 AEs and 8 EMs), which represent less than 0.4 percent of our ORBIS sample of firms.

To assess the persistence of the zombie status, we compute the probability of a firm remaining zombie in the next year *t+1* divided by the total number of zombie firms in the current year *t*. The left panel in Figure 3 shows that the likelihood of a zombie firm remaining zombie is quite persistent, hovering around 70-80 percent for listed firms, and around 65-70 percent for private firms. The lower probability we find of a private firm remaining zombie is in line with the previous finding that private zombie firms exit the market at a significantly faster rate than listed zombie firms. The right panel shows that the probability of a nonzombie firm becoming zombie is low, of around 2 percent for listed firms, slightly higher compared to private firms. Furthermore, the mean duration of zombie status has steadily been increasing in the aftermath of the GFC, in line with evidence in Banerjee and Hofmann (2022) for selected OECD countries (Figure C.4 in Appendix C). The most recent available year suggests that a firm remains in zombie status for roughly four years.

Figure 3: Probability of remaining and becoming a zombie firm

Notes: Left panel: number of zombie firms that remain zombies in *t+1* divided by number of zombie firms in *t*. Right panel: number of nonzombie firms in *t* that become zombies in *t+1* divided by the number of nonzombie firms in *t*.

Figure C.5 in Appendix C shows that zombie shares exhibit considerable cross-country heterogeneity, without a discernible difference between AEs and EMs (with the exception of private firms before 2007, but this should be taken with a pinch of salt given the lack of representativeness of private firms in EMs). In addition, Figure C.6 shows that listed firms in developed European countries, such as Austria, Finland, Spain, Germany, The Netherlands, and France, tend to have smaller zombie shares over the full 2000-21 sample, but other AEs, such as Canada, Republic of Korea, and Australia are associated with a higher share of zombie firms. Although there are some differences in the incidence of zombification between listed and private firms across countries—Australia and Republic of Korea exhibit a lower share of zombification among private firms (Figure C.7)—we find that countries with a higher share of

listed zombies also seem to have a higher share of private zombies (Figure C.8).[13] In Section 3.5 we discuss which country characteristics seem to play a role in determining differences in the incidence of zombification across countries. Specifically, zombification tends to be more prevalent in countries with a looser macroprudential stance, less-prepared corporate insolvency frameworks, weaker GDP growth, and lower interest rates.

Heterogeneity in zombie shares across countries may also be partly explained by differences in the industry structure, although zombie shares exhibit more dispersion across countries than across industries (Figures C.15 and C.16 in Appendix C). Starting with listed firms, we find a higher share of zombie firms in real estate, and in energy, potentially as a result of a higher propensity of these industries to experience boom-busts in asset prices, and consequently large swings in demand (Figure C.17). This chimes with the findings that nontradable industries tend to be more financially vulnerable, less productive, experience more debt booms, and face weaker growth opportunities (Albuquerque, 2023; Müller and Verner, 2023). Along the same lines, we also find high zombie shares in other industries involved in the production of durable goods, such as information technology, materials, and consumer discretionary. In contrast, we find lower shares of zombie firms in industries that are less sensitive to the business cycle, such as utilities and consumer staples. As for private firms, the highest zombie shares are in the entertainment sector, information and communication, professional activities, and real estate (Figure C.18). While there is not a one-to-one match in the industries' definitions between GICS and NACE2, overall we find that industries in nontradable services and that produce durable goods tend to be associated with higher levels of zombification, which contrast with industries with more stable demand (utilities and consumer staples).

We end this section by comparing our baseline zombie definition with those available elsewhere. First, Storz et al. (2017) define zombie firms as those firms that record for at least two consecutive years a negative ROA, negative net investments, and debt servicing capacity, measured as EBITDA over financial debt, below 5 percent. Second, McGowan et al. (2018)'s zombie criteria take an ICR below one for three consecutive years, and at least ten years old. Third, Acharya et al. (2019) take the three-year median ICR implied rating of BB or lower, and the ratio of interest expenses lower than highly-rated peers, i.e., AAA-rated firms. Since ratings are not available for all firms, we infer them from the ICR as in Acharya et al. (2019).[14] Fourth,

[13] Figures C.9 to C.12 in Appendix C show the time series of zombie shares for each country, while Figures C.13 and C.14 show the map distribution of listed zombie firms in 2021 and private zombie firms in 2020.

[14] BB-rated firms or lower have a three-year ICR below the first quartile of the median industry, while AAA-rated firms are those firms in the upper quartile of the industry ICR distribution.

Altman et al. (2022) take the three-year moving average of ICR below one, and a Z-score or a Z"-score below zero, which measure the firm's likelihood of bankruptcy.[15] Finally, we use a similar definition to my baseline, but replacing negative sales growth with a measure of total factor productivity (TFP) to better capture persistently unproductive firms. Specifically, we identify zombies as firms with a TFP below the median sample in each country instead of negative sales growth. We estimate TFP following the production function approach proposed by Olley and Pakes (1996). Although TFP may be preferable as a proxy of productivity, it comes with the cost of estimation uncertainty, while data constraints restrict the sample to fewer firms.[16]

The left panel on Figures C.19 and C.20 in Appendix C show that our zombie shares stand between the lower end and the average of alternative measures used elsewhere. The right panel indicates that the absolute number of zombie firms is not that different across definitions, excluding Storz et al. (2017), and Acharya et al. (2019). The latter is a clear outlier, reinforcing the view that using a concept of a subsidized interest rate may come with important caveats when defining zombie firms: this definition may capture several firms that have low ICRs but may have strong fundamentals.

3.3 Balance sheet characteristics of zombie firms

Our zombie definition assumes, by construction, that zombie firms exhibit a low ICR, high leverage, and weak sales growth. In this section, we shed more light on how zombies differ from nonzombies across other balance sheet characteristics. We run a parametric exercise of key balance sheet indicators on a binary zombie dummy, while controlling for country-industry-specific characteristics. Specifically, we run the following regression:

$$Y_{i,c,n,t} = \beta \text{Zombie}_{i,c,n,t} + \zeta_{c,n,t} + \epsilon_{i,c,n,t}, \tag{1}$$

where $Y_{i,c,n,t}$ refers to several balance sheet indicators for firm i in country c and industry n and at time t. $\text{Zombie}_{i,c,n,t}$ is a binary variable taking the value of one for zombie firms, and zero otherwise. The coefficient of interest is β, which gives us the average difference in selected indicators between zombies and nonzombies within each country-industry pair. Time-varying

[15] Since we cover several countries, we use the modified Z" score that is more suitable to international firms: 3.25 + 6.56 × (current assets - current liabilities)/assets + 3.26 × retained earnings/assets + 6.72 × EBIT/assets + 1.05 × book value of equity/liabilities. Due to data constraints, we cannot compute it for private firms.

[16] We do not use the Banerjee and Hofmann (2022) definition—ICR below one, and a Tobin's q below the median firm in the industry, over a two-year period— since the Tobin's q cannot be computed for private firms, while data availability issues prevent us from also computing it for several listed firms.

country-industry specific shocks are captured by $\zeta_{c,n,t}$. We run this regression on quarterly data for listed firms, and on annual data for private firms.

We use a wide range of balance sheet variables on the left-hand side. Our main measure of investment growth is the log percentage change in the net capital stock, specifically related to (tangible) capital expenditures in physical capital, namely property, plant, and equipment. We also complement our analysis with intangible assets, as recent literature has documented a steady increase in the importance of knowledge and organizational capacity, i.e., investment in employees, brand, and knowledge capital.[17] While tangible investment is relatively easy to measure, and widely reported on firms' balance sheets in Compustat, intangible investment is, however, more challenging to measure. We follow Peters and Taylor (2017) and compute intangible investment by summing Research and Development (R&D) costs and 30 percent of Selling, General, and Administrative (SG&A) expenses to capture organizational capital (the remaining 70 percent refer to operating costs).[18]

The remaining variables on the left-hand side of Equation (1) are as follows: employment growth measured as the year-on-year log percentage change in the total number of employees; liquid assets as the ratio of current assets (cash and short-term investments, receivables, inventories, and other current assets) net of current liabilities (short-term debt, accounts payable, income taxes payable, and other current liabilities) to total assets; leverage ratio as total debt (short and long) to total assets; the implicit interest rate computed as the four-quarter rolling sum of interest expenses divided by total debt; sales growth as the year-on-year change in net sales; the level of the estimated TFP to proxy for firm productivity; the log of assets, which proxies for firm's size; the ICR to capture the ability of firms to meet their interest expenses with internal cash flows; the return on assets (ROA), computed as the four-quarter rolling sum of EBIT divided by total assets; the probability of default in 12 months, a modified version of Merton's distance-to-default model; age measured since the year of foundation; and the share of bank loans in total debt following (Crouzet, 2021).[19] Given lack of data for private firms in ORBIS, we are not able to compute the probability of default, and the loan share.

[17] Available estimates on the importance of intangible investment range from one-third (Corrado et al., 2009) to one-half of firms' total capital stock (Ewens et al., 2019; Belo et al., 2022; Eisfeldt et al., 2022).

[18] To construct SG&A expenses, Peters and Taylor (2017) suggest to subtract R&D from SG&A, as Compustat typically adds them together in the item *xsga*, given that firms tend to report SG&A and R&D separately.

[19] Compustat does not provide data on the debt structure of firms, while for Capital IQ the coverage of firms with information on their debt structure is relatively poor, and the data only starts after 2001. We thus follow Crouzet (2021) and sum short-term notes payable (*cp*) and other long-term debt (*dlto*) and then divide by total debt. Crouzet (2021) shows that this ratio for US nonfinancial firms compares rather well with the aggregate share of loans for the nonfinancial corporate sector from the Flow of Funds.

Tables 1 and 2 present the β from Equation (1) for each balance sheet indicator on the sample of listed and private firms. Overall, both tables show that zombie firms within a particular industry and country have substantially weaker balance sheets than nonzombies along many dimensions, and are at a higher risk of default. For instance, Panel A of Table 1 shows that listed zombie firms invest less than their nonzombie peers, both in tangible and intangible assets: the tangible capital stock is 57 percent smaller than nonzombies, tangible investment growth is on average 2.6 p.p. weaker for zombie firms relative to nonzombie firms, and growth in intangibles is roughly 3.7 p.p. lower. Panel A of Table 2 shows the same pattern for private firms, but with larger differences in investment growth relative to their private nonzombie peers.

Table 1: Characteristics of zombie firms: listed firms

Panel A

	(1) Log K	(2) ΔK	(3) ΔIntan	(4) ΔEmp	(5) Liq.asset	(6) Debt	(7) ΔDebt	(8) Int.rate
Zombie	-0.524***	-2.604***	-3.607***	-9.762***	-19.498***	18.244***	-2.519***	0.033
	(0.011)	(0.038)	(0.051)	(0.104)	(0.125)	(0.091)	(0.077)	(0.059)
Observations	1,764,996	1,668,411	1,315,336	919,854	1,759,840	1,768,959	1,612,920	1,224,423
Adjusted R^2	0.254	0.173	0.144	0.068	0.140	0.165	0.037	0.127

Panel B

	(1) ΔSales	(2) TFP	(3) Log Assets	(4) ICR	(5) ROA	(6) PD	(7) Age	(8) Loan shr
Zombie	-3.947***	-0.146***	-0.628***	-26.531***	-9.442***	0.829***	-1.897***	1.750***
	(0.052)	(0.004)	(0.009)	(0.736)	(0.083)	(0.013)	(0.099)	(0.134)
Observations	1,330,104	743,705	1,768,959	1,172,042	1,314,380	1,372,046	1,382,276	1,767,958
Adjusted R^2	0.140	0.007	0.250	0.083	0.142	0.292	0.276	0.149

Notes: All regressions include country-industry-quarter fixed effects. Standard errors in parentheses clustered by country-industry-quarter. Asterisks, *, **, and ***, denote statistical significance at the 10%, 5%, and 1% levels.

Zombies' balance sheets look more vulnerable to shocks as their net liquid assets holdings are substantially smaller than nonzombie firms while, by construction, being significantly more leveraged than nonzombies. Panel B indicates that zombies are less productive and profitable, as shown by a lower TFP and ROA. Zombie firms tend to be smaller, proxied with the log of total assets, and more dependent on bank loans: the bank loan share is 1.8 p.p. higher relative to nonzombie firms operating in the same country and industry.

Two differences between listed and private zombie firms relative to their respective nonzombie peers are age and the cost of debt. Listed zombie firms tend to be slightly younger (but not 'young', as the unconditional mean of age for listed zombies is 33 years), while private

Table 2: Characteristics of zombie firms: private firms

Panel A

	(1) Log K	(2) ΔK	(3) ΔIntan	(4) ΔEmp	(5) Liq.asset	(6) Debt	(7) ΔDebt
Zombie	-0.238***	-12.146***	-6.617***	-9.896***	-18.934***	15.833***	-9.747***
	(0.015)	(0.205)	(0.225)	(0.128)	(0.422)	(0.412)	(0.306)
Observations	35,525,890	34,537,929	17,898,246	21,061,384	36,735,014	36,735,193	25,099,230
Adjusted R^2	0.247	0.046	0.036	0.021	0.092	0.202	0.022

Panel B

	(1) Int.rate	(2) ΔSales	(3) TFP	(4) Log Assets	(5) ICR	(6) ROA	(7) Age
Zombie	-7.350***	-17.593***	-0.224***	-0.176***	-84.280***	-12.947***	2.974***
	(0.481)	(0.397)	(0.005)	(0.016)	(2.241)	(0.145)	(0.091)
Observations	26,228,449	35,382,471	19,527,399	36,735,193	32,829,521	35,476,335	36,681,987
Adjusted R^2	0.077	0.047	0.010	0.255	0.099	0.080	0.135

Notes: All regressions include country-industry-year fixed effects. Standard errors in parentheses clustered by country-industry-year. Asterisks, *, **, and ***, denote statistical significance at the 10%, 5%, and 1% levels.

firms tend to be slightly older. But it is challenging to draw firm conclusions on age given that private firms are much younger than listed firms (average age of the private firm is 17 years). In turn, listed firms may face a higher cost of debt than nonzombies (although not significant at conventional levels), as measured with the implicit interest rate, whereas private zombie firms seem to experience a lower interest rate burden than their nonzombie counterparts. Taking the caveats on the implicit interest rate into account, our results for listed firms, not private firms, suggest that it is challenging to identify zombie firms empirically as firms with funding costs below benchmark risk-free rates, as in Caballero et al. (2008) and Acharya et al. (2019). Recent evidence on US firms indeed underscores the pitfalls of using subsidized interest rates to define zombie firms. For instance, Favara et al. (2022) show that banks charge a higher spread on bank loans to zombie firms, while also requiring more collateral relative to nonzombie firms. In addition, using the Federal Reserve's Y-14 data on detailed loan-level information, Faria-e-Castro et al. (2022) show that zombie firms pay relatively high interest rates, and higher than nonzombies. They show theoretically that interest rates for zombies could have been even higher if lenders' behavior had not been driven by evergreening incentives.

Overall, our results are broadly in line with McGowan et al. (2018), Banerjee and Hofmann (2022), and Favara et al. (2022). The only difference we have relative to McGowan et al. (2018) is about size: they find that zombie firms tend to be large. This stands at odds with our results

and with Altman et al. (2022), Banerjee and Hofmann (2022), and with Favara et al. (2022) for US firms. Differences in country coverage and in the zombie definition—McGowan et al. (2018) condition on an ICR below one for three years and older than ten years— may explain part of the differences in the incidence of zombification across the firm size spectrum, as older firms tend to be larger. In addition, McGowan et al. (2018) show unconditional non-parametric descriptive statistics of zombie firms, while we compare zombie firms to nonzombies in the same country and industry.

3.4 Evolution of balance sheets of zombies

We follow closely Banerjee and Hofmann (2022) and track the evolution of several balance sheet indicators before and after a listed firm enters the zombie status relative to healthy firms. Specifically, we estimate the following regression:

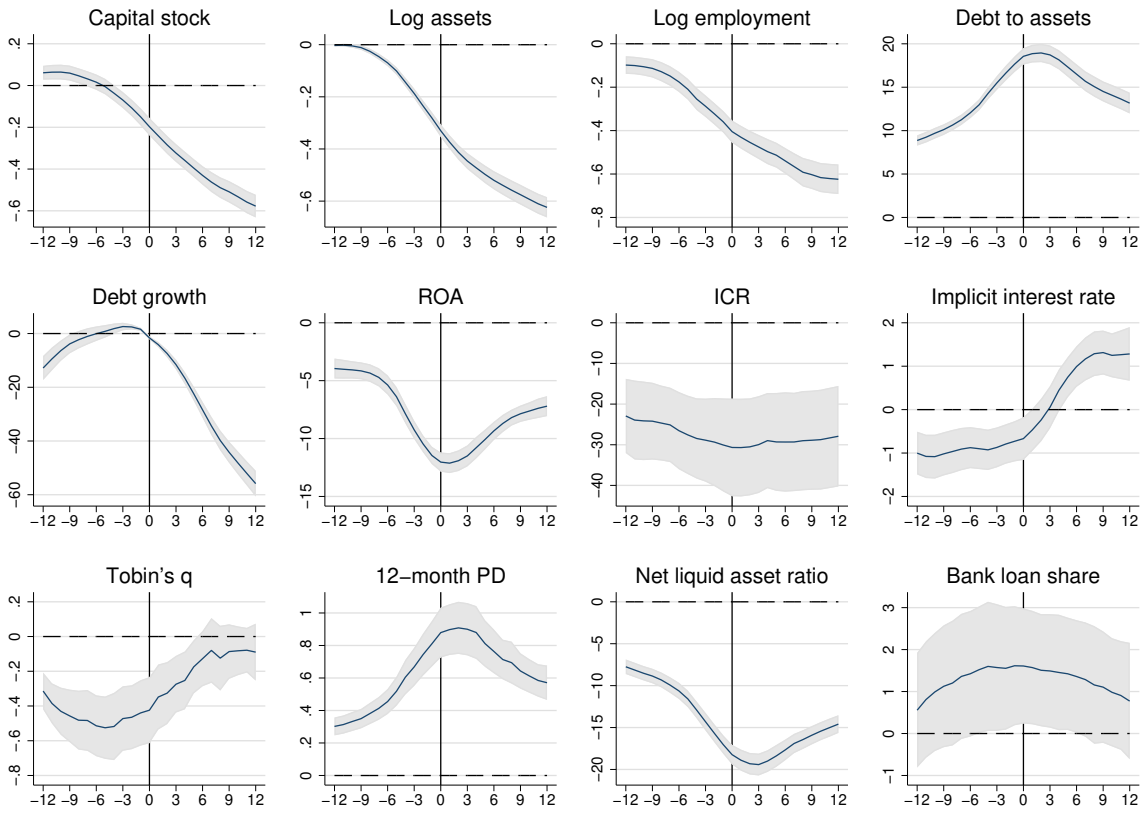
$$Y_{i,c,n,t+h} = \beta^h \text{Newzom}_{i,c,n,t} + \delta^h \text{Oldzom}_{i,c,n,t} + \lambda^h X_{i,c,n,t-20} + \zeta_{c,n,t+h} + \epsilon_{i,c,n,t+h}, \qquad (2)$$

where the *Newzom* dummy takes the value of one if a firm becomes zombie at t=0, while *Oldzom* takes the value of one if the zombie firm had already been classified as such in t-1. Our coefficient of interest is then β^h, which captures the difference between new zombies and nonzombies in selected balance sheet variables from horizons t-12 to t+12 quarters. In addition, the inclusion of country-industry-quarter fixed effects means that we compare new zombies to healthy firms in the same country-industry pair and for each quarter. We cluster the standard errors at the country-industry level. To deal with a possible survivorship bias in the comparison of the dynamics of firms' performance arising from 'bad' firms dropping out from the sample, we follow Banerjee and Hofmann (2022) and focus only on firms that are still alive in t+12.

Figure 4 shows that the balance sheets of firms that become zombies at t=0 typically look weaker than nonzombies already three years before entering the zombie status. In fact, the performance of new zombies deteriorates considerably several quarters before they become zombies, as indicated by the ROA, and the ICR, amid lower growth opportunities (Tobin's q). At the same time, zombie firms start reducing their capital stock, assets, including net liquid assets, and employment two to three years before becoming zombies. By contrast, the debt-to-asset ratio is on an upward trend, mostly reflecting the shedding of assets. The probability of default of the new zombie starts to increase in the preceding three years before zombification, as finan-

cial markets price in the perceived increasing risk. Interestingly, the cost of debt, proxied with the implicit interest rate, is estimated to be lower for zombies before entering the zombie status, suggesting that easy financing conditions may also be a contributing factor of zombification.

