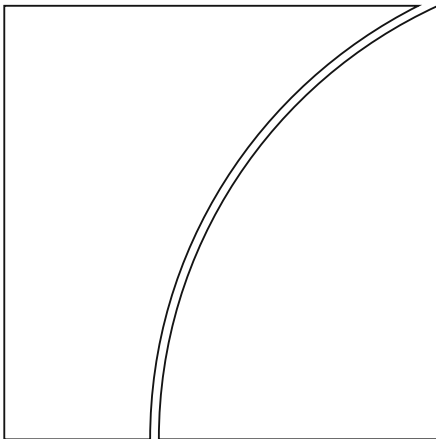




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by Ryan Banerjee and Boris Hofmann

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Corporate zombies: Anatomy and life cycle¹

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ABSTRACT

Using firm-level data on listed non-financial companies in 14 advanced economies, we document a rise in the share of zombie firms, defined as unprofitable firms with low stock market valuation, from 4% in the late 1980s to 15% in 2017. These zombie firms are smaller, less productive, more leveraged, invest less in physical and intangible capital and shrink their assets, debt and employment. Their performance deteriorates several years before zombification and remains significantly poorer than that of non-zombie firms in subsequent years. Over time, some 25% of zombie companies exited the market, while 60% exited from zombie status. However, recovered zombies underperform compared to firms that have never been zombies and they face a high probability of relapsing into zombie status.

Keywords: zombie companies, firm behaviour, economic dynamism, productivity growth, bankruptcy.

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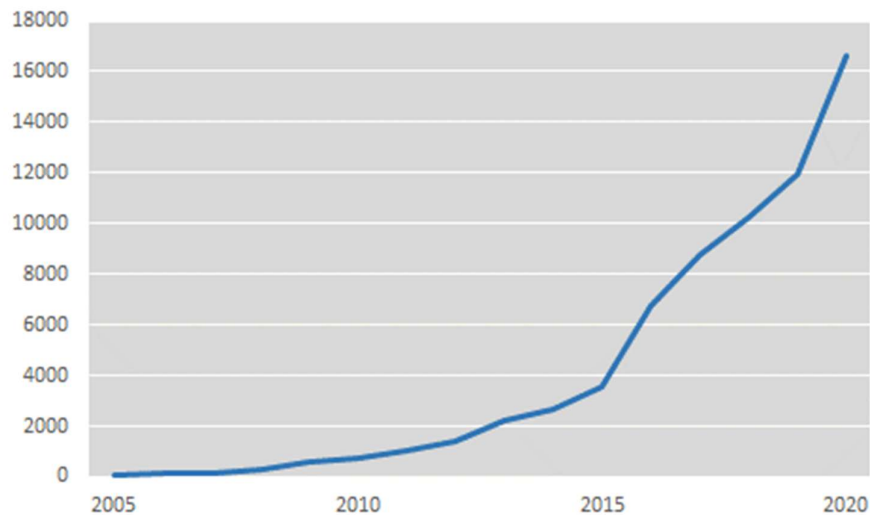
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1. Introduction

The rising number of so-called zombie firms, generally defined as firms that are unprofitable but remain in the market rather than exiting through takeover or bankruptcy, has attracted increasing attention in the public debate (Graph 1). The Covid-19 pandemic has given further impetus to this debate as the crisis puts severe strains on the corporate sector which governments seek to counteract through large-scale support measures (e.g. Financial Times (2020), Lynch (2020)).

The public debate about zombie firms¹

Graph 1



Cumulative number of times the words "zombie firms" or "zombie companies" appeared in English, German, French, Italian and Japanese-language newspapers and news magazines as well as in blog or board entries.

Sources: Authors' search in Factiva.

The literature has so far focused largely on the causes and the consequences of the rise of these firms for other firms and for aggregate productivity. But little is known about the zombies themselves, except that they are commonly found to be less productive than their non-zombie peers. In this paper, we aim to fill this gap by exploring the anatomy and life cycle of zombie companies. Ultimately, better understanding the anatomy and life cycle of zombie firms helps understand what generates these firms, what keeps them going and what determines their death or recovery. At the same time, it also enhances our understanding of their consequences on the corporate sector and the economy more widely, which depends on the characteristics of these firms, their economic weight but also on their ultimate destiny, i.e. if they are doomed or if they can be salvaged.