Figure 4: Dynamics of balance sheet variables before and after zombification: listed firms



Notes: The blue line is the average difference in selected variables between firms that become zombies at time t=0 and nonzombies. The grey area is the 95 percent confidence bands from the standard errors clustered at the country-industry level.

After entering the zombie status, we only find some tentative evidence for a very gradual recovery in new zombies' financial performance. For instance, the ROA, the Tobin's q, the probability of default, and the debt-to-assets improve to some extent—supported by a large fall in debt growth—relative to zombies. These results are not surprising at face value, on the back of markets' and investors' increased expectations about a successful recovery of zombies as time passes. But it is noteworthy that zombies' financial performance still remains well-below the one of nonzombies after three years.[20] In addition, the gap between zombies and nonzombies in the capital stock, total assets, and employment continues to widen over time. Finally, zombies' cost of debt goes above the one of nonzombies, suggesting a repricing of risk from lenders.

[20] We find similar results on annual data for private firms.

3.5 What explains cross-country differences in the share of zombie firms?

In this section we shed more light on cross-country specificities that may explain the large heterogeneity in the share of zombie firms across countries. The literature had found that the development of the high-yield market and differences in creditor rights and debt enforcement efficiency explain a large fraction of cross-country differences in the share of zombie firms in a sample of 20 (mostly) advanced economies (Altman et al., 2022). Moreover, the number of zombie firms tends to be higher in countries with weak insolvency regimes, especially if coupled with weak banks (McGowan et al., 2018; Andrews and Petroulakis, 2019), and during downturns (Becker and Ivashina, 2022).

We run the following panel regression at the country level to investigate which variables correlate with a higher share of zombie firms:

$$ZShare_{c,t} = \lambda X_{c,t} + \alpha_c + \zeta_t + \epsilon_{c,t}, \tag{3}$$

where $ZShare_{c,t}$ is the asset-weighted zombie share for each country c and year t. α_c are country fixed effects, ζ_t capture unobserved time-varying shocks, and $X_{c,t}$ includes the following country-level covariates: (i) low-interest rate environment for each country, captured with a dummy variable that takes the value of one when the country-specific three-month interest rate is below the median of its distribution; (ii) real GDP growth; (iii) the share of small firms (firms with total assets under $50 USD million for listed firms); (iv) the share of micro firms (firms with total assets under $2 USD million for private firms); (v) the share of young firms (firms below the median sample age); (vi) tight iMaPP, which takes the value of one for periods when the overall macroprudential stance for each country is above its own sample median distribution;[21] and (vii) and the interaction of the iMaPP with Araujo et al. (2022)'s crisis preparedness indicator along several percentiles.

Our main results suggest that countries with tighter macroprudential policies tend to be associated with fewer zombie firms (Table 3). In addition, we find that countries with tighter macroprudential (columns 3 and 7) but with less-prepared insolvency regimes—as seen in the interaction term of the iMaPP with a dummy for the Araujo et al. (2022)'s crisis preparedness indicator below the median—tend to actually be associated with a larger number of zombie

[21] We transform all 17 macroprudential indices from the IMF's iMaPP database into cumulative terms for each country and quarter taking the beginning of the dataset in 1990 as the starting point.

firms. This suggests that tighter macroprudential policies should be accompanied by strong and well-prepared corporate insolvency frameworks. We also find some evidence that periods of low economic growth tend to be associated with a rise in zombie shares, but this seems to be the case only in the sample of private firms. Moreover, we also find some support for the conjecture that a period of low interest rates may have contributed to the creation of zombie firms, in line with Altman et al. (2022), as cheap credit and unconventional policies may have stimulated risk-taking. By contrast, we do not find that age is relevant to determine the incidence of zombification, which contrasts with McGowan et al. (2018) who condition zombie firms on being ten or more years old.[22]

Table 3: Determinants of country zombie shares

	Listed firms				Private firms			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Low int. rate	0.355	0.303	0.258	0.232	0.889***	0.582*	0.650**	0.599*
	(0.228)	(0.237)	(0.237)	(0.239)	(0.299)	(0.330)	(0.319)	(0.324)
ΔGDP	-0.163**	-0.009	-0.001	-0.014	-0.290***	-0.201**	-0.206**	-0.203**
	(0.097)	(0.099)	(0.098)	(0.098)	(0.077)	(0.084)	(0.087)	(0.084)
Small firms share	0.136***	0.119***	0.112***	0.107***				
	(0.023)	(0.030)	(0.029)	(0.027)				
Micro firms share					-0.045**	-0.072**	-0.066**	-0.070***
					(0.021)	(0.028)	(0.026)	(0.027)
Young firms share	-0.011	0.002	-0.010	0.003	0.023	0.028	0.011	0.027
	(0.011)	(0.013)	(0.014)	(0.013)	(0.018)	(0.021)	(0.018)	(0.020)
Tight iMaPP	-0.655**	0.231	-0.328	0.820***	-1.155***	-0.716*	-0.015	0.905*
	(0.278)	(0.334)	(0.392)	(0.271)	(0.347)	(0.402)	(0.420)	(0.509)
Tight iMaPP×insolvency<p25		-0.277		-0.552		0.362		0.502
		(0.571)		(0.576)		(0.660)		(0.726)
Tight iMaPP×insolvency<p50			1.262***				1.768***	
			(0.374)				(0.645)	
Tight iMaPP×insolvency>p75				-2.306***				-0.574
				(0.662)				(0.569)
Country FE	✓	✓	✓	✓	✓	✓	✓	✓
Time FE	✓	✓	✓	✓	✓	✓	✓	✓
No. countries	34	27	27	27	30	24	24	24
Observations	2,287	1,946	1,946	1,946	550	439	439	439
Adjusted R^2	0.460	0.454	0.457	0.462	0.511	0.512	0.523	0.512

Notes: See the main text for the full definitions. Standard errors in parentheses clustered by country-time. Asterisks, *, **, and ***, denote statistical significance at the 10%, 5%, and 1% levels.

There is one noteworthy difference between listed and private firms regarding size. We find that countries with a larger share of small listed firms are associated with a greater share of zombie firms, while we find the opposite for micro private firms. Part of this result can be explained by differences in the definition: 'small' listed firms (over $50 USD million in assets) are not small in the sample of private firms (the median private firm has $0.750 USD million in assets), so the results are not strictly comparable. In addition, and as we have discussed before,

[22] Our results remain qualitatively unchanged when using additional controls, such as inflation, the REER, the current account balance as a percentage of GDP, and the Chinn-Ito index, which measures a country's degree of capital account openness, i.e. the higher the index the more financially opened a country is (Chinn and Ito, 2006). On the latter one, we find a negative and statistically significant coefficient, pointing to financial openness of a country playing an important role in reducing the number of zombie firms, possibly as greater openness may stimulate more competition between firms.

private firms exhibit significantly higher exit rates, which can explain that more vulnerable (micro) firms are be less likely to become zombie firms.

4 Congestion effects from zombification

4.1 Intensive margin

In a perfectly competitive market, and without any distortions in the banks' and investors' incentives, zombie firms would normally exit the market. This would allow the remaining healthy firms to operate more efficiently, while promoting the entry of new productive firms. In this paper, we have shown, however, that zombification is quite persistent, and the mean duration a firm remains zombie has been steadily climbing, particularly since the GFC.

The literature has found that the presence of zombie firms generates important negative spillovers to, or congestion effects on, healthy firms, weighing on their productivity and growth (Peek and Rosengren, 2005; Caballero et al., 2008; McGowan et al., 2018; Acharya et al., 2019; Banerjee and Hofmann, 2022). These spillovers amount to economic inefficiencies or misallocation of resources away from healthy firms. By keeping zombie firms alive, banks can create distortions in the economy through congestion effects in the markets or industries where zombie firms operate. These congestion effects can materialize in increased competition for input goods and excessive supply of goods; lower market prices for healthy firms' products, and higher market wages, as low-productivity workers from zombie firms crowd the market. Overall, by not exiting the market, the survival of zombie firms reduces the profits of productive and healthy firms, and thus their investment and growth opportunities.

Our contribution to the literature is as follows. First, we extend the analysis of congestion effects to nonzombies' credit conditions. Second, we trace out the dynamics of congestion effects over time, trying to assess the short- to medium-run effects. Third, in the next section we explore congestion effects through the extensive margin, i.e. how the presence of zombie firms may weigh on the probability of a firm exiting the market, or discourage new entrants. Fourth, in Section 5 we investigate whether strengthening banks, a tighter macroprudential stance, and more-prepared corporate insolvency frameworks can alleviate these negative spillover effects.

We follow Caballero et al. (2008)'s seminal paper and run the following firm-level regression:

$$Y_{i,c,n,t} = \beta_1 \text{NZ}_{i,c,n,t} + \beta_2 \text{NZ}_{i,c,n,t} \times \text{ZShare}_{c,n,t} + \lambda X_{i,c,n,t} + \alpha_i + \zeta_{c,n,t} + \epsilon_{i,c,n,t}, \tag{4}$$

where our main coefficient of interest β_2 is given by the interaction of the nonzombie dummy with the two-digit GICS asset-weighted industry zombie share ($ZShare_{c,n,t}$). This coefficient indicates the change in the nonzombies' performance of indicator Y relative to zombies as the share of zombie firms increases in each country-industry pair. A negative coefficient indicates a congestion effect, whereby the presence of zombie firms leads to a reduction in, say, nonzombies' investment or employment relative to zombies in the same country-industry. We add firm fixed effects α_i to control for permanent differences between firms, and country-sector-time fixed effects $\zeta_{c,n,t}$ to absorb all country-industry time-varying shocks that may differentialy affect firms. We thus restrict our comparison to firms within each country-industry pair and for each quarter. We include in $X_{i,c,n,t}$ the log of total assets to control for size, and the net liquid asset ratio to control for the amount of liquidity firms have at their disposal to mitigate shocks.

Table 4 shows evidence of congestion effects to nonzombies as the industry share of zombies increases, for both listed firms (Panel A) and private firms (Panel B). Specifically, healthy firms in industries with a higher share of zombie firms experience a reduction in their investment growth, both tangible and intangible, employment, sales, and TFP relative to zombie firms in the same industry. This is suggestive of zombie firms crowding out profits of healthy firms by competing for inputs and by having an excess supply of goods in a particular industry. Our results are economically important. For instance, a one-standard deviation increase in the zombie share of an industry (amounting to 11.8 p.p. for listed firms, and 8.7 p.p. for private firms) is associated with lower investment growth of 0.26 p.p. and lower employment growth of 0.35 p.p. for listed nonzombies. For private nonzombie firms the respective effects are -1.24 p.p. for investment growth and -0.44 p.p. for employment growth. These are sizeable economic effects: for instance, they account respectively for roughly 32 percent and 16 percent of listed nonzombies' average sample investment growth and employment growth.[23]

[23] We find that congestion effects are not sensitive to the zombie definition used. As an example, we estimate the congestion effects on investment growth of listed firms for a set of alternative zombie definitions used in the literature. We show in Table D.1 in Appendix D that our baseline results remain qualitative similar. The only exception is the one that relies on subsidized interest rates from Acharya et al. (2019), as congestion effects are estimated less precisely. This contrasts with Acharya et al. (2022) who find that congestion effects are only present for US listed firms in definitions that use a concept of subsidized credit. Moreover, we also do not find that our results are sensitive to accounting for a more granular industry classification, specifically by taking the four-digit GICS (Table D.3).

What is less discussed in the literature is the effect of the presence of zombies on credit conditions for the healthy firms. One of the exceptions is Andrews and Petroulakis (2019). This paper finds, on a sample of four large euro area countries, that credit is less available for healthy firms that operate in industries with a higher share of zombie firms. The sample period is, however, short (2009-2013), and the coverage of firms limited, which raises questions about extrapolating their findings to other settings. When we use the change in the real stock of debt as a proxy for credit growth, we find that congestion effects also materialize in lower credit for healthy listed and private firms (column 7). This is in line with evergreening motives. By extending credit to zombie firms, to avoid recognizing the losses in their balance sheets, banks may have less scope to lend to healthy firms, which ultimately create a misallocation of credit away from healthy firms that operate in industries with a higher share of zombie firms. This misallocation only seems to affect the supply of credit, and not its price, as evidenced by a statistically insignificant coefficient on the implicit interest rate (column 6).

Table 4: Contagion effects from zombies to nonzombies

Panel A: listed firms

	(1) ΔK	(2) ΔIntan	(3) ΔEmp	(4) ΔSales	(5) TFP	(6) Int.rate	(7) ΔDebt
Nonzombie	1.690***	2.713***	6.701***	2.752***	0.233***	-0.620***	3.692***
	(0.056)	(0.078)	(0.132)	(0.082)	(0.006)	(0.099)	(0.118)
Nonzombie× zombie share	-0.015***	-0.032***	-0.027***	-0.033***	-0.001*	0.009	-0.018**
	(0.004)	(0.006)	(0.010)	(0.006)	(0.000)	(0.010)	(0.008)
Controls	✓	✓	✓	✓	✓	✓	✓
Firm FE	✓	✓	✓	✓	✓	✓	✓
Country×Industry×Time FE	✓	✓	✓	✓	✓	✓	✓
Observations	1,660,513	1,307,290	912,962	1,321,498	737,488	1,216,135	1,604,197
Adjusted R^2	0.205	0.195	0.305	0.195	0.028	0.400	0.044

Panel B: private firms

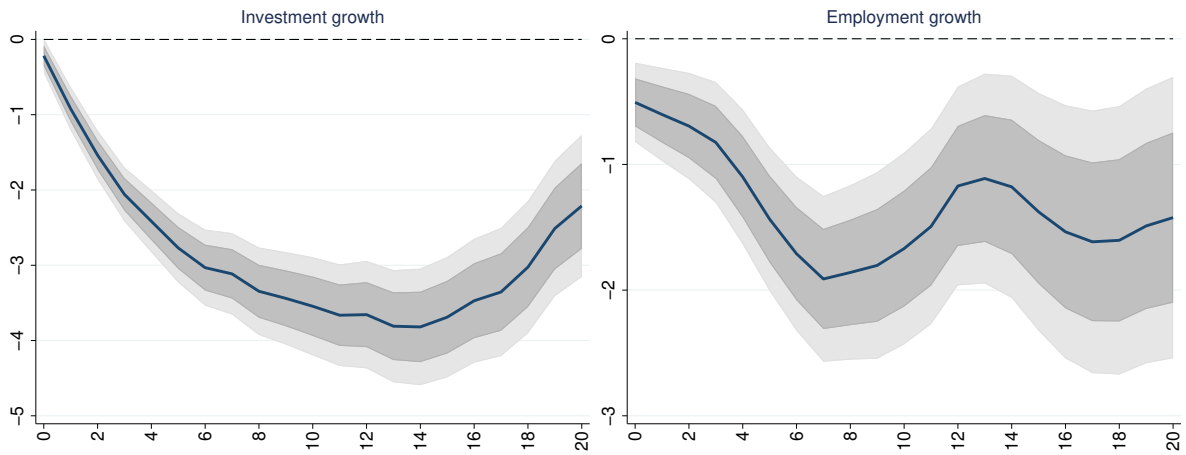
	(1) ΔK	(2) ΔIntan	(3) ΔEmp	(4) ΔSales	(5) TFP	(6) Int.rate	(7) ΔDebt
Nonzombie	7.810***	6.781***	6.768***	9.001***	0.187***	6.732***	7.855***
	(0.164)	(0.279)	(0.158)	(0.354)	(0.005)	(0.494)	(0.356)
Nonzombie×zombie share	-0.139***	-0.021	-0.042**	-0.226***	-0.004***	-0.172***	-0.328***
	(0.022)	(0.028)	(0.017)	(0.042)	(0.001)	(0.044)	(0.042)
Controls	✓	✓	✓	✓	✓	✓	✓
Firm FE	✓	✓	✓	✓	✓	✓	✓
Country×Industry×Time FE	✓	✓	✓	✓	✓	✓	✓
Observations	34,429,627	17,641,297	20,738,701	35,287,208	19,527,363	25,968,191	24,828,102
Adjusted R^2	0.093	0.055	0.021	0.089	0.016	0.521	0.003

Notes: Each column represents a different regression. Dependent variables are: the log percentage change in real tangible capital stock (ΔK), log percentage change in real intangible investment (ΔIntan), log percentage year-on-year change in employment (ΔEMP), log percentage change in real sales (ΔSales), Total Factor Productivity (TFP), implicit interest rate (Int.rate), and log percentage change in real total debt (ΔDebt). Control variables not reported. Standard errors in parentheses clustered by country-industry-time. Asterisks, *, **, and ***, denote statistical significance at the 10%, 5%, and 1% levels.

We find that congestion effects on healthy firms seem to come mainly from zombie firms, rather from financially constrained firms who are profitable. To capture distressed firms that are not zombies, we select firms that meet the first two requirements of zombie firms, namely an ICR below one and a debt ratio above the median peers for two consecutive years, but with positive sales growth. In this context, the only difference between these distressed nonzombies and zombie firms is profitability, as measured with sales growth. We then add one additional interaction term with the share of distressed nonzombies to Table D.2 in Appendix D. Our results show that congestion effects originate mostly from zombie firms. The evidence of congestion effects stemming from distressed nonzombies is less clear, with most of the coefficients turning out not significant (only intangible investment and employment seem to be affected). All in all, we find convincing results that the presence of unprofitable and unviable firms are harmful for the overall financial performance of healthy firms operating in the same industry.

To check the persistence of the congestion effects, we use Jordà (2005)'s local projections and run several regressions of Equation (4) for horizons up to 20 quarters ahead (for listed firms) and up to five years (for private firms). Using investment growth and employment growth as dependent variables, we find that that congestion effects are quite persistent over time (Figures 5 and 6). Our results show similar effects for private and listed firms: healthy firms that operate in industries with a one-standard deviation higher zombie share experience on average lower investment and employment growth of up to 2-4 p.p. over the medium term.

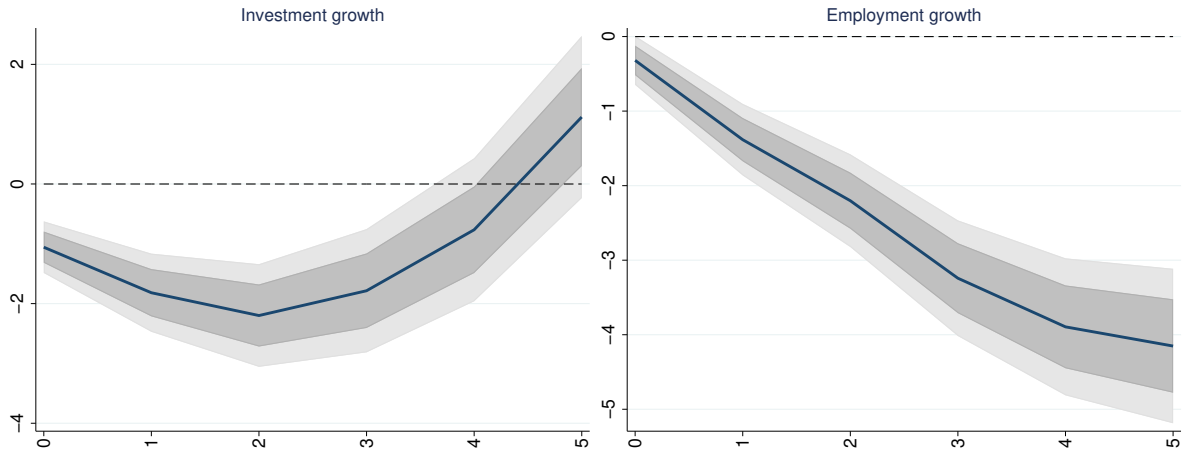
Figure 5: Dynamics of nonzombies' investment and employment in industries with a higher zombie share: listed firms



Notes: Cumulative impulse responses over 20 quarters of nonzombies' investment growth and employment growth to a one-standard deviation increase in the industry asset-weighted share of zombie firms. The blue line is the average response, while the dark (light) grey areas refer to the associated 68 (90) percent confidence bands.

We end this section with the investigation of possible nonlinearities in the congestion effects.

Figure 6: Dynamics of nonzombies' investment and employment in industries with a higher zombie share: private firms



Notes: Cumulative impulse responses over five years of nonzombies' investment growth and employment growth to a one-standard deviation increase in the industry asset-weighted share of zombie firms. The blue line is the average response, while the dark (light) grey areas refer to the associated 68 (90) percent confidence bands.