Using firm-level data covering 14 advanced economies and spanning three decades, we identify zombie companies based on (i) their persistent lack of profitability, i.e. profits insufficient to cover interest payments on debt (interest coverage ratio below one); and (ii) poor expected future growth potential revealed through low equity valuations, i.e. a low ratio of the market value of firm assets to their book value relative to their peers (relatively low Tobin's q). The data for the analysis are from the Worldscope database, providing annual financial statements of listed companies going back to the 1980s.

We explore the anatomy of zombie firms by analysing their characteristics and performance compared with those of non-zombie firms. To this end, we look, *inter alia*, at their size, capital expenditure, intangible investment, employment, productivity, profitability, leverage, borrowing and equity issuance. As mentioned before, while the literature has extensively documented that zombie firms are less productive than their profitable peers, there has been very little analysis of other aspects of their anatomy.

To characterise the life cycle of zombie firms, we analyse the development of their balance sheet, profit and cash flow accounts in the years before and after they are first classified as zombies. This analysis sheds light on the questions of how companies turn into zombies and what happens to them afterwards. In this vein, we also assess how the survival probability of zombie firms compares to that of non-zombies and how long firms remain in zombie status.

We then zoom in on those firms that have managed to recover from zombie status. The number of these firms turns out to be rather high which raises the question whether the zombie problem is just an illusion. The answer to this question depends on the performance of the recovered zombies, whether they become fully normal firms or whether there are indications of some long-term damage from their previous zombification. To assess this point, we calculate the probability of recovered zombie firms relapsing into zombie status and compare their performance with those firms that have never been zombies.

We also assess the economic consequences of the rise of zombie companies. Previous studies have shown that zombies tend to be less productive (Caballero et al. (2008), Adalet McGowan et al. (2017)). Therefore, the higher share of zombie companies could be weighing on aggregate productivity. Moreover, the survival of zombie firms may crowd out investment in and employment at healthy firms. We assess these effects for more countries and a longer period.

Finally, we assess whether there are indications of reduced pressure on zombie firms over time which may explain their rising share and growing persistence since the early 2000s. To this end, we test whether there has been a change in their relative economic and financial performance relative to non-zombie firms since the beginning of the new millennium. We complement this analysis by testing whether low rates and weak banks over this period have influenced the rise of zombie shares through firms' dependence on external financing.

We supplement the main analysis of the paper by a number of additional empirical exercises reported in annexes. In particular, given the novelty of our zombie definition, we assess the robustness of our results with respect to variations in the specification of our zombie definition and with respect to alternative zombie definitions used in the literature, specifically definitions based on old age and subsidised credit.

The main results of our analysis are as follows.

First, we find that the number of zombie firms has on average risen significantly since the 1980s across the 14 advanced economies covered by our analysis. The number of zombies rose from about 4% of all listed firms in the mid-1980s to as many as 15% in 2017. This upward trend is also visible in zombie shares weighted by capital, assets, sales or employment, although the economic weight of zombies is smaller than their weight based on the number of firms. Specifically, the share of listed corporations' employment and capital sunk in zombie firms is lower, in 2017 at 5% and 8%, respectively.

These estimates however likely understate the number and economic weight of zombie firms. This is because our analysis focuses on listed companies which allows us to cover a much longer time span of data and to take into account in our zombie definition the perceived future growth potential as reflected in equity prices. Our analysis therefore does not cover unlisted small and medium-sized enterprises (SMEs), which play an important role in many economies. If SMEs are more susceptible to zombification, then our analysis may understate the number and the economic weight of zombie firms. Indeed, we find that zombie shares are considerably higher in Anglo-Saxon countries, where there is a higher propensity to list on the stock market, in particular for SMEs, than in continental European countries and in Japan. Moreover, we find that amongst listed SMEs, the share of zombie firms in assets, capital and debt is around 40%.

Second, we find that zombies' anatomy differs significantly from that of their non-zombie peers. Specifically, we find that, compared with other firms, zombie

companies are smaller, less productive, and grow less in terms of assets and employment, while spending less on physical and intangible capital. At the same time, they are more leveraged. However, their debt shrinks, albeit at a slower pace than their assets, and they issue more equity compared to other companies. We further find evidence that zombies receive “subsidised” credit as the interest they pay in their debt is not significantly higher than that of non-zombie firms despite their lower profitability and greater riskiness.

Third, the life cycle of zombie companies is marked by a number of key features. In the years before they become a zombie, they experience subdued and falling profitability, productivity, employment and investment compared to non-zombie firms. The deterioration in performance is most pronounced in the two years before zombification, which in part mechanically reflects the way zombie firms are identified. Initially, zombies stay afloat by increasing borrowing and increasing equity issuance as well as by increasing asset disposals relative to non-zombie firms. After zombification, their performance, if they manage to stay in operation, remains significantly poorer than that of non-zombie firms. A zombie firm faces a significantly higher probability of exiting the market through bankruptcy or takeover compared to non-zombie firms, by about 7 percentage points after about five years and staying at that level thereafter.

Fourth, out of the total number of zombie firms that emerged since the mid-1980s, about 25% have exited the market so far (died). Around 60% of zombie firms have managed to recover, meaning that they were at some point no longer identified as zombie firms by our criteria. The recovered zombie firms however remain weak and fragile. Their productivity, profitability, investment and employment growth remain well below those of non-zombies. Reflecting this weak performance, they face a high probability of relapsing into zombie state. By 2017, the probability of becoming a zombie firm in the subsequent year was, at 17%, three times higher for a recovered zombie compared to a firm that has never been a zombie firm. This relapse probability of recovered zombies has increased more than threefold over the past decade.

Fifth, the zombie firms identified through our criteria, besides being less productive, also crowd out growth in more productive firms by locking resources (so-called “congestion effects”), in line with findings reported in the earlier literature. Moreover, we find that an increase in the zombie share in an economy by one percentage point lowers aggregate productivity growth by around 0.1 percentage points in the long run.

Finally, there is evidence of reduced pressure on zombie firms since the early 2000s. Their interest paid as well as their leverage and asset disposal have become indistinguishable from that of non-zombie firms over this period. At the same time, the productivity gap between the two types of firms has widened. Lower interest rates operating through firms' external finance dependence have been a significant contributor to higher sectoral zombie shares over this period.

The remainder of the paper is organised as follows. This section ends with a brief overview of the related literature. Section 2 describes how zombie companies are identified in our analysis. Section 3 provides key facts on the anatomy of zombie firms. In Section 4, we explore the life cycle of zombies. Section 5 zooms in on the recovered zombie firms. Section 6 analyses congestion effects of zombie firms on healthy companies and their impact on aggregate productivity. In section 7, we explore whether there is evidence of any changes in zombie anatomy since the early 2000s linked to reduced financial pressure through low interest rates or weak banks. Section 8 concludes.

Related literature

Our paper contributes to the growing literature on zombie firms and their wider economic causes and consequences. The phenomenon was first observed in Japan, where the emergence of zombie companies was highlighted as a potentially important reason for Japan's lost decade (Caballero et al. (2008)). Adalet McGowan et al. (2018) have documented that the number of zombie firms has increased significantly across the advanced economies in the wake of the Great Financial Crisis (GFC), while Banerjee and Hofmann (2018) document a longer-lasting trend increase since the 1980s. These studies find that the main consequence of zombie firms is reduced economic dynamism and performance. Specifically, zombie firms are found to be less productive and at the same time create congestion effects for other, more productive firms.

With respect to the causes, the literature has identified weak banks as a key factor behind the emergence of zombie firms. Caballero et al. (2008) find that the rise of zombie firms in Japan in the 1990s was linked to weakly capitalised banks which evergreened loans to avoid charge-offs that would have pushed them against regulatory capital limits. More recently, Storz et al. (2017) and Schivardi et al. (2017) document a similar link between weak banks and zombies in the wake of the GFC. Andrews and Petroulakis (2017) highlight the role of bankruptcy laws in the nexus between weak banks and zombie firms.

Press commentaries often point to persistent low interest rates as a key driver of corporate zombification (e.g. Sharma (2019), Taylor (2019), Armstrong (2020)), as they reduce debt service burdens and may induce banks or creditors more generally to evergreen loans to non-viable firms. Yet, analytical studies that formally explore this link are, so far, few. Acharya et al. (2019) find that euro area banks used the capital gains on their bond holdings arising from the launch of the ECB's Outright Monetary Transactions (OMT) in 2012 to increase credit supply mainly to low-quality firms with which they had pre-existing lending relationships. Banerjee and Hofmann (2018) present evidence of a positive link between low rates and the number of zombie companies at the country and at the sectoral level.

2. Identifying zombie firms

We define a zombie company based on a persistent lack of profitability and low stock market valuation. The rationale for this definition is that firms which cannot generate profits over an extended period and whose stock market valuation suggests that they will also not do so in the future should normally exit the market.