First, we find that congestion effects have become more prominent since the GFC, specifically for investment and sales growth of nonzombies (Figure D.4).[24] This suggests that deep recessions accompanied by financial crises, together with substantial policy support (both fiscal and monetary), may have played a role in amplifying the negative spillovers from zombie firms to healthy firms (McGowan et al., 2018; Banerjee and Hofmann, 2022). Second, we find mixed results on the differences in congestion effects between AEs and EMs (Figure D.5). For instance, congestion effects seem to be stronger for EMs when assessing the impact on nonzombies' intangible investment growth, sales growth, and interest rates, but seem smaller when looking at TFP, and debt growth. This suggests that evergreening incentives and spillover effects from zombie firms are a global phenomenon (Albuquerque and Mao, 2023).[25]

4.2 Extensive margin

We have assessed the congestion effects so far through the intensive margin, i.e. how the concentration of zombie firms may affect healthy firms' financial performance conditional on survival. In this section, we document important congestion effects also through the extensive margin: how the prevalence of zombie firms may affect the exit of healthy firms that compete in the same industry, and/or discourage new firms from entering the market.

[24] We augment Equation 4 with a post-GFC dummy (2008Q1 onwards), and its interaction with $NZ_{i,c,n,t} \times ZShare_{c,n,t}$.

[25] Our baseline congestion effects arising from the prevalence of zombie firms are not limited to within-industry effects. When we remove industry fixed effects, allowing us to compare spillovers *between* industries within the same countries, we find similar results to the baseline. Results available upon request

Since we do not observe firm closures or bankruptcies, we compute a firm exit dummy that takes the value of one in the last quarter (or year in ORBIS) in which the firm last reports its balance sheet. Similarly, the entry dummy takes the value of one in the first quarter (or year in ORBIS) in which the firm first reports its balance sheet. One of the caveats of our measure is that an exit in Compustat or ORBIS may not necessarily reflect a firm filling for bankruptcy or closing its activity. For listed firms, an exit may reflect a firm being delisted, while for private firms it may be the opposite, i.e. a private firm going public.[26]

We first run Equation 4 but with the exit dummy as the dependent variable (multiplied by 100 to facilitate the interpretation of the coefficients). We run the estimation until 2019 for listed firms, and until 2018 for private firms, as the lack of balance sheet data after this period may not necessarily mean that a firm has exited the market due to reporting lags. First, we find that nonzombies tend to be less likely than zombie firms to exit the market (first row in Table 5). This is something we have seen previously in Figure 2. Second, we find that industries with a higher share of zombie firms tend to drive healthy firms out of the market compared to industries with a lower share of zombie firms. We find quantitatively stronger effects for private firms, which tend to exhibit significantly higher exit rates than listed firms.

Table 5: Congestion effects: probability of exit of healthy firms

	(1) Listed	(2) Private
Nonzombie	-0.218***	-7.992***
	(0.028)	(0.226)
Nonzombie×zombie share	0.004**	0.067***
	(0.002)	(0.024)
Controls	✓	✓
Country×Industry×Time FE	✓	✓
Observations	1,536,524	36,735,014
Adjusted R^2	0.012	0.097

Notes: Dependent variable is firm exit, measured as dummy variable times 100 to facilitate the interpretation of coefficients. Control variables not reported. Standard errors in parentheses clustered by country-industry-time. Asterisks, *, **, and ***, denote statistical significance at the 10%, 5%, and 1% levels.

In a second exercise, we aggregate the data at the industry level for both listed and private firms. This allows us to also assess the spillovers from zombie firms on the dynamics of entry rates. We compute exit (entry) rates at the industry level by dividing the number of exits (entries) in each period and within each industry as a proportion of the total number of firms

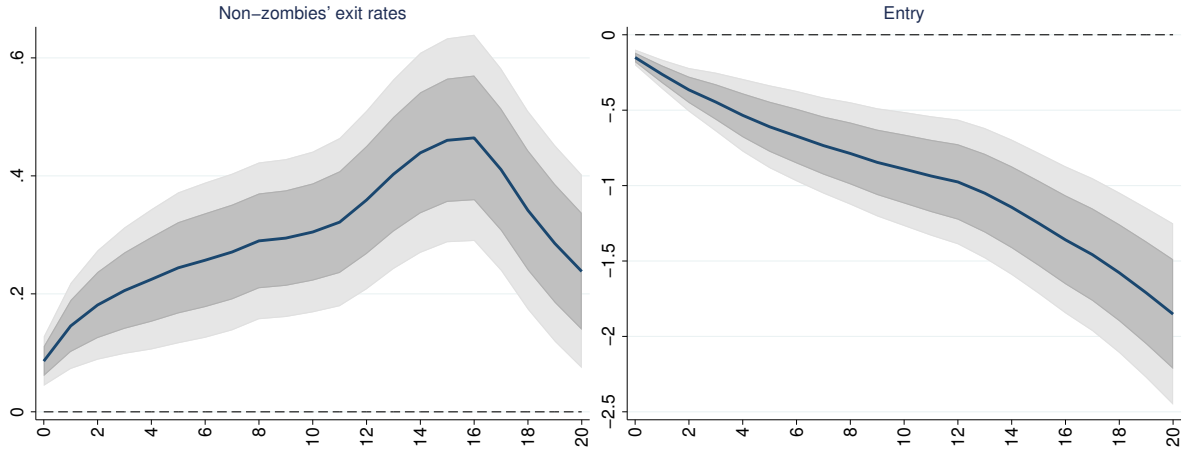
[26] We exclude most of the potential mergers and acquisitions by dropping observations when acquisitions are larger than 5 percent of total assets.

in that industry. We use Jordà (2005)'s local projections methods and run separate regressions for each horizon h=0, 1,. . . , 20 quarters (h=0, 1,..., 5 years for private firms):

$$Y_{c,n,t+h} = \beta^h \text{ZShare}_{c,n,t} + \lambda^h X_{c,n,t} + \alpha_n^h + \zeta_t^h + \epsilon_{c,n,t+h}, \tag{5}$$

where $Y_{c,n,t+h}$ represents the cumulative entry or exit rates at the industry level, obtained by summing up entries or exits up to $t+h$ periods ahead, and dividing them by the total number of firms at time t. We fix the denominator at time t to avoid spurious relationships that would arise if we were to just accumulate entry/exit rates, as a large number of exits (entries) would decrease (increase) the denominator and thus mechanically increase (decrease) future entry (exit) rates. The coefficient of interest β^h gives us the relationship between an increase in zombie shares and entry/exit rates. We caution that our reduced-form regression cannot be interpreted as causal. But the inclusion of industry fixed effects α_n^h, to control for industry-specific characteristics, and time fixed effects ζ_t^h, to control for aggregate shocks, act to minimize confounding factors. Similarly to Equation (4), $X_{c,n,t}$ includes the log of total assets to proxy for industry size, and the net liquid asset ratio to proxy for industry's liquidity position.[27]

Figure 7: Congestion effects: exit and entry rates at the industry-country level: listed firms



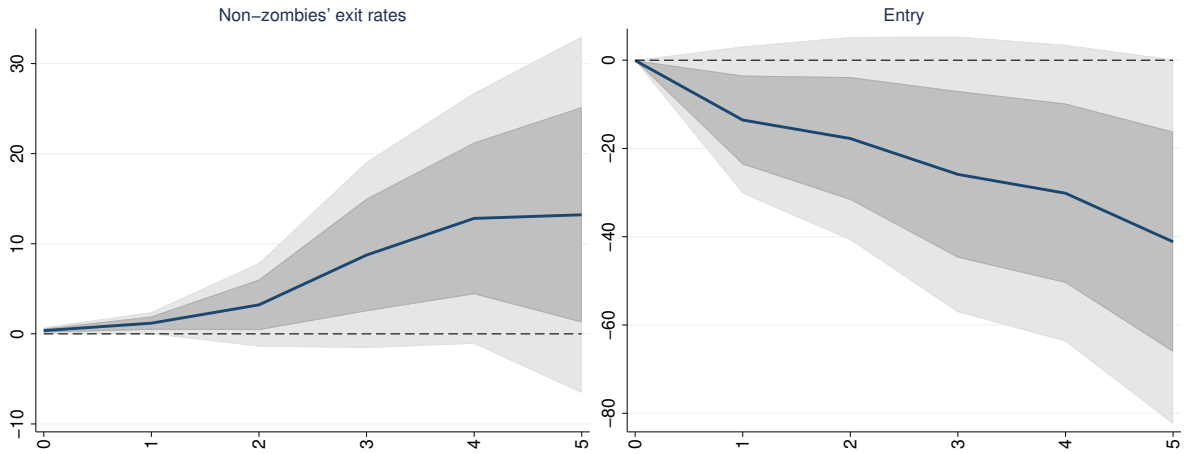
Notes: Cumulative impulse responses over 20 quarters of nonzombies' exit rates and entry rates of all firms to a one-standard deviation increase in the industry asset-weighted share of zombie firms. Blue lines and dark (light) grey areas refer to the average response of exit and entry rates and associated 68 (90) percent confidence bands.

We find that industries with a greater share of zombie firms tend to affect the industries' creative destruction process. Firm entry rates tend to be lower, presumably because new entrants may need to clear a higher productivity bar or threshold to compensate for depressed market prices and high wages, and healthy firms tend to exit the market at a higher rate rela-

[27] We compute industry-level controls for each country through a bottom-up aggregation of all firms' total assets or net liquid assets in the respective industry and within each country.

tive to industries with lower industry shares (Figure 7 for listed firms and Figure 8 for private firms). In particular, we find that industries that stand at a one-standard deviation above the zombie share mean experience greater exit rates of healthy firms, in the order of 0.4 p.p. over the medium term for listed firms, and roughly 10 p.p. for private firms, although the latter estimates are surrounded by large uncertainty. Moreover, we find that these effects are larger since the GFC (Figure C.21 in Appendix C).[28]

Figure 8: Congestion effects: exit and entry rates at the industry-country level: private firms



Notes: Cumulative impulse responses over 20 quarters of nonzombies' exit rates and entry rates of all firms to a one-standard deviation increase in the industry asset-weighted share of zombie firms. Blue lines and dark (light) grey areas refer to the average response of exit and entry rates and associated 68 (90) percent confidence bands.

5 Policies to address zombification

We have shown important congestion effects from zombie firms to healthy firms. An open question is about the role of policy to mitigate these negative spillover effects.

The literature has found stronger incentives of low-capitalized banks to evergreen zombie loans (Peek and Rosengren, 2005; Caballero et al., 2008). According to the evidence first found in Japan in the early-90s, weak banks faced incentives not to write off the credit granted to zombie firms as this would lead them to breach regulatory capital requirements. This relationship between weak banks and zombie lending seems to also have been at play in Europe in the aftermath of the GFC (Storz et al., 2017; Acharya et al., 2019; Andrews and Petroulakis, 2019; Schivardi et al., 2022).

To break the evergreening incentives facing banks, the literature has argued for tighter bank supervision and regulation to improve the health of the banking sector: (i) bank recapitaliza-

[28] We get similar results for the sample of private firms. Results available upon request.

tions to help remove banks' incentives to engage in risky behavior (Giannetti and Simonov, 2013; Acharya et al., 2021; Schivardi et al., 2022; Blattner et al., 2023); (ii) increase the number of unannounced on-site inspections (Bonfim et al., 2023); (iii) and perform credible stress testing exercises (Favara et al., 2022). Furthermore, well-prepared restructuring and bankruptcy laws for corporates may also help support the creative destruction process by facilitating the restructuring of zombie firms (Andrews and Petroulakis, 2019; Kulkarni et al., 2021; Altman et al., 2022; Araujo et al., 2022; Becker and Ivashina, 2022).

We investigate how congestion effects can be mitigated by: (i) higher regulatory capital buffers or lower NPLs; (ii) a tighter macroprudential stance to limit banks' zombie lending practices; and (iii) countries' preparedness to handle a large-scale restructuring of corporates. We contribute to this literature as follows. First, although the literature has studied the relationship between weak banks and zombies' performance (Storz et al., 2017; Acharya et al., 2019; Andrews and Petroulakis, 2019), it has not yet focused on how the health of the banking sector can mitigate the congestion effects on healthy firms that operate in industries populated by a large number of zombies.[29] Second, the role of macroprudential policies in mitigating the spillovers from zombies, to the best of our knowledge, has not yet been studied in the literature. And, third, we use a new indicator to capture how prepared a country is to deal with the restructuring of insolvent firms.

We use country-level data, given data limitations at a more granular level. We first use two indicators to proxy for the health of the banking sector: banks' non-performing loans (NPLs), and regulatory capital buffers, computed by taking the difference between the banks' actual regulatory capital to risk-weighted assets and the minimum required risk-based regulatory capital ratio. We then assess how macroprudential policies can affect the zombie congestion effects. Using the IMF's iMaPP database (Alam et al., 2019), we transform all macroprudential indices into cumulative terms for each country and quarter to have a better sense of their stringency: we follow Akinci and Olmstead-Rumsey (2018) and sum up the dummy indices for each instrument taking the beginning of the dataset in 1990 as the starting point. Our proxy

[29]The exceptions are Kulkarni et al. (2021), and Schivardi et al. (2022). The former studies the impact on Indian banks' probability of recognizing zombie borrowers as nonperforming from a new bankruptcy law in 2016, which was later combined with a regulatory intervention to limit banks' incentives to conceal zombies. They find that only when the regulatory intervention entered into force, did Indian banks, especially undercapitalized banks, increase the recognition of zombie lending as nonperforming. In turn, Schivardi et al. (2022) focus on Italian banks and firms during the GFC and the European sovereign debt crisis over 2008-2013. Although they find that low-capitalized banks were more likely to extend credit to zombie firms, while cutting credit to healthy firms, reducing the number of bankruptcies of weak firms during a severe economic recession may have helped to mitigate disruptions to supply chains and to aggregate demand externalities. This may explain their findings of limited negative spillovers from zombie firms to healthy firms, measured with the dispersion in TFP.

for the overall macroprudential stance is the sum of all the 17 macroprudential indicators.

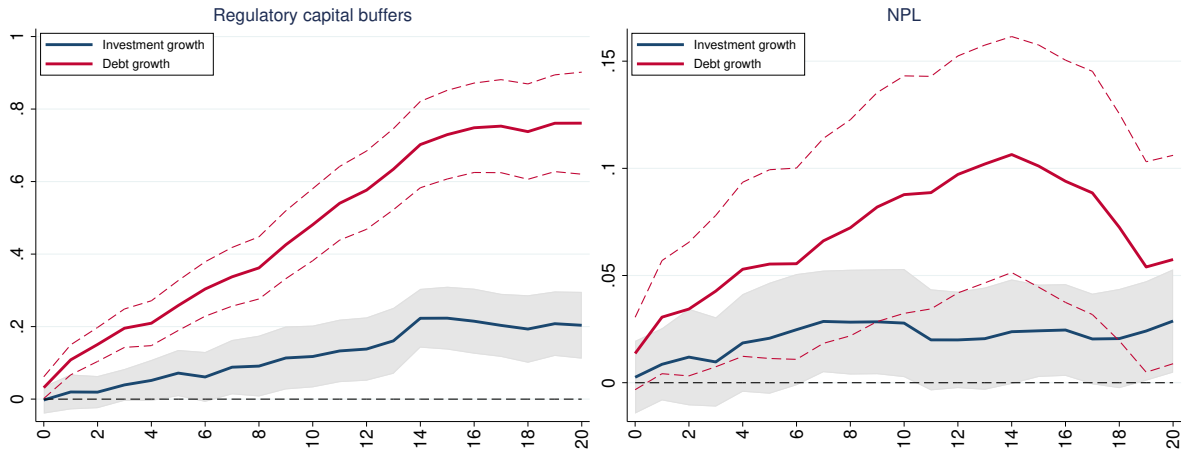
We expand Equation (4) with a triple interaction of the nonzombie dummy with the asset-weighted industry zombie share and with the country-level indicators ($I_{c,t}$) mentioned above, one at a time:

$$\begin{aligned} Y_{i,c,n,t} = &\beta_1 \text{NZ}_{i,c,n,t} + \beta_2 \text{NZ}_{i,c,n,t} \times \text{ZShare}_{c,n,t} + \beta_3 \text{NZ}_{i,c,n,t} \times \text{ZShare}_{c,n,t} \times \text{I}_{c,t} + \\ &\lambda X_{i,c,n,t} + \alpha_i + \zeta_{c,n,t} + \epsilon_{i,c,n,t}, \end{aligned} \tag{6}$$

where our main coefficient of interest β_3 indicates the marginal change in the congestion effects on nonzombies' performance vis-à-vis zombies as the share of zombies increases for countries that stand at a one-standard deviation above the sample in a particular indicator (capital buffers, NPL, or macroprudential stance). A positive coefficient suggests that improvements in bank health or in the macroprudential environment are able to mitigate the congestion effects we found in the previous section. To illustrate our point, we show the effects on investment and on debt growth for listed firms, which summarize the investment crowding-out effect and the misallocation of credit we have discussed previously. We focus on the sample of listed firms since the Compustat dataset matches the (quarterly) frequency of the country indicators, and overcomes the issue of annual data from ORBIS potentially masking important within-year changes in the country-specific bank indicators.

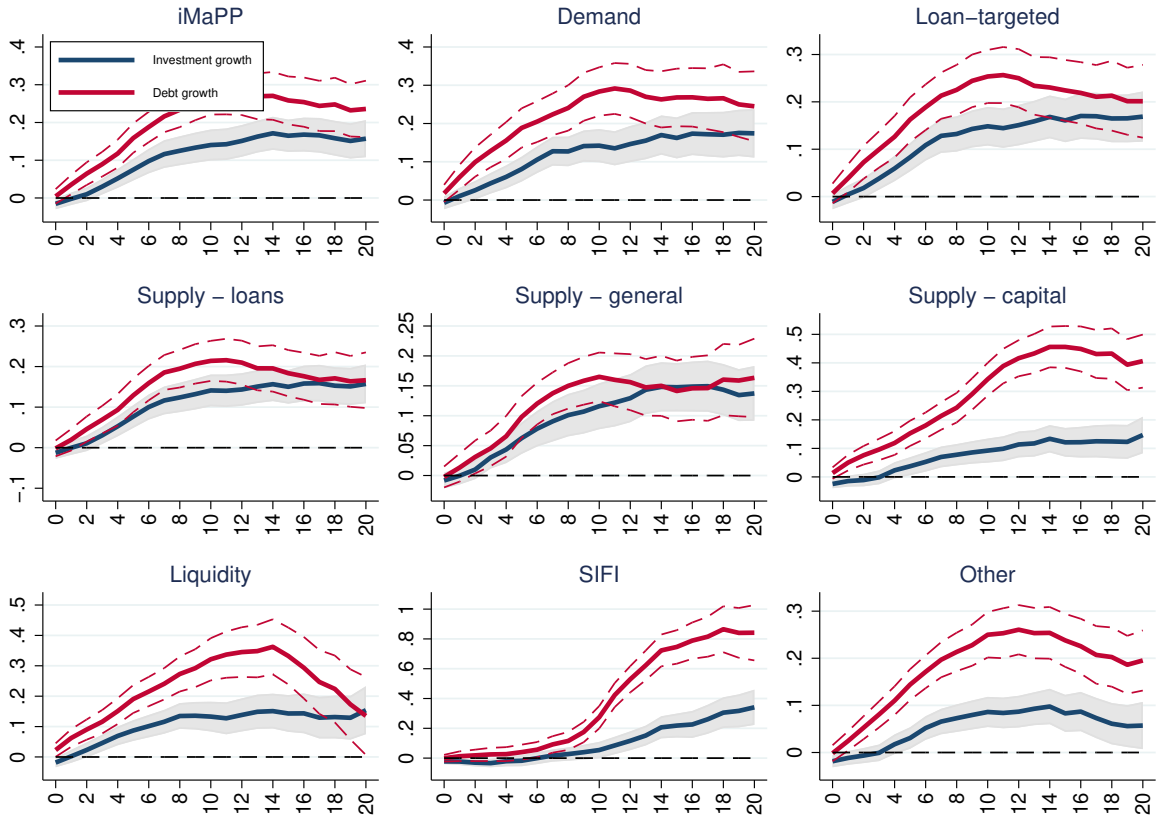
We find that congestion effects tend to be mitigated in countries with stronger banks and tighter macroprudential policies (Figures 9 and 10). Specifically, nonzombies that operate in countries with regulatory capital buffers that stand at a one-standard deviation above the sample mean tend to experience smaller falls in investment and debt growth relative to zombie firms (Figure 9). We get similar results when exploring cross-country differences in the banks' NPLs. These are economically important effects to reducing the congestion effects we estimated in Section 4: for instance, increasing banks' capital buffers by one-standard deviation would mitigate the congestion effects on nonzombies' investment growth by 0.2 p.p. after five years, which is roughly 10 percent of the estimated congestion effect from Figure 5. Moreover, we also find reduced congestion effects from tighter macroprudential policies, particularly actions that focus on constraints on credit supply, and on improving bank capital (Figure 10). We find similar results on the extensive margin; Figure C.22 in Appendix C shows the results when splitting the countries into tight and loose macroprudential stance, computed as countries below (above) the median sample of the iMaPP indicator.