Our analysis is based on firm-level data from the Worldscope database, which provides financial statement data for listed companies. We examine a sample of almost 32,000 publicly quoted firms from 14 OECD countries going as far back as 1980.³ Focusing on publicly quoted firms has two main advantages. First, the longer time span of data on these firms allows analysis over several business cycles. Second, it is possible to take into account the perceived future growth potential as reflected in equity prices, which is a key criterion in our zombie definition. A drawback is that publicly quoted firms may not fully representative of the whole population of companies in the economy.

We classify a firm as a zombie if the following conditions are met over two years: (i) its interest rate coverage ratio (ICR), defined as earnings before interest and taxes (EBIT) over interest payments, is below one; and (ii) the ratio of its assets' market value to replacement cost (Tobin's q) is below the median within its sector.⁴ We require some persistence in the lack of profitability and low stock market

³ In order to mitigate the influence of outliers on the analysis, we winsorise all variables in our analysis at the 1st and 99th percentiles.

⁴ We use a relative rather than absolute criterion for Tobin's q in order to avoid that general stock market swings drive the zombie firm count. If we were using an absolute criterion for Tobin's q, general stock market booms would artificially reduce the identified number of zombies, while busts would artificially inflate it.

valuations in order to mitigate the effect of transitory fluctuations of profits and stock prices on the classification. In this vein, we also require a firm to have an ICR larger than one or a Tobin's q above the median also for two consecutive years before it is declassified as a zombie firm. In other words, we require also some persistency in performance improvement before a firm is counted as recovered from zombie status.

Our definition extends profitability-based zombie definitions adopted in previous studies (e.g. Adalet McGowan et al. (2018), Storz et al. (2017), Schivardi et al. (2017)) by adding the requirement that the firm also has a low future profit potential in the eyes of investors as reflected in a relatively low Tobin's q. The purpose of this extension is to avoid characterising firms as zombies that may make losses today but are seen as profitable in the future. This also helps to avoid misclassifying young start-ups that may need some warm-up time to generate profits but are seen by markets as being profitable in the future. In the previous literature, this consideration was often sought to be taken care of by an age restriction, requiring zombie firms to be old. The drawback of this approach is that young firms are ruled out to be zombie firms by definition, although it is not clear *a priori* why they could not be unviable. At the same time, it is not clear why older loss-making firms could not have high growth potential.

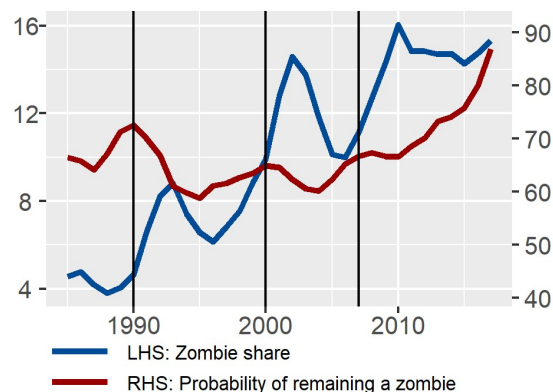
The data suggest that the presence of zombies has increased significantly since the mid-1980s. Graph 2, left-hand panel, shows the evolution of the share of firms classified as zombies in the total population of listed firms (blue line). Across 14 advanced economies, the share rose by 2017 to 15%. This is a more than threefold increase from the level of around 4% that prevailed in the late 1980s. The increase was not steady. Upward shifts linked to economic downturns in the early 1990s, the early 2000s and in 2008 were only partly reversed in subsequent years. The increase that occurred in the wake of the GFC was more persistent than the previous rises. The zombie share peaked in 2010 at 16% and declined in the subsequent recovery by a mere 2 percentage points. Since 2015, the share of zombie companies is already rising again, reaching again 15% in 2017.

The rise of corporate zombies

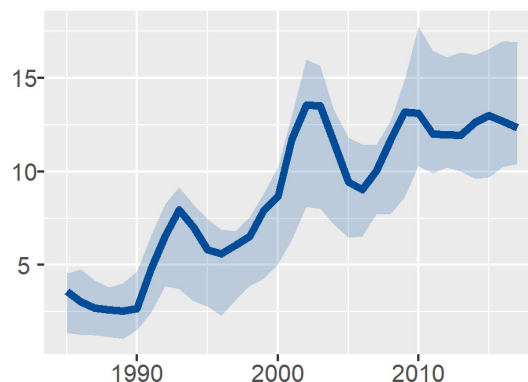
In percent

Graph 2

Share of zombies and zombie persistence¹



Range of zombie share estimates across definitions²



¹ Zombie firms defined as firms with both an interest coverage ratio of less than 1 and a Tobin's q below the median firm in the sector over two years. To be declassified as a zombie firm, an ICR larger than one or a Tobin's q above the sector median over two years is required. Zombie share is the ratio of zombie firms to all firms. The probability of remaining a zombie firm is calculated as the number of firms that are classified a zombie in year t that remain a zombie in year $t+1$ divided by the number of firms that are classified a zombie in year t . Vertical lines indicate major business cycle peaks across the 14 countries covered by our analysis in 1990, 2000 and 2007. ² The shaded area shows the median and range of the estimated share of zombie firms across 8 definitions: (1) baseline definition described in footnote 1; (2) 3-year entry/exit: a firm is defined a zombie if it has an ICR<1 and Tobin's q is below the industry median for three consecutive years and only exits zombie state if either the firm's ICR ≥ 1 or its Tobin's q is above the industry median for three consecutive years; (3) EBITDA based interest coverage ratio: Same definition as footnote 1, except that income defined as EBITDA instead of EBIT in the interest coverage ratio; (4) Country median Tobin's q : a firm is defined a zombie if it has an ICR<1 for two consecutive years and its Tobin's q is below the country median. A firm only exits zombie state if either the firm's ICR ≥ 1 for two consecutive years or if its Tobin's q is above the country median for two consecutive years; (5) ICR<1 for 3 years, and age >10: a firm is classified as zombie if its ICR<1 for 3 years, and age >10 years following the definition in Adalet McGowan et al. (2018); (6) Subsidised credit: a firm is defined a zombie if its ICR<1 and the average interest rates on debt in non-AAA firms is less than that of AAA-rated firms based on their ICR. Following Acharya et al (2019) we split firms into those with short-term debt above and below 50% of total debt when comparing a firm's average interest rate to AAA firms; (7) Excluding commodity sectors: baseline definition described in footnote 1 but sample excluding commodity sectors; (8) Excluding US and UK firms: baseline definition described in footnote 1 but sample excluding US and UK firms.

Sources: Datastream Worldscope; authors' calculations.

At the same time, there has been a greater persistence in zombification, with firms staying in a zombie state for longer. Graph 2, left-hand panel, reports the evolution over time of the probability of a firm remaining in the zombie state from one year to the next (red line). This probability is calculated as the number of firms that are classified as a zombie in year t and that remain a zombie in year $t+1$ divided by the number of firms that are classified as a zombie in year t . The chart shows that the probability of a zombie remaining a zombie in the following year rose from around 70% in the late 1980s to 85% in 2017.

The upward trend in the zombie share is robust to modifications of the definition and of the country and sector coverage, as shown in Graph 2, right-hand panel, which displays the range of zombie shares obtained from a number of robustness checks discussed in more detail in Annex 1. There we show that the precise specification of our zombie definition with respect to the number of years the criteria have to be met or the choice of the reference Tobin's q , sectoral or

national, or whether we based the profitability criterion on EBITDA rather than EBIT does not qualitatively affect our results. This is demonstrated in Annex 1. Applying our criteria over a three year instead of a two-year window and using the median of Tobin's q within the country rather than the sector as the benchmark yield a very similar pattern of the evolution of the zombie share over time and also very similar results with respect to the anatomy and life cycle of the identified zombie firms (see Annex 1). Similarly, excluding countries with large equity markets (United States and United Kingdom) or high-zombie share sectors (commodities and mining) does not eliminate the secular upward trend.

In Annex 1, we further consider two alternative zombie firm definitions that have been used in previous studies: the definition of Adalet McGowan et al. (2018) requiring a zombie firm to have an $ICR < 1$ for at least three years and at least ten years of age; and a definition factoring in subsidised credit similar to Acharya et al. (2019). Also here we obtain an upward ratcheting pattern of the zombie share over time similar to that in Graph 2. That said, there are differences with respect to the quantitative assessment of the extent of zombification, in particular at the end of the sample period. These discrepancies reflect the fact that the alternative definitions identify zombie firms with somewhat different characteristics compared to those identified by our criteria. In particular, as discussed in Annex 1, the alternative zombie definitions identify firms as zombies that on average have a high Tobin's q , which seems inconsistent with the notion of unviability.