Figure 9: Congestion effects: dynamics of nonzombies' investment and debt following an improvement in selected bank health indicators



Notes: Cumulative impulse responses of nonzombies' investment growth (blue line) and debt growth (red line) to a one-standard deviation increase (decrease) in the banks' regulatory capital buffer (NPLs) for a given zombie industry share. The grey area and dashed red lines are the 90 percent confidence bands.

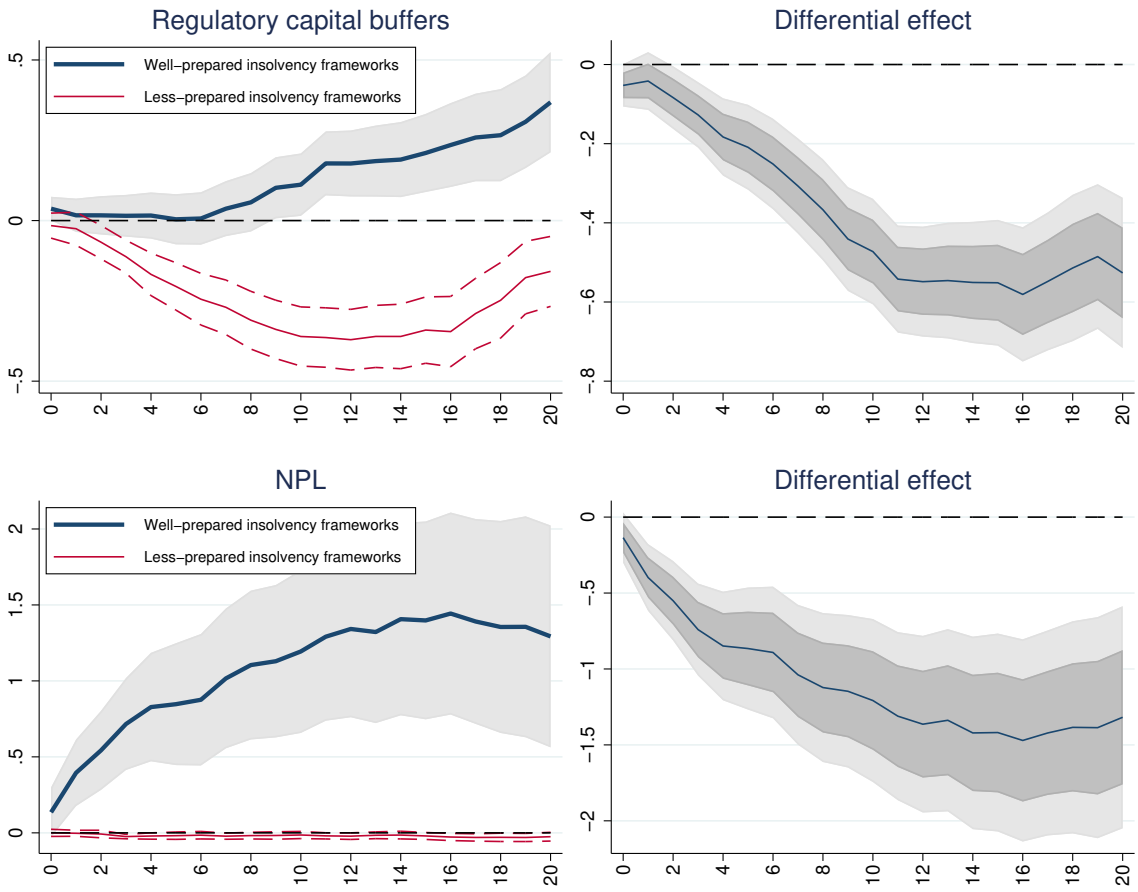
Figure 10: Congestion effects: dynamics of nonzombies' investment and debt following a tightening in selected macroprudential measures



Notes: Cumulative impulse responses of nonzombies' investment growth (blue line) and debt growth (red line) to a one-standard deviation tightening in selected macroprudential measures for a given zombie industry share. The grey area and dashed red lines are the 90 percent confidence bands.

Overall, evergreening incentives are mitigated when banks can absorb the losses from previous zombie lending, and the regulatory framework makes it more challenging for banks to window-dress their balance sheets (this in line with Albuquerque and Mao, 2023, who use the same dataset to find that global congestion effects driven by US monetary policy tighening can be mitigated by a tighter macroprudential framework). But strengthening the banking sector may, however, not be a sufficient condition to mitigating the congestion effects if the existing frameworks to deal with the restructuring or insolvency of zombie firms are weak and costly for the lenders. In this scenario, the bank would face a lower expected recovery value of the debt the zombie firm owed them, potentially promoting evergreening incentives even more.

Figure 11: Congestion effects: dynamics of nonzombies' investment following an improvement in selected bank health indicators for well- and less-prepared insolvency regimes



Notes: Cumulative impulse responses of nonzombies' investment growth to a one-standard deviation increase (decrease) in banks' regulatory capital buffer (NPLs) for a given zombie industry share. Left panels: solid blue (red) line with the respective 90 percent confidence bands refer to the average response for well-(less-)prepared insolvency frameworks, computed as countries above (below) the median sample of the Araujo et al. (2022) crisis preparedness indicator. Right panels: dark (light) grey areas refer to the 68 (90) percent confidence bands of the difference between less- and well-prepared insolvency regimes.

We investigate this more formally by comparing the differential effect of an improvement in banks' health on the congestion effects, conditional on the preparedness of insolvency regimes.

Specifically, we augment Equation (6) with another interaction term capturing cross-country differences in the insolvency frameworks for firms. In particular, we use the crisis preparedness indicator from Araujo et al. (2022), which measures countries' preparedness to handle a large-scale restructuring of corporates. We define a dummy variable that takes the value of one for countries with well-prepared insolvency frameworks, i.e. that stand above the sample median of the indicator, and zero otherwise, which we will call less-prepared insolvency frameworks. In Figure 11 we show that strengthening banks' regulatory capital buffers (or decreasing NPLs) may not be enough to mitigating the congestion effects from zombie lending if the insolvency frameworks in place are weak and costly. We find that healthy firms' investment growth does not improve in countries with less-prepared frameworks (shown by the red lines) when the regulatory capital buffer increases or banks' NPLs fall; only in countries with well-prepared insolvency frameworks (solid blue line). We find similar results when using debt growth as the dependent variable (Figure C.23 in Appendix C, or when using macroprudential measures (Figure C.24 to Figure C.27).

6 Conclusion

In this paper we build a new dataset of listed and private nonfinancial zombie firms for a large set of AEs and EMs over the last two decades. Using a definition of zombie firms based on financial distress and profitability indicators, we find that the number of zombie firms has been rising worldwide, especially since the GFC. After a temporary decline in zombification between 2016 and 2019, we show that the upward trend has resumed during the Covid-19 pandemic.

In novel results, we show that the share of zombies among private firms is lower than the one for listed firms. This apparent surprising result can be rationalized by lower survival rates of private firms relative to listed firms, which brings down the rates of zombification.

We further contribute to the literature by studying the macrofinancial spillover effects of zombie firms to nonzombies operating in the same industry and country. In line with the literature, we find that nonzombies in industries with a greater number of zombie firms tend to experience lower TFP, investment and employment growth. But we also show that credit supply to nonzombies that compete with zombie firms is reduced, echoing the research findings from Japan's lost decade. In addition, we document important findings along the extensive margin: nonzombies in industries populated with a higher number of zombie firms tend to exit

the market at a faster rate, and entry rates are lower.

We find these congestion effects to be quite persistent, indicating that zombie firms may cast a long shadow on the economy. To mitigate these negative spillover effects, we find that countries with higher regulatory capital buffers or lower NPLs, tighter macroprudential policies, or policies that minimize banks window-dressing their balance sheets, are typically associated with lower zombie shares and with stronger nonzombies. Improving the banking sector may, however, not be sufficient if insolvency frameworks are not well-prepared to deal with the restructuring or insolvency of firms.

Overall, the increased zombification in the world economy is associated with important trade-offs for policymakers. On the one hand, public support, including credit guarantees and forbearance, may be important to reduce insolvencies in the short term, and contain the collapse in aggregate demand during periods of large financial shocks. But, on the other hand, untargeted policy support combined with lax macroprudential and supervisory measures and deficient insolvency frameworks may delay a necessary creative destruction with negative consequences for long-term productivity growth.

Appendix A: Sample selection and variable definitions – Compustat

We use quarterly data on nonfinancial listed corporations for 63 countries, 32 EMs and 31 AEs, from S&P Compustat North America and Compustat Global. Our final sample covers an unbalanced panel of 42,760 nonfinancial firms over 2000q1-2021q4, resulting in 1,770,521 firm-quarter observations. We exclude financial firms, namely banks, diversified financials, and insurance firms from our analysis: GICS codes ranging from 4010 to 4030. We make the following adjustments to the sample:

- we convert non-USD to USD using: (i) end-of-period exchange rates for stock balance sheet data; and (ii) quarterly average exchange rates for income statement and cash flow data, and for financial market data
- drop observations for missing assets and liabilities
- replace negative values for assets and liabilities with zeros
- drop observations if capital stock or total debt are missing
- drop observations when acquisitions are larger than 5 percent of total assets to exclude potential mergers and acquisitions
- drop firms with total debt larger than 100 percent of total assets
- drop firms with fewer than three years of data on the leverage ratio, the capital stock, the ICR, and sales
- drop observations for countries with fewer than five firms for each quarter
- winsorize key variables at the 2.5/97.5 percentiles at the country level
- drop countries with fewer than eight years of data on the leverage ratio, the capital stock, and the ICR from 2000 onwards
- compute zombie firms for industries which have at least three firms per country for each quarter
- drop countries with fewer than 12 years of data on zombie shares

- we take four-quarter rolling sums of flow variables—EBIT, sales, interest expenses—before computing ratios when the denominator is a stock variable: e.g. ROA, and the implicit interest rate

- deflate nominal variables with the respective country CPI deflator

Table A.1: Variable definitions

Variable	**Definition**	**Source**
Net capital stock	PPENTQ	Compustat
R&D	XRDQ	Compustat
SG&A	XSGAQ - XRDQ - RDIPQ	Compustat
Intangible investment	R&D + 0.3×SG&A	Compustat
Employment[b]	EMP	Compustat
Total debt (book value)	DLCQ + DLTTQ	Compustat
Long-term debt (book value)	DLTTQ	Compustat
Short-term debt (book value)	DLCQ	Compustat
Total assets (book value)	ATQ	Compustat
Current assets	ACTQ	Compustat
Current liabilities	LCTQ	Compustat
Net current assets	ACTQ - LCTQ	Compustat
Cash + short-term investments	CHEQ	Compustat
Net income	NIQ	Compustat
Interest payments	XINTQ	Compustat
Depreciation & amortization	DPQ	Compustat
Stock prices	PRCQQ	Compustat
EBITDA	SALEQ - COSGQ - XSGAQ	Compustat
EBIT	SALEQ - COSGQ - XSGAQ - DPQ	Compustat
Debt ratio	(DLCQ + DLTTQ) / ATQ	Compustat
ICR	EBIT / XINTQ	Compustat
ROA	EBIT / ATQ	Compustat
Equity (book value)	SEQQ + TXDITCQ - Preferred stock	Compustat
Tobin's Q	(ATQ + PRCCQ×CSHOQ - Equity) / ATQ	Compustat
Implicit interest rate	XINTQ / (DLCQ + DLTTQ)	Compustat
Sales	SALEQ	Compustat
Acquisitions	AQCY[a]	Compustat
Loan share[b]	(NP + DLTO)/(DLCQ + DLTTQ)	Compustat
Age	Foundation year	Capital IQ
PD in 12 months	PRCQQ	NUS-CRI

a. Transformation from year-to-date to quarterly. *b.* Annual data interpolated to quarterly.

Table A.2: Industry composition: listed firms

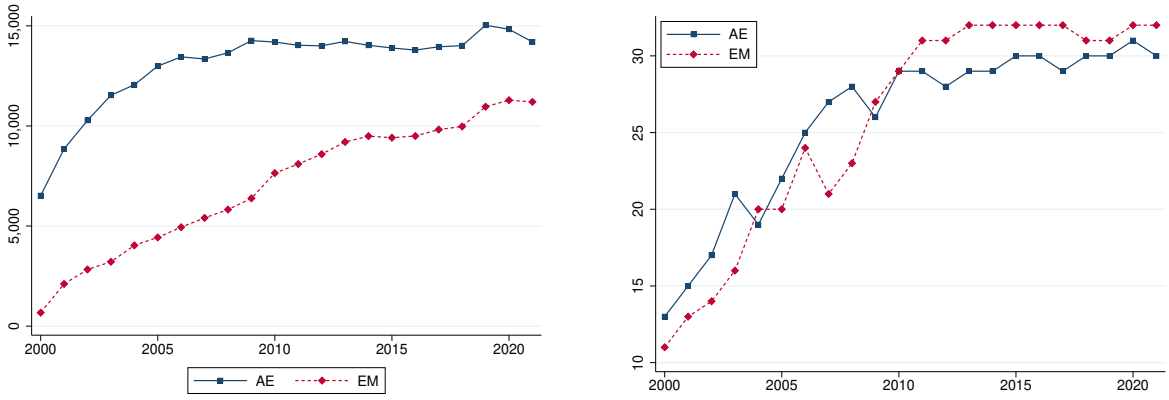
Industry	GICS codes	N	%	% zombies
Energy	1010	76,379	4.4	9.5
Materials	1510	242,442	14.0	8.4
Industrials	2010-2030	403,778	23.2	6.5
Consumer discretionary	2510-2550	327,083	18.8	7.9
Consumer staples	3010-3030	149,958	8.6	6.1
Health care	3510-3520	127,056	7.3	6.4
Information technology	4510-4530	267,859	15.4	8.4
Communication services	5010-5020	74,474	4.3	7.8
Utilities	5510	45,141	2.6	3.7
Real estate	6010	23,261	1.3	10.6

Table A.3: Descriptive statistics: listed firms

	N	mean	sd	p10	p50	p90
log real capital stock	1,757,775	3.60	2.49	0.29	3.69	6.75
Δlog real capital stock	1,664,330	0.55	11.55	-8.77	-0.38	10.39
Δlog intangible investment	1,313,860	3.15	15.34	-9.55	0.70	21.14
log employment	1,074,675	-0.04	2.05	-2.62	-0.07	2.61
$\Delta_4$log employment	922,093	1.39	17.18	-14.84	0.91	18.44
Debt / assets	1,761,732	23.65	18.76	1.43	20.71	49.79
Δlog real debt	1,608,888	-0.03	26.75	-22.62	-0.68	23.81
Net current assets / assets	1,752,643	16.50	26.10	-10.86	15.81	48.27
Δlog real sales	1,328,797	2.07	13.09	-9.93	0.66	16.36
TFP	741,557	0.00	0.49	-0.38	0.01	0.41
Log real assets	1,761,732	5.21	2.10	2.66	5.12	7.94
Implicit interest rate	1,222,493	10.28	22.82	1.78	5.66	17.35
ICR	1,170,793	18.08	105.04	-7.09	2.97	46.34
ROA	1,312,600	2.47	21.59	-8.34	3.85	16.66
PD in 12 months	1,370,825	0.54	1.01	0.01	0.18	1.40
Age	1,381,173	38.25	33.61	8.00	27.00	86.00
Loan share	1,760,729	39.50	37.24	0.00	30.99	97.89
Tobin's q	302,907	2.41	29.13	0.82	1.41	3.99

Sources: Compustat, Capital IQ, National University of Singapore's Credit Research Initiative (CRI), and authors' calculations.
Notes: The log is applied to nominal variables expressed in USD millions. All ratios and growth rates are expressed in percent.

Figure A.1: Number of firms and countries over time: Compustat



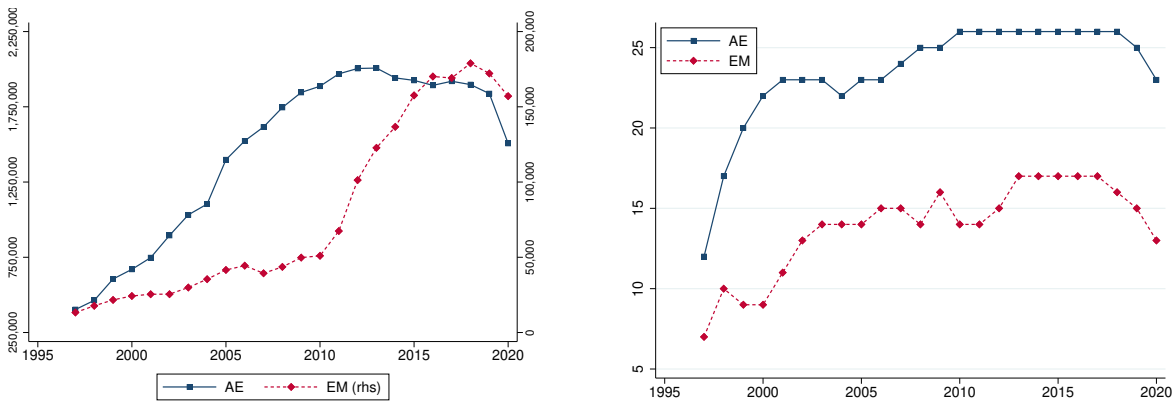
Notes: Number of unique firms (left panel) and countries (right panel) in the Compustat sample over time in Advanced Economies (AE) and Emerging Markets (EM).

Appendix B: Sample selection and variable definitions – ORBIS

For nonfinancial private firms, we use data from Bureau van Dijk Orbis for 43 countries (29 AEs and 17 EMs). The final dataset is an unbalanced panel of 4,394,313 nonfinancial firms over 1997-2020, resulting into 36,774,234 firm-year observations. We clean the dataset following Kalemli-Özcan et al. (2015), and Díez et al. (2021). We then drop financial firms from our sample, specifically banks, insurance companies and their auxiliary activities according to NACE2 codes 64, 65, and 66. Importantly, we select only private firms by keeping firms which are 'Unlisted' or 'Delisted' according to 'main_exchange'. To avoid firm-year duplicates, from the same firm reporting under different consolidation codes, we first prioritize consolidated accounts, and only take unconsolidated accounts for firms that consistently report under unconsolidated accounts. We make the additional following adjustments:

- drop observations where total assets, sales, operating revenue turnover, capital expenditures, or total debt are missing
- drop observations for negative assets, total fixed assets, and for sales
- drop firms with total debt to assets above 100 percent
- winsorize the data at the 2.5/97.5 percentiles at the country level
- drop firms with fewer than three years of data
- deflate nominal variables with the respective CPI deflator

Figure B.1: Number of firms and countries over time: ORBIS



Notes: Number of unique firms (left panel) and countries (right panel) in the ORBIS sample over time in Advanced Economies (AE) and Emerging Markets (EM).

Table B.1: Variable definitions in ORBIS

Variable	**Definition**
Net capital stock	tangible_fixed_assets
Intangible investment	R&D + 0.3×SG&A
Employment	number_of_employees
Total debt (book value)	long_term_debt + loans
Long-term debt (book value)	long_term_debt
Short-term debt (book value)	loans
Total assets (book value)	total_assets
Current assets	current_assets
Current liabilities	current_liabilities
Net current assets	total_assets - current_liabilities
Cash + short-term investments	cash_and_cash_equivalent
Interest payments	interest_paid
Depreciation & amortization	depreciation_and_amortization
EBITDA	ebitda
Debt ratio	Total debt / total_assets
ICR	EBITDA / interest_paid
ROA	EBITDA / total_assets
Implicit interest rate	interest_paid / Total debt
Sales	sales
Asset turnover ratio	sales / total_assets
Age	age
State Ownership	state_shr

Table B.2: Industry composition: private firms

Industry	NACE2 codes	N	%	% zombies
Agriculture	01-03	856,836	2.3	3.3
Mining	05-09	119,173	0.3	3.7
Manufacturing	10-33	6,612,804	18.0	3.2
Utilities	35	280,402	0.8	1.5
Water supply	36-39	241,053	0.7	2.1
Construction	41-43	5,117,241	13.9	3.7
Wholesale retail	45-47	9,088,183	24.7	4.4
Transportation	49-53	1,658,854	4.5	2.7
Accommodation & food	55-56	1,904,805	5.2	4.2
Information & comm.	58-63	1,237,219	3.4	4.8
Real estate	68	3,327,063	9.0	4.6
Professional activities	69-75	2,851,198	7.8	4.7
Administrative activities	77-82	1,369,025	3.7	4.0
Education	85	313,031	0.9	4.7
Social work	86-88	826,733	2.2	2.7
Entertainment	90-93	451,296	1.2	5.3
Other services	94-96	512,431	1.4	4.3
Miscellaneous	84, 97-99	6,887	0.0	5.5

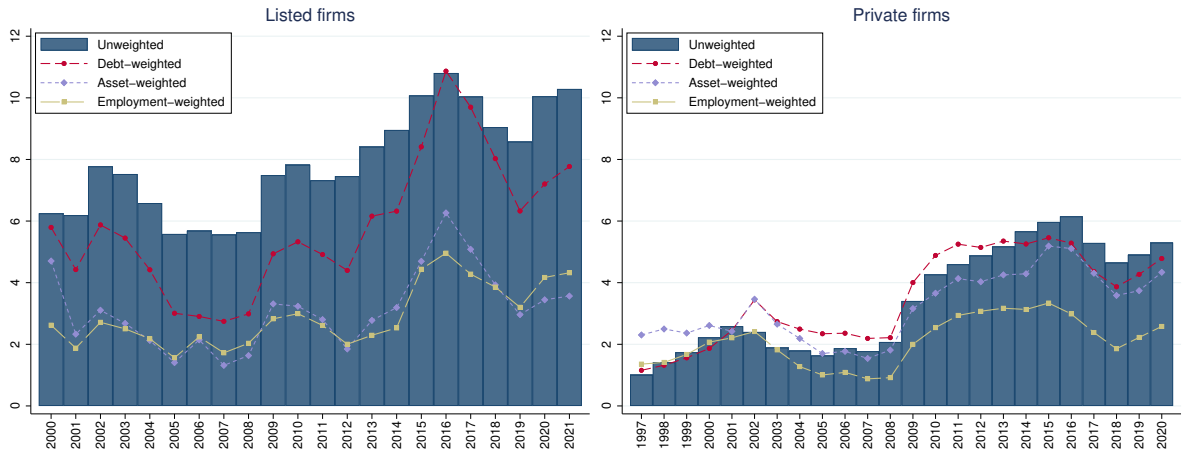
Table B.3: Descriptive statistics: private firms

	N	mean	sd	p10	p50	p90
log real capital stock	35,564,529	11.70	2.40	8.69	11.66	14.73
Δlog real capital stock	34,576,298	-0.56	49.22	-48.00	-6.93	55.02
Δlog intangible investment	17,908,235	-8.72	68.34	-72.49	-8.49	52.62
log employment	23,867,511	2.02	1.42	0.00	1.79	3.87
Δlog employment	21,093,232	1.18	27.38	-28.77	0.00	30.23
Debt / assets	36,774,234	20.56	23.71	0.00	11.50	57.66
Δlog real debt	25,127,763	-2.02	80.86	-76.69	-5.22	83.04
Net current assets / assets	36,774,055	14.44	38.38	-27.18	14.96	59.32
Δlog real sales	35,421,435	3.59	51.39	-40.22	0.49	42.09
TFP	19,527,399	0.00	0.43	-0.36	0.01	0.38
Log real assets	36,774,234	13.73	1.78	11.63	13.59	16.01
Implicit interest rate	26,258,603	25.58	165.77	1.32	5.76	32.37
ICR	32,864,287	79.10	587.41	-3.39	6.38	114.46
ROA	35,514,808	8.90	15.96	-3.82	7.76	25.91
Age	36,720,924	16.60	13.41	4.00	13.00	33.00

Sources: ORBIS, and authors' calculations.
Notes: The log is applied to nominal variables expressed in USD. All ratios and growth rates are expressed in percent.

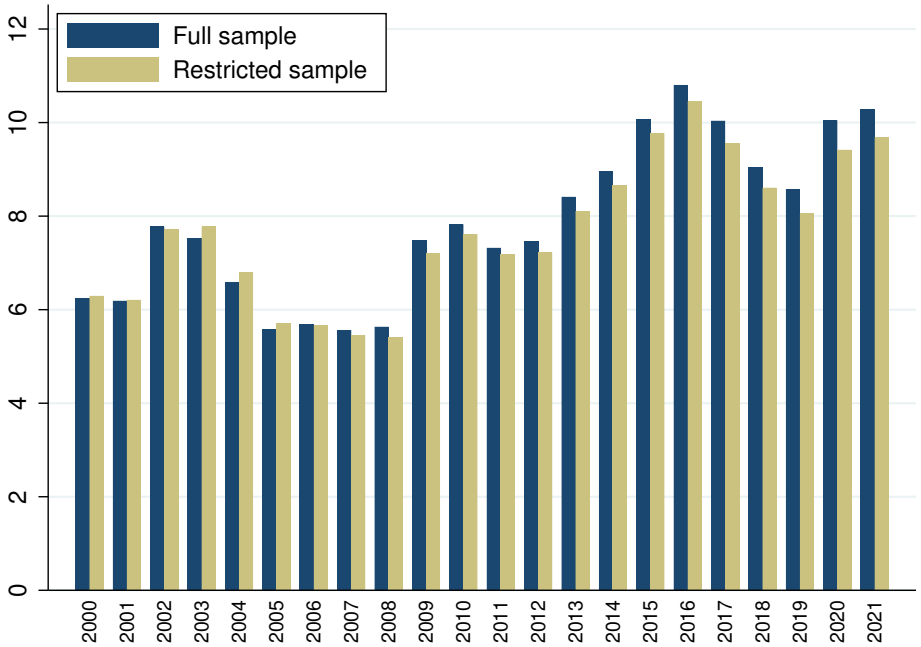
Appendix C: Additional figures

Figure C.1: Share of zombie firms: listed vs private firms



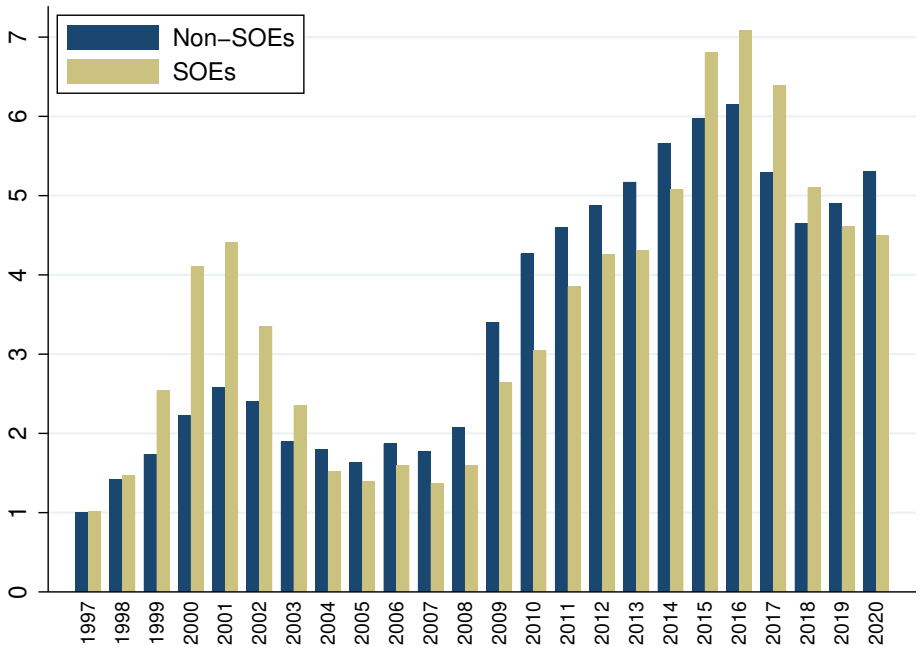
Notes: The blue bars refer to the unweighted percentage share of zombie firms, while the different lines refer to zombie shares weighted by total debt, total assets, or employment.

Figure C.2: Share of zombie firms: Compustat sample



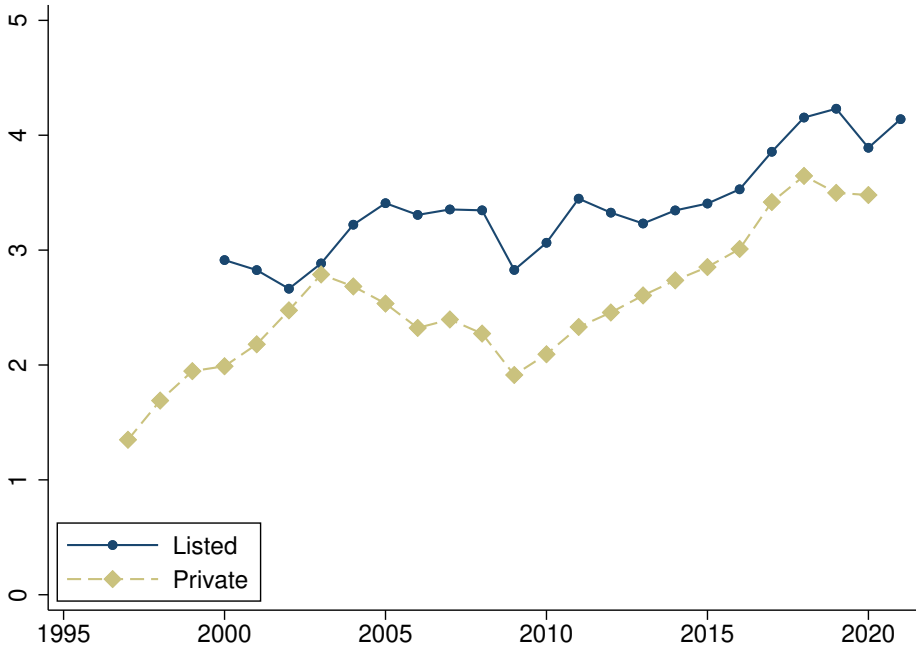
Notes: The blue bars refer to the percentage share of listed zombie firms in the baseline Compustat dataset, while the khaki bars refer to a sample that is restricted to the country sample of ORBIS.

Figure C.3: Share of zombie firms: SOEs vs non-SOEs



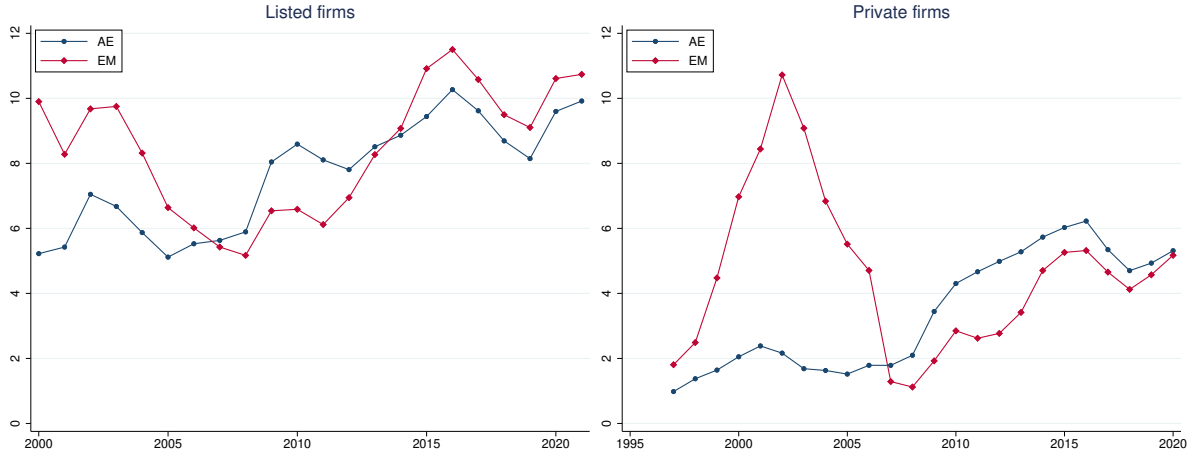
Notes: The blue bars refer to the percentage share of private zombie non-SOEs, and the khaki bars to private zombie SOEs.

Figure C.4: Mean duration of zombie status



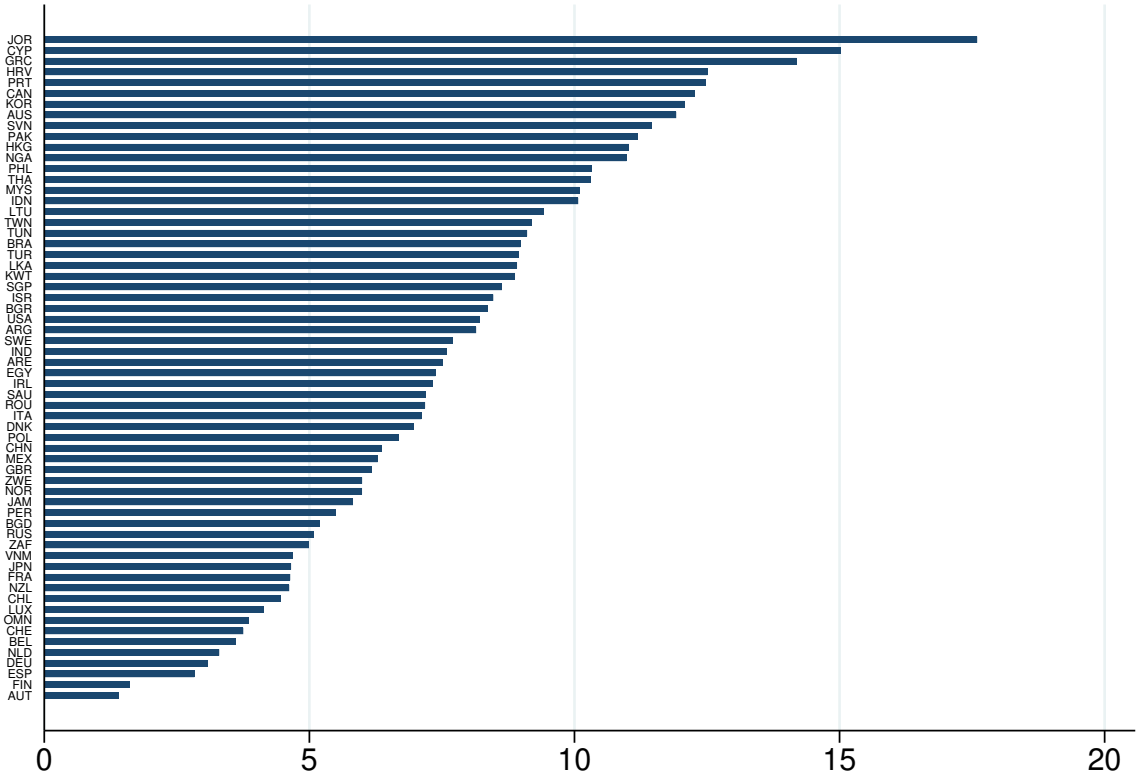
Notes: Duration of zombie status takes the mean of the number of years a firm remains zombie.

Figure C.5: Share of zombie firms by country group



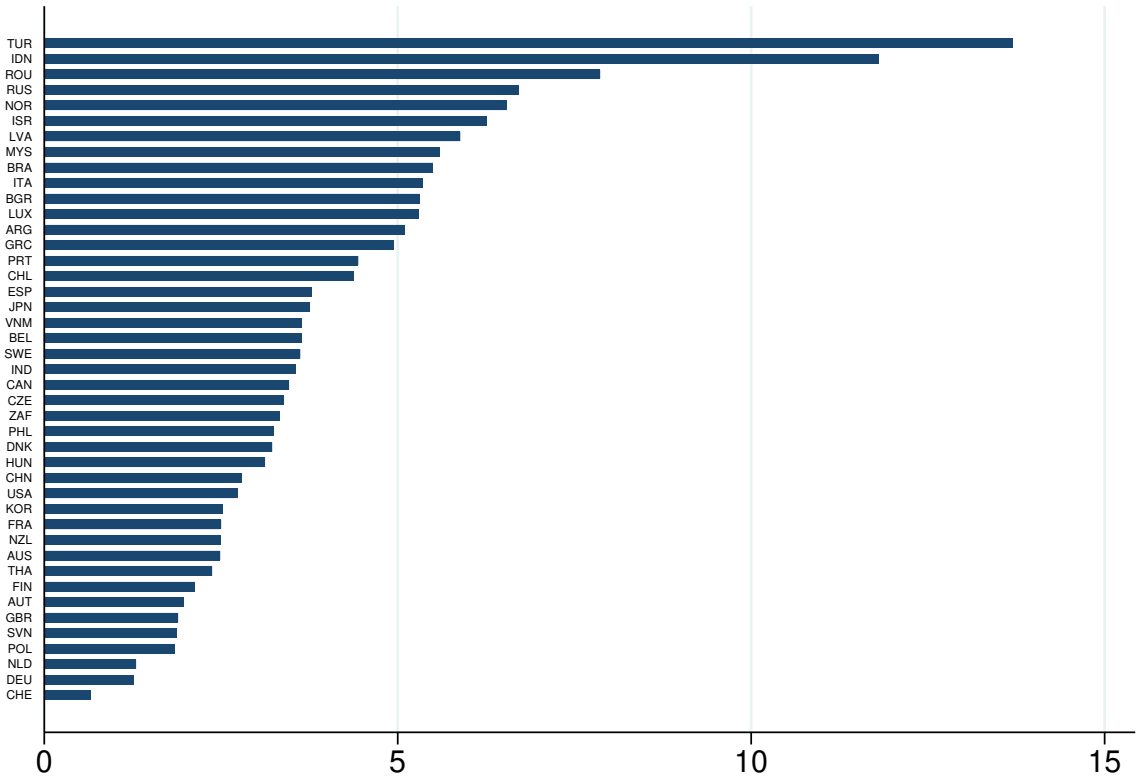
Notes: Percent share of zombie firms within each group: Advanced Economies (AE), and Emerging Markets (EM).

Figure C.6: Average share of zombie firms by country: listed firms



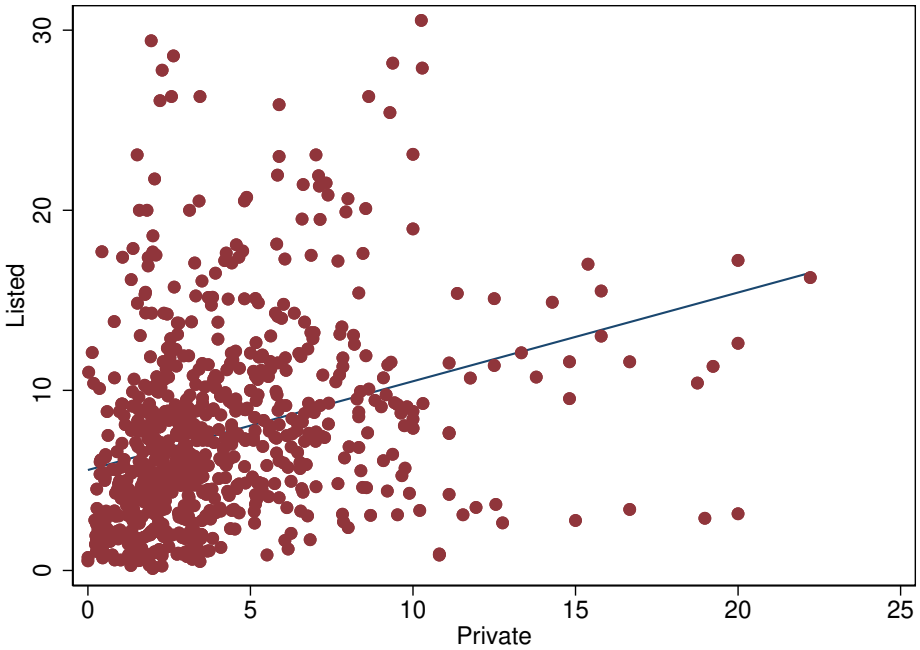
Notes: Average zombie shares for listed firms over the 2000-2021 period.

Figure C.7: Average share of zombie firms by country: private firms



Notes: Average zombie shares for private firms over the 1997-2020 period.

Figure C.8: Country zombie shares: correlation between listed and private firms



Notes: Each red circle refers to a country-year pair, while the solid blue line is the linear fitted values.

Figure C.9: Share of zombie firms (I)

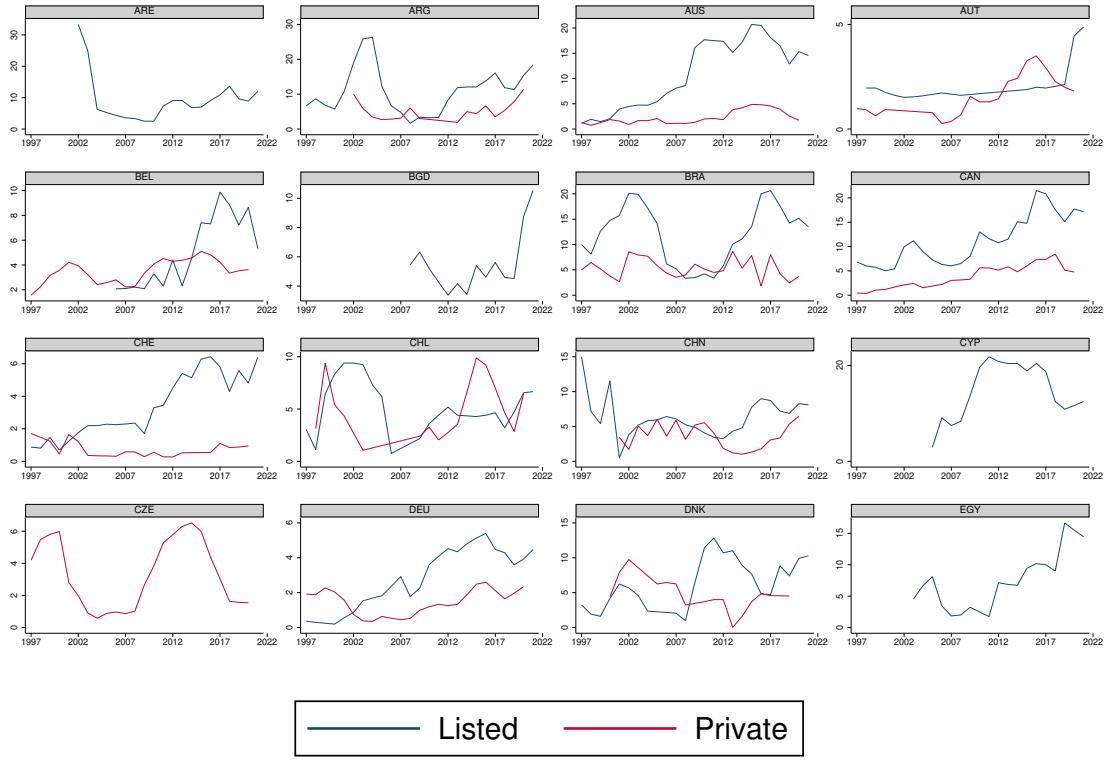


Figure C.10: Share of zombie firms (II)

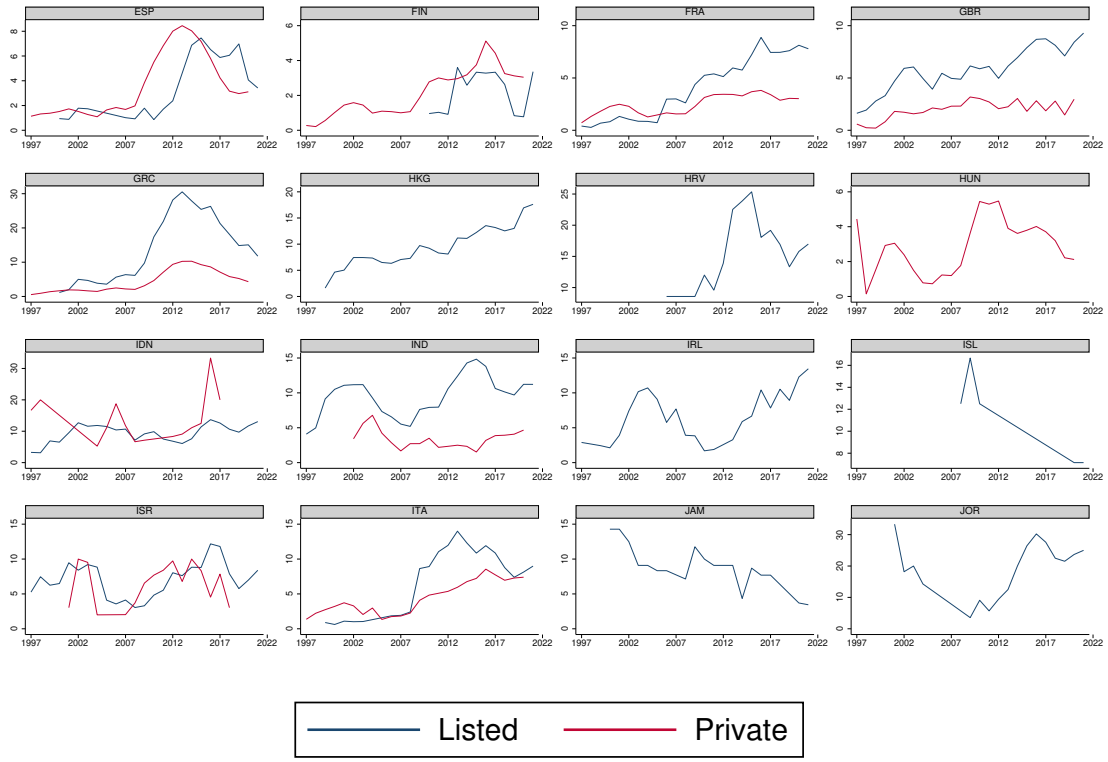


Figure C.11: Share of zombie firms (III)

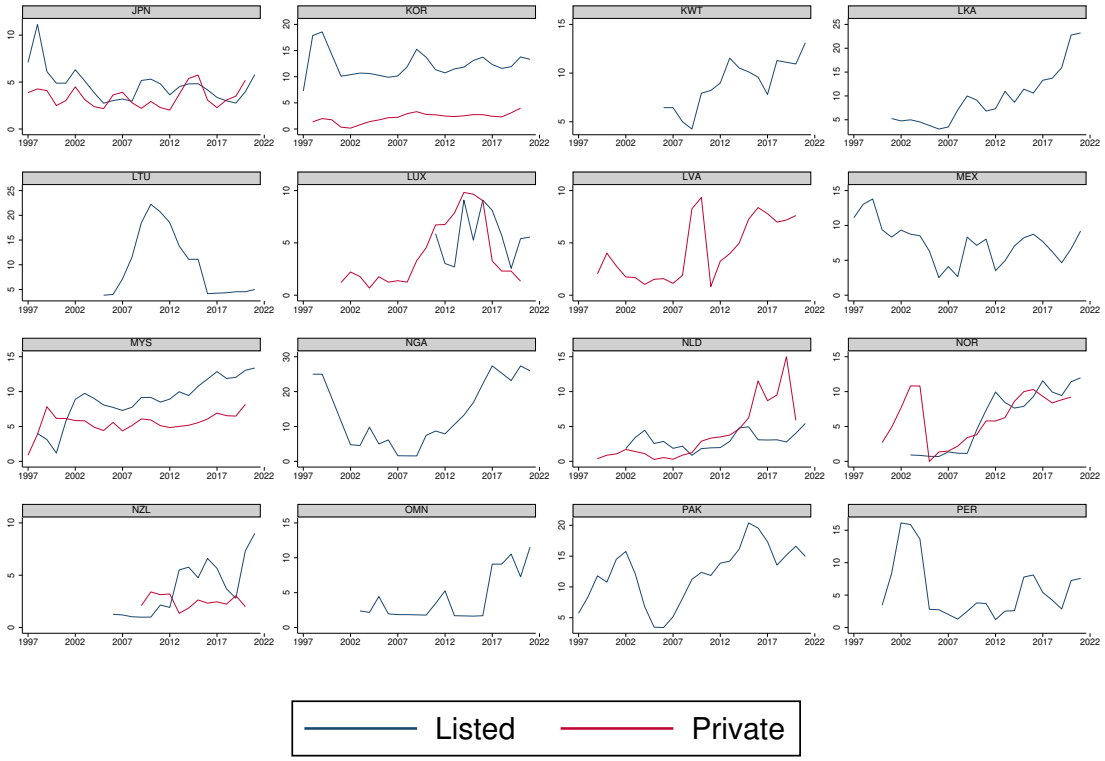


Figure C.12: Share of zombie firms (IV)

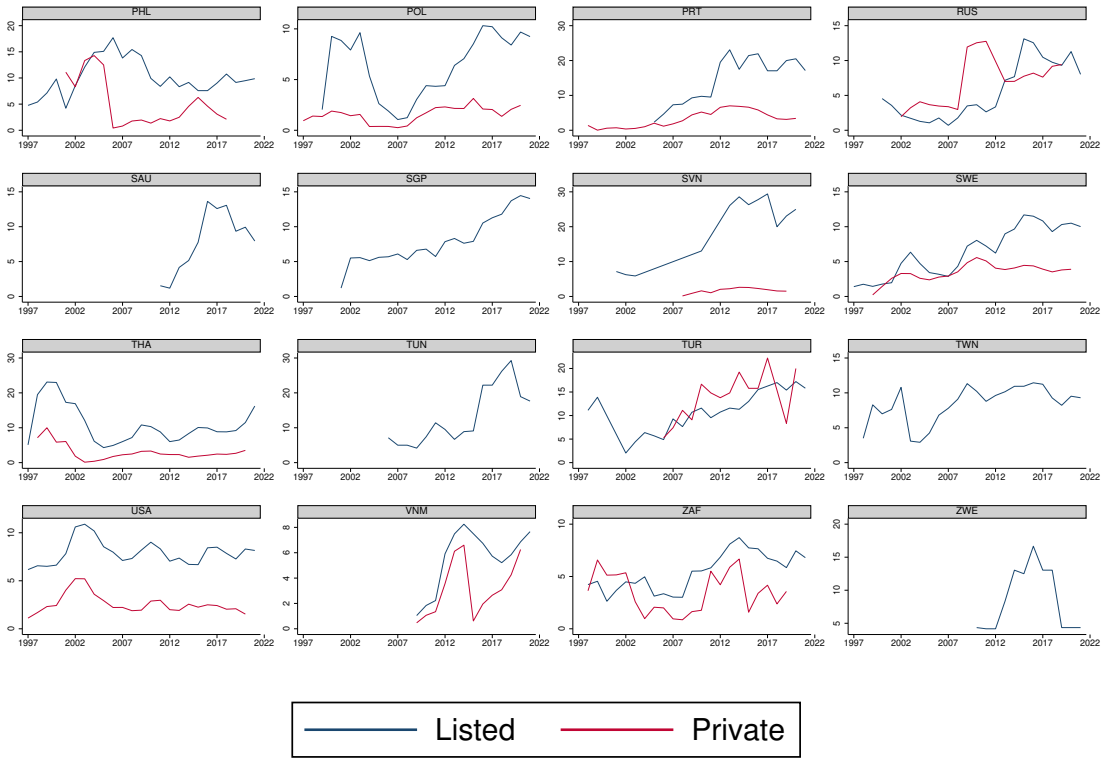
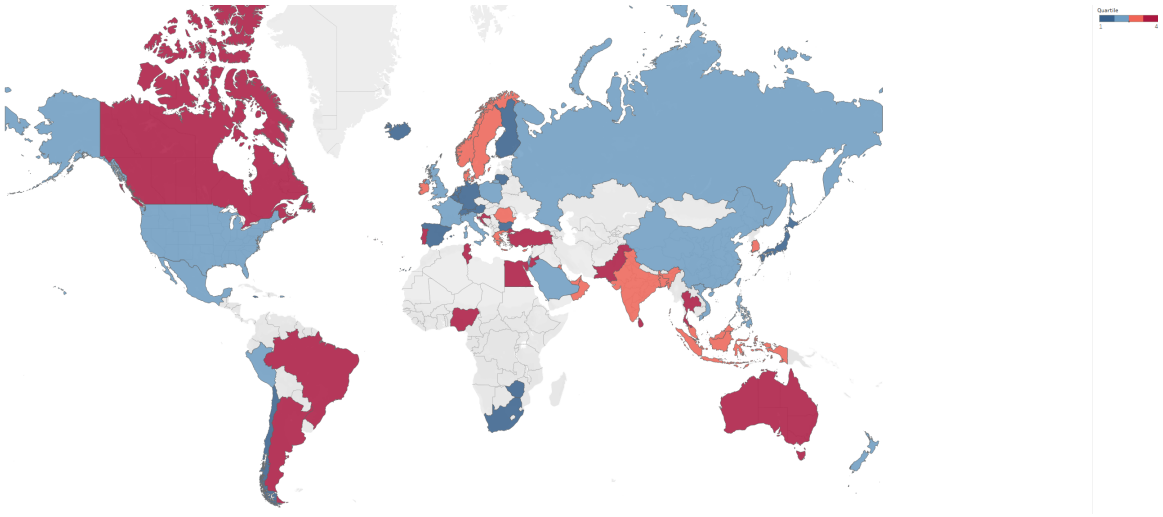
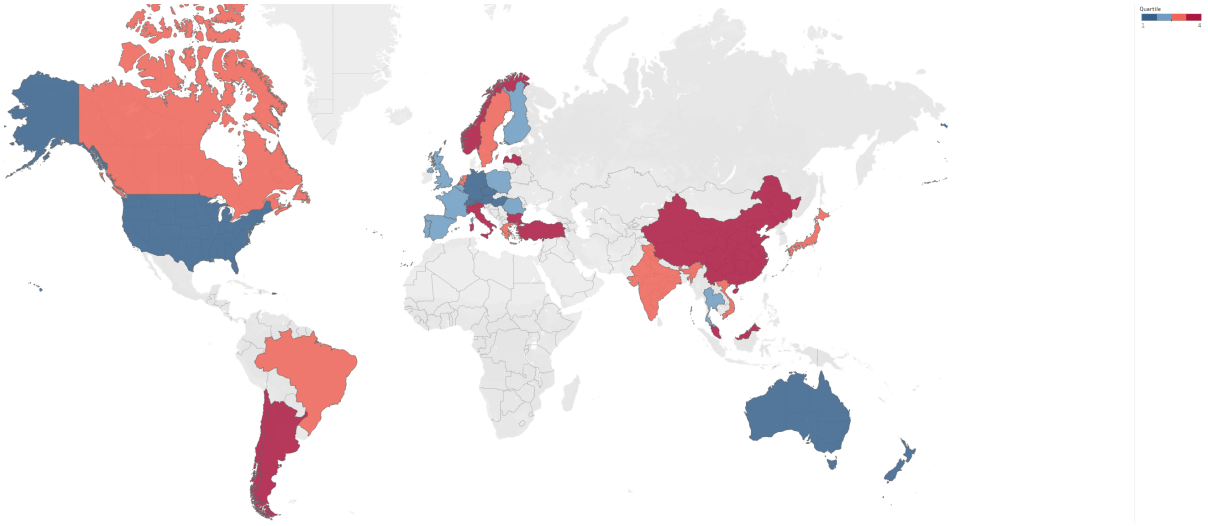


Figure C.13: Share of listed zombie firms in 2021



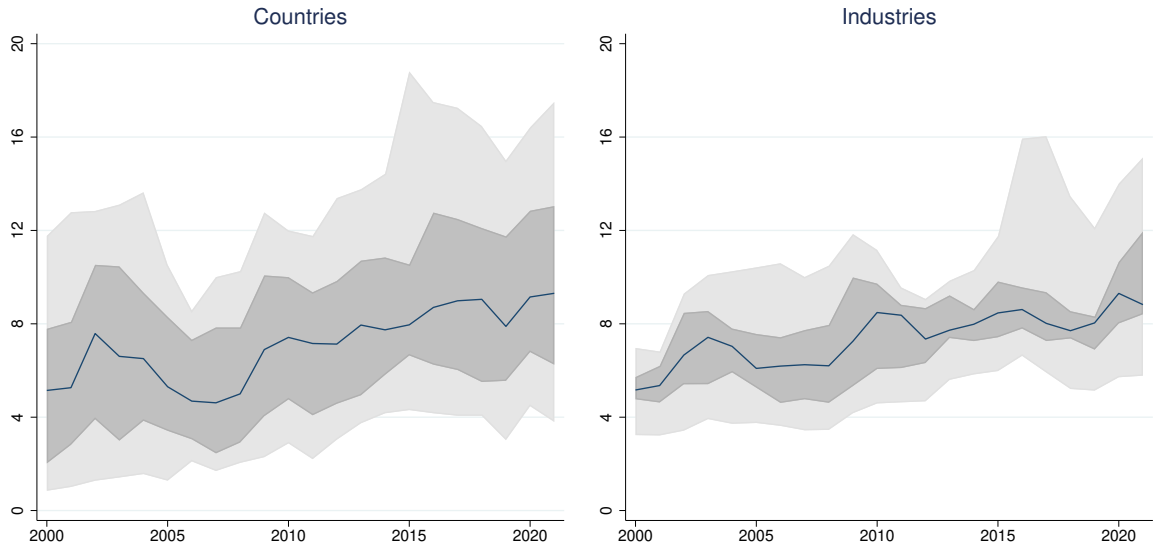
Notes: Dark (light) blue colors refer to the first (second) quartiles of the country zombie shares in 2021, and orange (red) colors to the third (fourth) quartiles.

Figure C.14: Share of private zombie firms in 2020



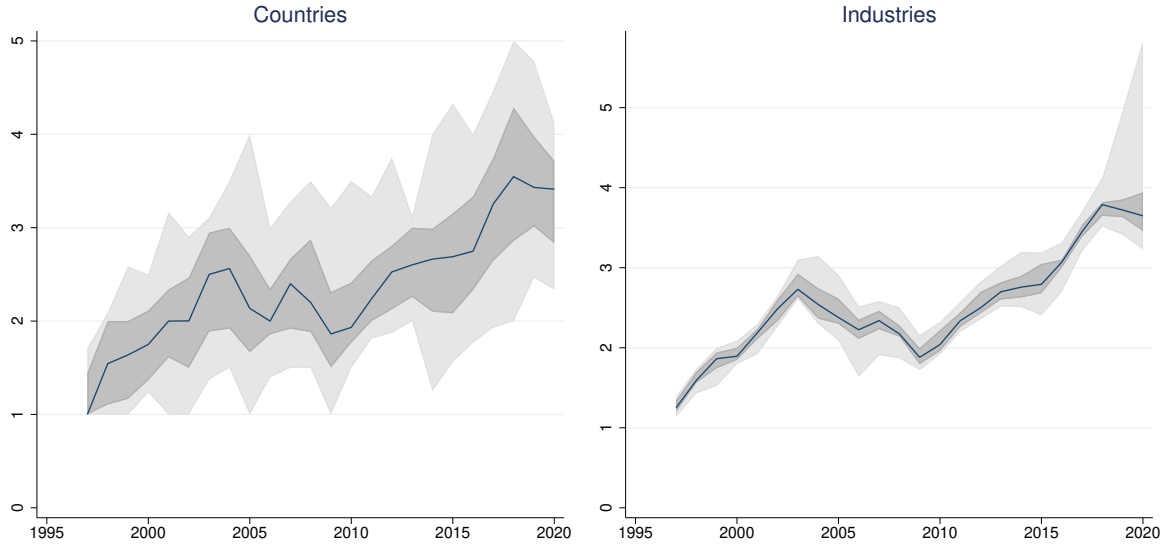
Notes: Dark (light) blue colors refer to the first (second) quartiles of the country zombie shares in 2021, and orange (red) colors to the third (fourth) quartiles.

Figure C.15: Dispersion in zombie shares across countries and industries: listed firms



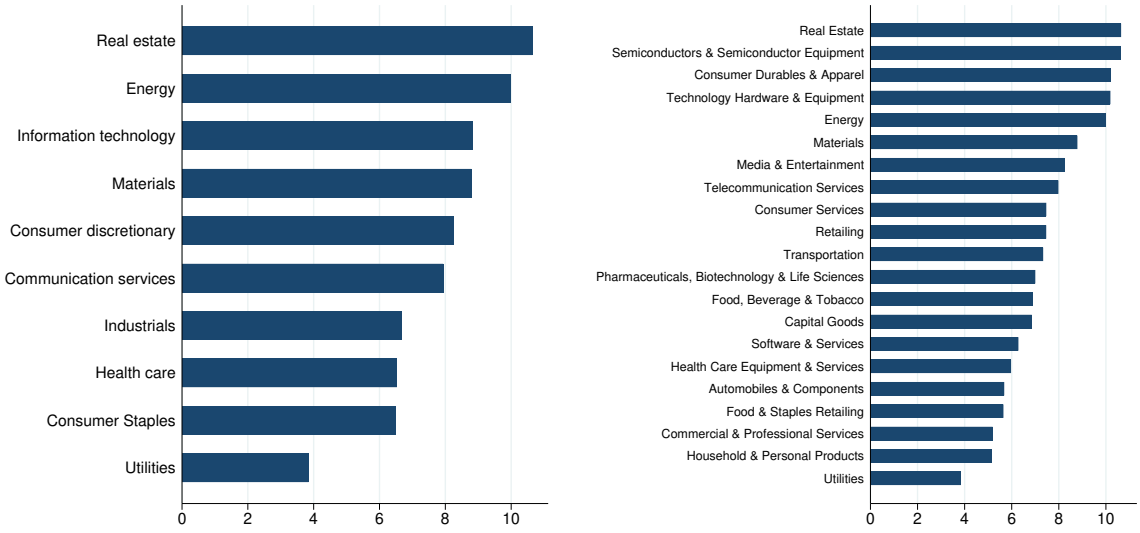
Notes: The solid blue line refers to the median zombie share for all countries (left panel) and industries (right panel). Light (dark) grey areas represent the dispersion in zombie shares for the $10^{th}/90^{th}$ ($25^{th}/75^{th}$) percentiles.

Figure C.16: Dispersion in zombie shares across countries and industries: private firms



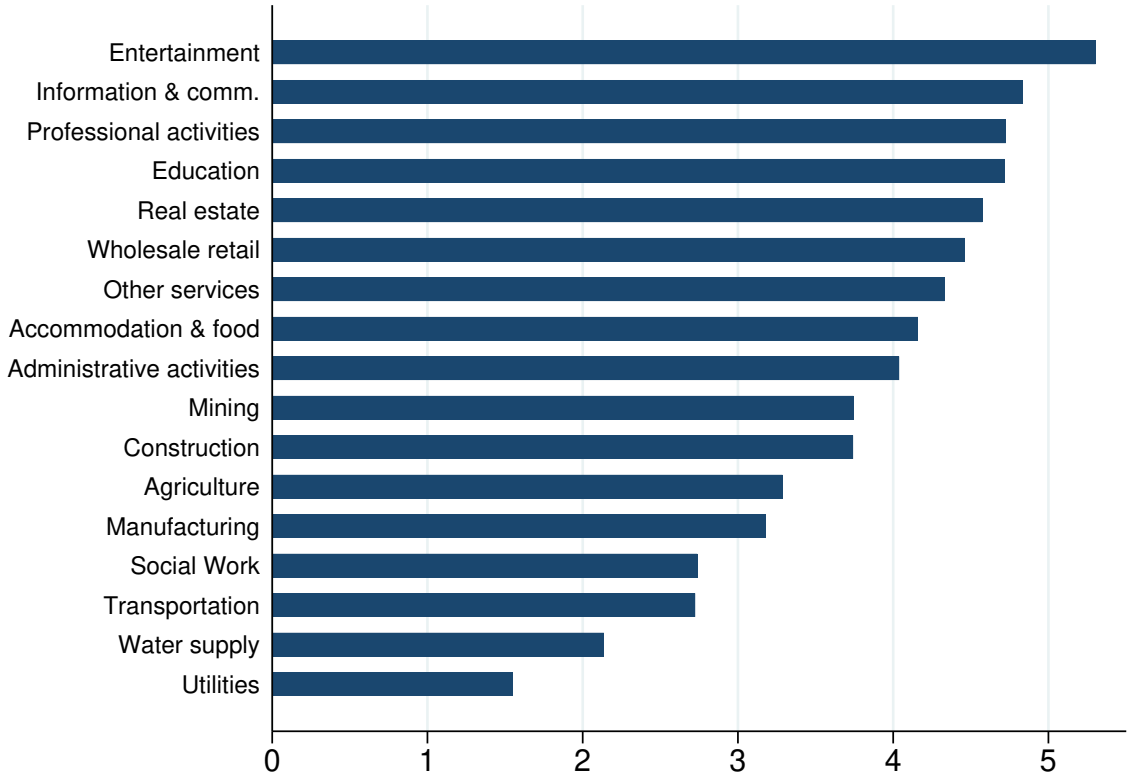
Notes: The solid blue line refers to the median zombie share for all countries (left panel) and industries (right panel). Light (dark) grey areas represent the dispersion in zombie shares for the $10^{th}/90^{th}$ ($25^{th}/75^{th}$) percentiles.

Figure C.17: Average share of zombie firms by industry: listed firms



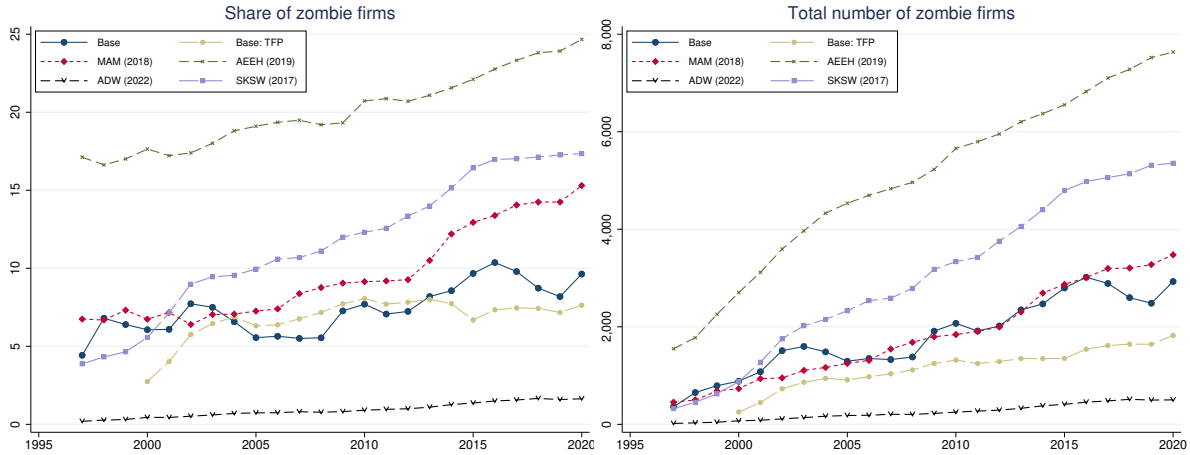
Notes: Average zombie shares at the industry level for listed firms over 2000-2021. Left panel takes the two-digit GICS and the right panel takes the four-digit GICS.

Figure C.18: Average share of zombie firms by industry: private firms



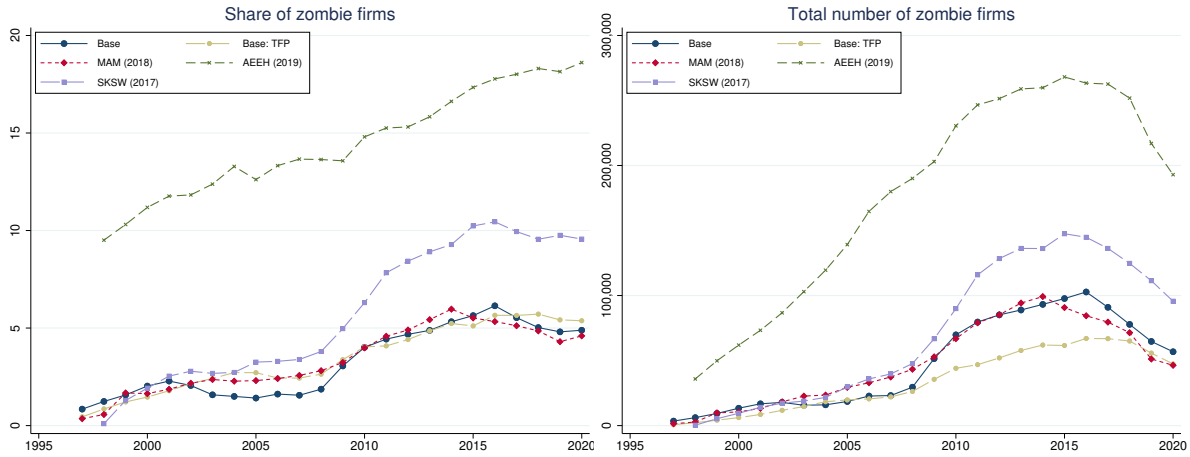
Notes: Average zombie shares at the one-digit NACE2 industry level for private firms over 1997-2020.

Figure C.19: Zombie firms across definitions: listed firms



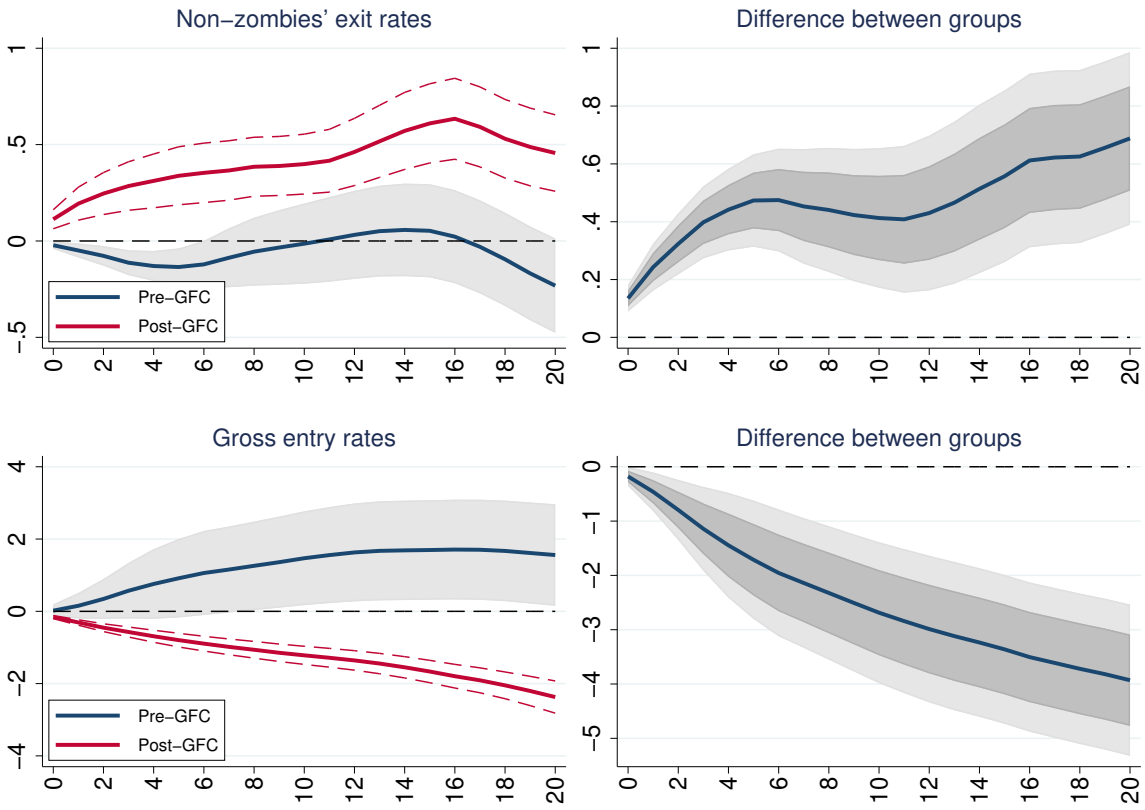
Notes: Percentage share of zombie firms across definitions (left panel), and total number of zombie firms in our sample (right panel).

Figure C.20: Zombie firms across definitions: private firms



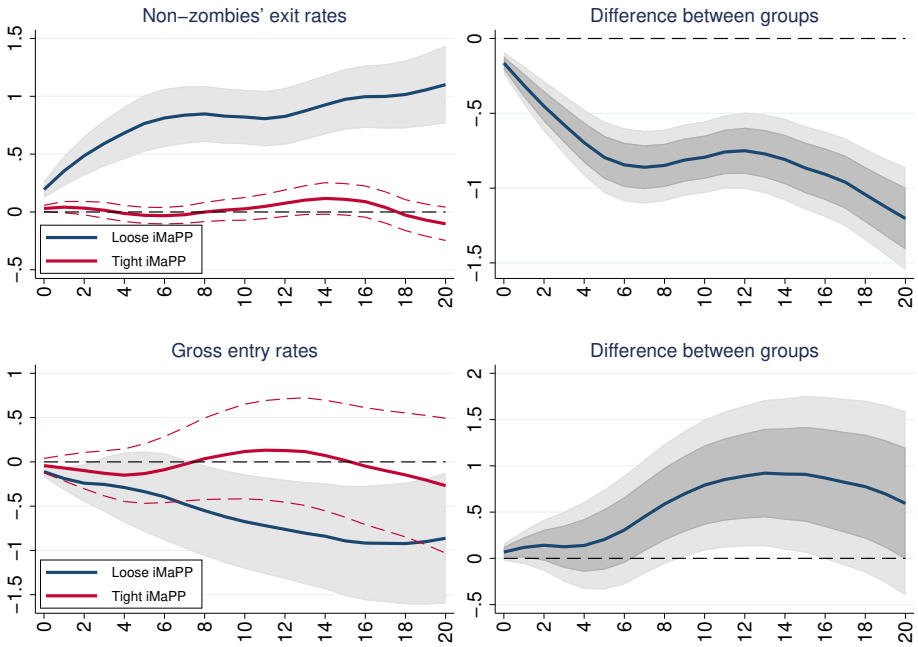
Notes: Percentage share of zombie firms across definitions (left panel), and total number of zombie firms in our sample (right panel).

Figure C.21: Congestion effects: exit and entry rates for pre- and post-GFC: listed firms



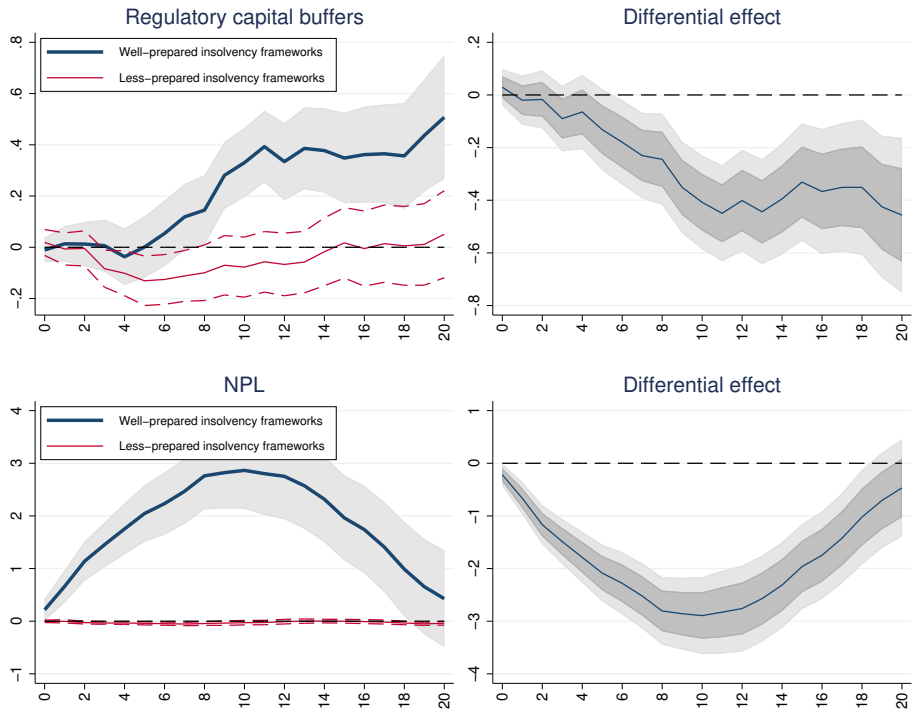
Notes: Cumulative impulse responses over 20 quarters of nonzombies' exit rates and entry rates of all firms to a one-standard deviation increase in the industry asset-weighted share of zombie firms. Left panels: blue (red) line is the average response for pre (post) GFC, with associated 90 percent confidence bands in grey (dashed red lines). Right panels: dark (light) grey areas are the 68 (90) percent confidence bands for the difference between post- and pre-GFC.

Figure C.22: Congestion effects: exit and entry rates in countries with tight vs loose overall macroprudential stance



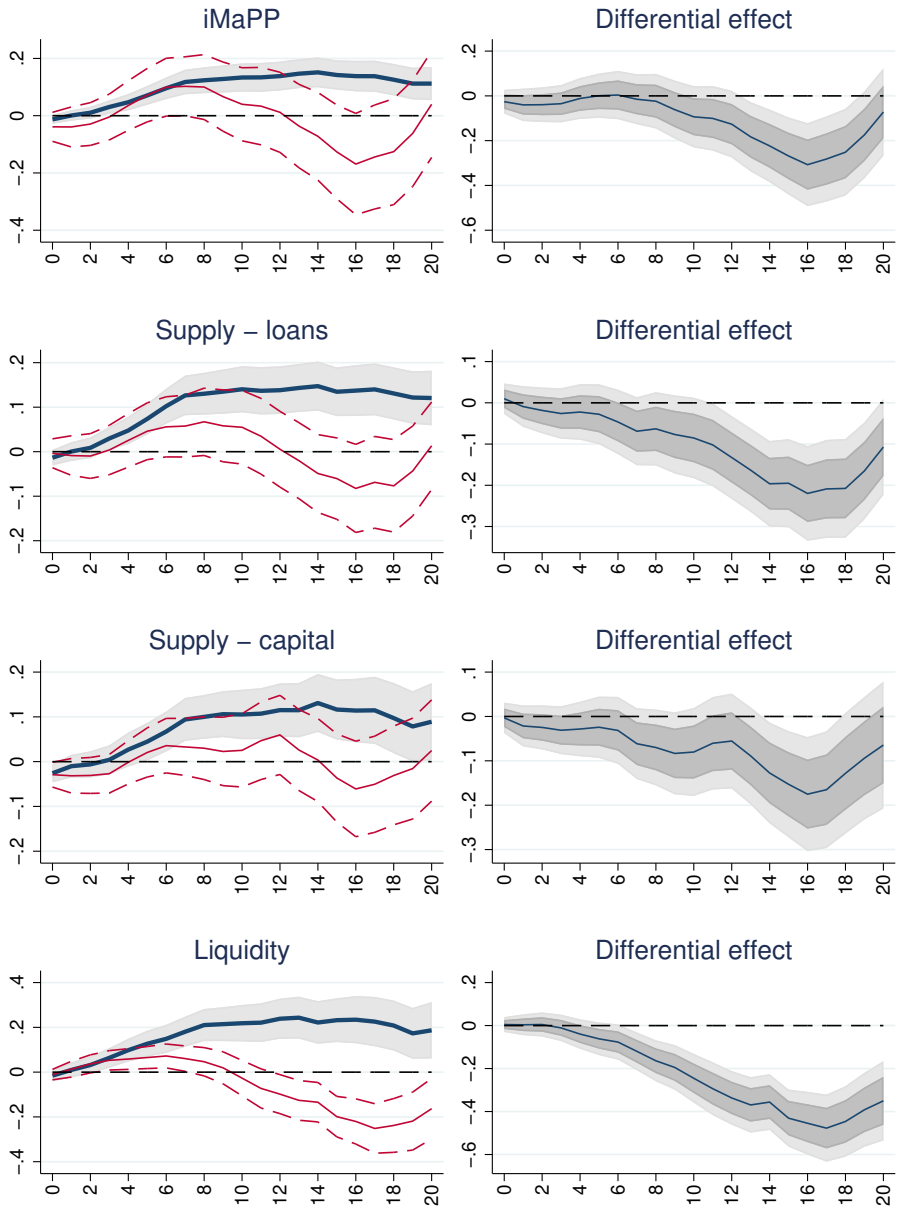
Notes: Cumulative impulse responses over 20 quarters of nonzombies' exit rates and entry rates of all firms to a one-standard deviation increase in the industry asset-weighted share of zombie firms. Left panels: blue (red) line and respective 90 percent confidence bands refer to the average response in countries with a loose (tight) macroprudential stance across countries, computed as countries below (above) the median sample of the iMaPP indicator. Right panels: dark (light) grey areas are the 68 (90) percent confidence bands for the difference between tight and loose macroprudential stance.

Figure C.23: Congestion effects: dynamics of nonzombies' debt following an improvement in selected bank health indicators for well- and less-prepared insolvency regimes



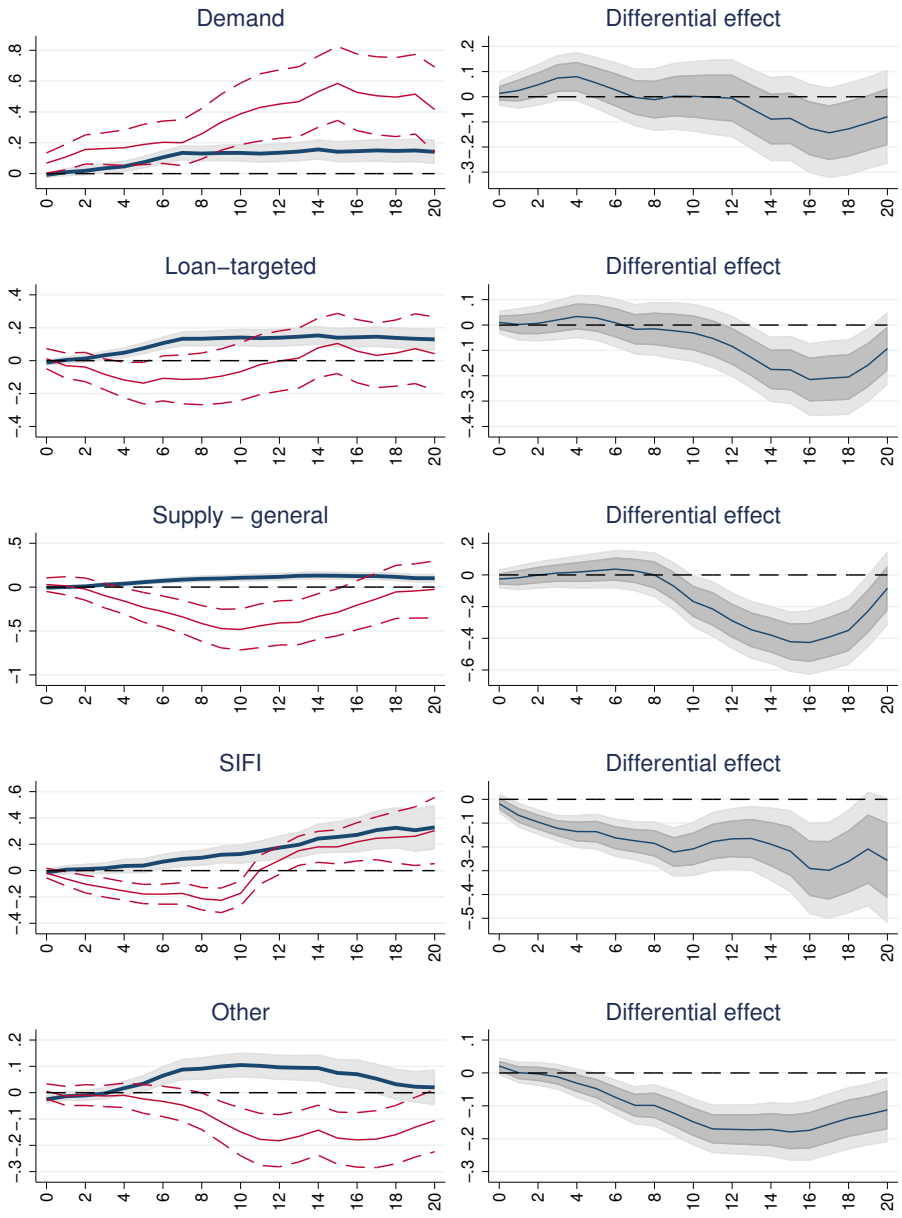
Notes: Cumulative impulse responses of nonzombies' debt growth to a one-standard deviation increase (decrease) in banks' regulatory capital buffer (NPLs) for a given zombie industry share. Left panels: solid blue (red) line with the respective 90 percent confidence bands refer to the average response for well-(less-)prepared insolvency frameworks, computed as countries above (below) the median sample of the Araujo et al. (2022) crisis preparedness indicator. Right panels: dark (light) grey areas are the 68 (90) percent confidence bands of the difference between less- and well-prepared insolvency regimes.

Figure C.24: Congestion effects: dynamics of nonzombies' investment following a tightening in selected macroprudential measures for well- and less-prepared insolvency regimes (I)



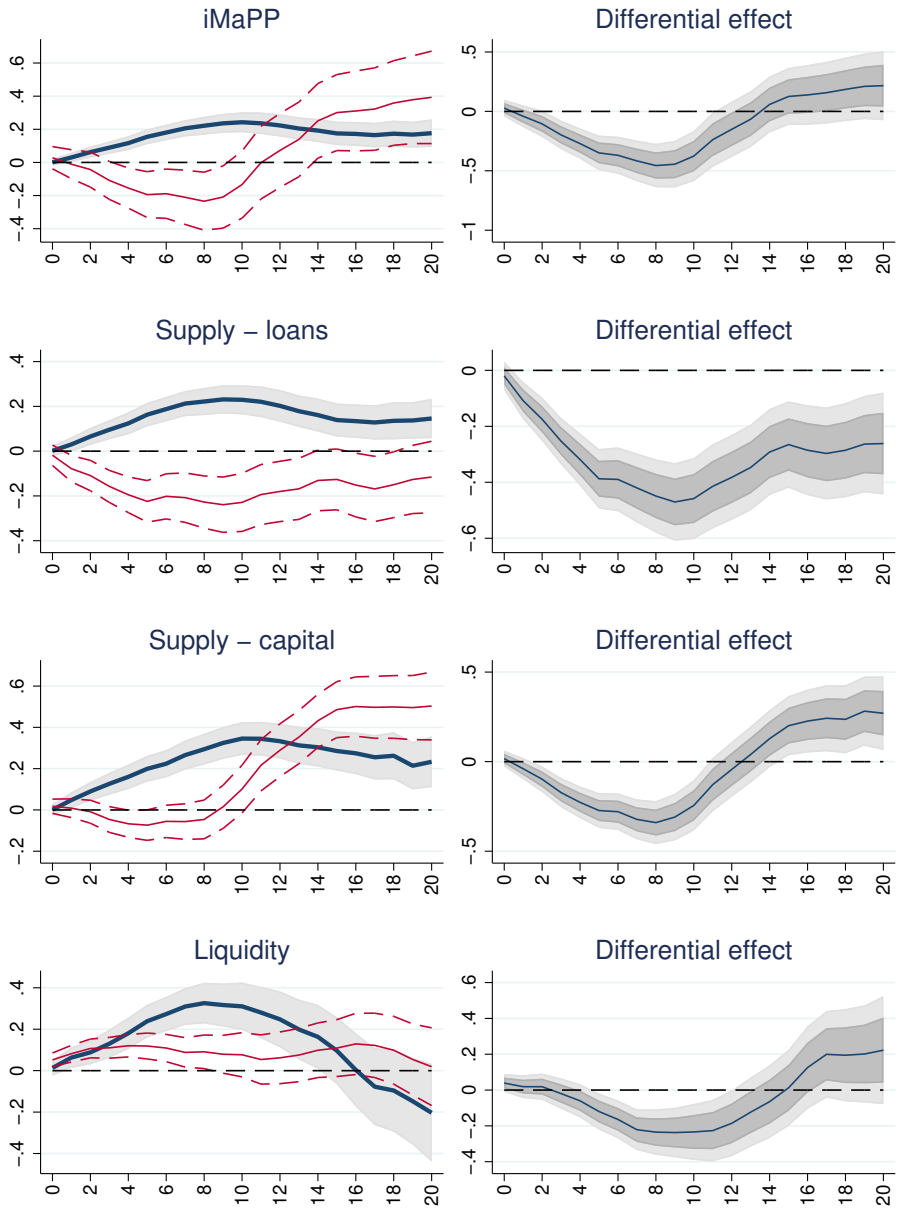
Notes: Cumulative impulse responses of nonzombies' investment growth to a one-standard deviation tightening in selected macroprudential measures for a given zombie industry share. Left panels: solid blue (red) line with the respective 90 percent confidence bands refer to the average response for well-(less-)prepared insolvency frameworks, computed as countries above (below) the median sample of the Araujo et al. (2022) crisis preparedness indicator. Right panels: dark (light) grey areas refer to the 68 (90) percent confidence bands of the difference between less- and well-prepared insolvency regimes.

Figure C.25: Congestion effects: dynamics of nonzombies' investment following a tightening in selected macroprudential measures for well- and less-prepared insolvency regimes (II)



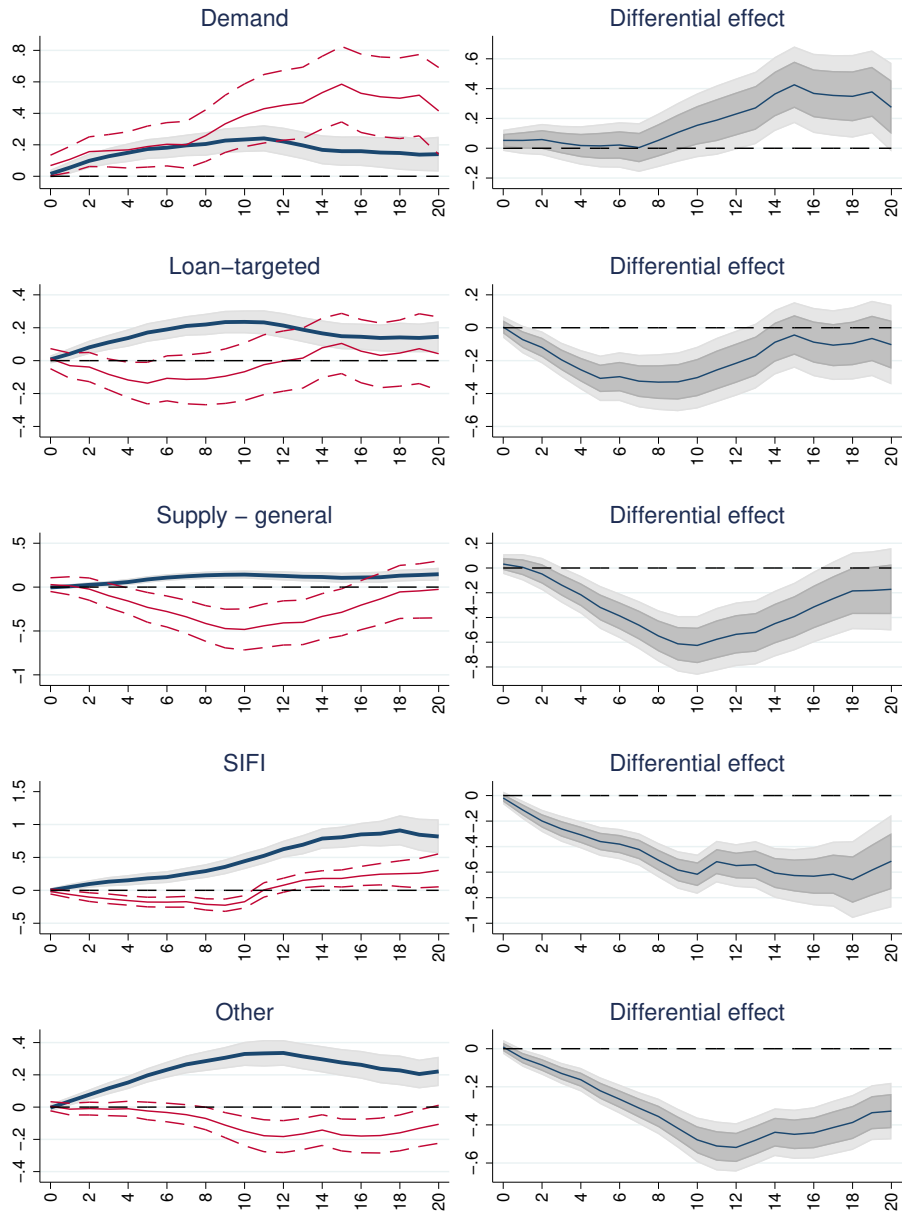
Notes: Cumulative impulse responses of nonzombies' investment growth to a one-standard deviation tightening in selected macroprudential measures for a given zombie industry share. Left panels: solid blue (red) line with the respective 90 percent confidence bands refer to the average response for well-(less-)prepared insolvency frameworks, computed as countries above (below) the median sample of the Araujo et al. (2022) crisis preparedness indicator. Right panels: dark (light) grey areas refer to the 68 (90) percent confidence bands of the difference between less- and well-prepared insolvency regimes.

Figure C.26: Congestion effects: dynamics of nonzombies' debt following a tightening in selected macroprudential measures for well- and less-prepared insolvency regimes (I)



Notes: Cumulative impulse responses of nonzombies' debt growth to a one-standard deviation tightening in selected macroprudential measures for a given zombie industry share. Left panels: solid blue (red) line with the respective 90 percent confidence bands refer to the average response for well-(less-)prepared insolvency frameworks, computed as countries above (below) the median sample of the Araujo et al. (2022) crisis preparedness indicator. Right panels: dark (light) grey areas refer to the 68 (90) percent confidence bands of the difference between less- and well-prepared insolvency regimes.

Figure C.27: Congestion effects: dynamics of nonzombies' debt following a tightening in selected macroprudential measures for well- and less-prepared insolvency regimes (II)



Notes: Cumulative impulse responses of nonzombies' debt growth to a one-standard deviation tightening in selected macroprudential measures for a given zombie industry share. Left panels: solid blue (red) line with the respective 90 percent confidence bands refer to the average response for well-(less-)prepared insolvency frameworks, computed as countries above (below) the median sample of the Araujo et al. (2022) crisis preparedness indicator. Right panels: dark (light) grey areas refer to the 68 (90) percent confidence bands of the difference between less- and well-prepared insolvency regimes.

Appendix D: Additional tables

Table D.1: Congestion effects on investment growth for alternative zombie definitions

	(1) Base	(2) Base: TFP	(3) MAM (2018)	(4) AEEH (2019)	(5) ADW (2022)	(6) SKSW (2017)
Nonzombie	1.690***	1.170***	1.323***	0.183**	0.126	1.232***
	(0.056)	(0.059)	(0.059)	(0.073)	(0.178)	(0.080)
Nonzombie×zombie share	-0.015***	-0.019***	-0.021***	-0.003	-0.094**	-0.053***
	(0.004)	(0.005)	(0.005)	(0.002)	(0.039)	(0.008)
Controls	✓	✓	✓	✓	✓	✓
Firm FE	✓	✓	✓	✓	✓	✓
Country×Industry×Time FE	✓	✓	✓	✓	✓	✓
Observations	1,660,513	1,195,607	1,320,174	1,644,995	1,631,468	1,652,015
Adjusted R^2	0.205	0.178	0.215	0.205	0.205	0.206

Notes: Each column represents a different regression. The dependent variables is the log percentage change in real tangible capital stock (ΔK). Control variables not reported. Standard errors in parentheses clustered by country-industry-time. Asterisks, *, **, and ***, denote statistical significance at the 10%, 5%, and 1% levels.

Table D.2: Congestion effects from zombies and distressed nonzombies to nonzombies

	(1) ΔK	(2) ΔIntan	(3) ΔEmp	(4) ΔSales	(5) TFP	(6) Int.rate	(7) ΔDebt
Nonzombie	1.679***	2.950***	6.888***	2.809***	0.231***	-0.632***	3.669***
	(0.061)	(0.090)	(0.147)	(0.092)	(0.007)	(0.107)	(0.132)
Nonzombie×zombie share	-0.015***	-0.030***	-0.024**	-0.032***	-0.001*	0.009	-0.018**
	(0.004)	(0.006)	(0.010)	(0.006)	(0.000)	(0.010)	(0.008)
Nonzombie×distressed NZ share	0.002	-0.040***	-0.041**	-0.011	0.000	0.002	0.005
	(0.006)	(0.008)	(0.017)	(0.008)	(0.001)	(0.009)	(0.012)
Controls	✓	✓	✓	✓	✓	✓	✓
Firm FE	✓	✓	✓	✓	✓	✓	✓
Country×Industry×Time FE	✓	✓	✓	✓	✓	✓	✓
Observations	1,660,195	1,306,965	912,732	1,321,198	737,272	1,216,007	1,603,966
Adjusted R^2	0.205	0.195	0.305	0.195	-0.028	0.400	0.044

Notes: Each column represents a different regression. Dependent variables are: the log percentage change in real tangible capital stock (ΔK), log percentage change in real intangible investment (ΔIntan), log percentage year-on-year change in employment (ΔEMP), log percentage change in real sales (ΔSales), Total Factor Productivity (TFP), implicit interest rate (Int.rate), and log percentage change in real total debt (ΔDebt). Control variables not reported. Standard errors in parentheses clustered by country-industry-time. Asterisks, *, **, and ***, denote statistical significance at the 10%, 5%, and 1% levels.

Table D.3: Congestion effects from zombies to nonzombies: four-digit industry

	(1) ΔK	(2) ΔIntan	(3) ΔEmp	(4) ΔSales	(5) TFP	(6) Int.rate	(7) ΔDebt
Nonzombie	1.676***	2.642***	6.611***	2.695***	0.230***	-0.601***	3.683***
	(0.056)	(0.077)	(0.129)	(0.080)	(0.006)	(0.097)	(0.117)
Nonzombie× zombie share	-0.017***	-0.033***	-0.032***	-0.034***	-0.001*	0.006	-0.018**
	(0.004)	(0.006)	(0.010)	(0.006)	(0.000)	(0.010)	(0.008)
Controls	✓	✓	✓	✓	✓	✓	✓
Firm FE	✓	✓	✓	✓	✓	✓	✓
Country×Industry×Time FE	✓	✓	✓	✓	✓	✓	✓
Observations	1,651,207	1,297,503	903,445	1,311,824	727,872	1,206,548	1,594,857
Adjusted R^2	0.209	0.200	0.309	0.198	0.017	0.409	0.047

Notes: Each column represents a different regression. Dependent variables are: the log percentage change in real tangible capital stock (ΔK), log percentage change in real intangible investment (ΔIntan), log percentage year-on-year change in employment (ΔEMP), log percentage change in real sales (ΔSales), Total Factor Productivity (TFP), implicit interest rate (Int.rate), and log percentage change in real total debt (ΔDebt). Control variables not reported. Standard errors in parentheses clustered by country-industry-time. Asterisks, *, **, and ***, denote statistical significance at the 10%, 5%, and 1% levels.

Table D.4: Congestion effects from zombies to nonzombies: pre-GFC vs post-GFC

	(1) ΔK	(2) ΔIntan	(3) ΔEmp	(4) ΔSales	(5) TFP	(6) Int.rate	(7) ΔDebt
Nonzombie	1.695***	2.728***	6.703***	2.760***	0.233***	-0.582***	3.698***
	(0.056)	(0.078)	(0.132)	(0.082)	(0.006)	(0.095)	(0.118)
Nonzombie×zombie share	0.012	0.020*	-0.034	-0.001	-0.005***	0.135***	0.013
	(0.008)	(0.012)	(0.024)	(0.011)	(0.001)	(0.039)	(0.017)
Nonzombie×zombie share×post-GFC	-0.033***	-0.062***	0.008	-0.038***	0.005***	-0.152***	-0.039**
	(0.008)	(0.013)	(0.024)	(0.011)	(0.001)	(0.037)	(0.018)
Controls	✓	✓	✓	✓	✓	✓	✓
Firm FE	✓	✓	✓	✓	✓	✓	✓
Country×Industry×Time FE	✓	✓	✓	✓	✓	✓	✓
Observations	1,660,513	1,307,290	912,962	1,321,498	737,488	1,216,135	1,604,197
Adjusted R^2	0.205	0.195	0.305	0.195	0.028	0.400	0.044

Notes: Each column represents a different regression. Dependent variables are: the log percentage change in real tangible capital stock (ΔK), log percentage change in real intangible investment (ΔIntan), log percentage year-on-year change in employment (ΔEMP), log percentage change in real sales (ΔSales), Total Factor Productivity (TFP), implicit interest rate (Int.rate), and log percentage change in real total debt (ΔDebt). Control variables not reported. Standard errors in parentheses clustered by country-industry-time. Asterisks, *, **, and ***, denote statistical significance at the 10%, 5%, and 1% levels.

Table D.5: Congestion effects from zombies to nonzombies: AEs vs EMs

	(1) ΔK	(2) ΔIntan	(3) ΔEmp	(4) ΔSales	(5) TFP	(6) Int.rate	(7) ΔDebt
Nonzombie	1.687***	2.702***	6.701***	2.739***	0.232***	-0.603***	3.708***
	(0.056)	(0.078)	(0.132)	(0.082)	(0.006)	(0.097)	(0.118)
Nonzombie×zombie share	-0.010*	-0.016**	-0.024**	-0.015*	-0.003***	-0.008	-0.038***
	(0.006)	(0.007)	(0.011)	(0.008)	(0.000)	(0.007)	(0.011)
Nonzombie× zombie share×EME	-0.009	-0.029***	-0.007	-0.032***	0.004***	0.031**	0.037***
	(0.006)	(0.009)	(0.017)	(0.009)	(0.001)	(0.015)	(0.014)
Controls	✓	✓	✓	✓	✓	✓	✓
Firm FE	✓	✓	✓	✓	✓	✓	✓
Country×Industry×Time FE	✓	✓	✓	✓	✓	✓	✓
Observations	1,660,513	1,307,290	912,962	1,321,498	737,488	1,216,135	1,604,197
Adjusted R^2	0.205	0.195	0.305	0.195	0.028	0.400	0.044

Notes: Each column represents a different regression. Dependent variables are: the log percentage change in real tangible capital stock (ΔK), log percentage change in real intangible investment (ΔIntan), log percentage year-on-year change in employment (ΔEMP), log percentage change in real sales (ΔSales), Total Factor Productivity (TFP), implicit interest rate (Int.rate), and log percentage change in real total debt (ΔDebt). Control variables not reported. Standard errors in parentheses clustered by country-industry-time. Asterisks, *, **, and ***, denote statistical significance at the 10%, 5%, and 1% levels.

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