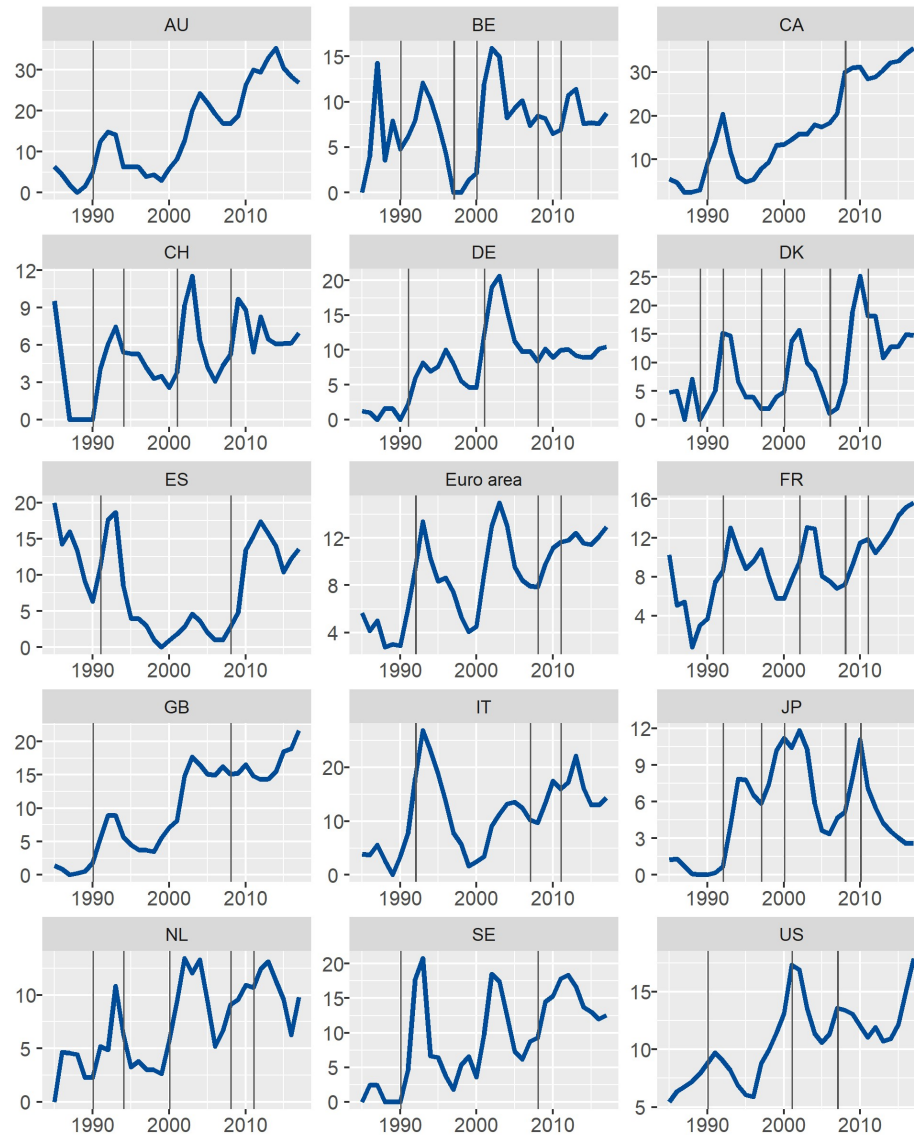
The aggregate zombie share shown in Graph 2 conceals considerable cross-country heterogeneity (Graph 3). Specifically, we find that the zombie share is highest in Anglo-Saxon countries. Australia and Canada register the highest zombie shares in 2017, ranging around 30%, and also in the United Kingdom and the United States the numbers are quite high, near 20%. In this group of countries, except for Australia, zombie shares have kept on rising in the wake of the GFC. In the euro area, the zombie shares are lower and below their GFC highs, but they have also tripled to above 12% since the late 1980s. Within the euro area, the exception is France, where the share more than doubled since 2008. In Japan, the zombie share is currently low at around 3%. Our analysis reproduces the sharp rise in Japanese zombie firms in the 1990s, as documented in Caballero et al. (2008) and the subsequent decline associated with the clean-up and recapitalisation of the Japanese banking sector in the 2000s.⁵

⁵ Our finding of a rather low zombie share in Japan is consistent with the decade-long debate on zombification in Japan. This debate highlighted that profitability-based zombie definitions tend to yield smaller zombie shares than those based on subsidised credit as the latter might misclassify healthy firms as zombies (see e.g. Fukuda and Nakamura (2011), Imai (2016)).

Zombie shares by country¹

In per cent

Graph 3



¹ Zombie firms defined as firms with both an interest coverage ratio of less than 1 and a Tobin's q below the median firm in the sector over two years. To be declassified as a zombie firm, an ICR larger than one or a Tobin's q above the sector median over two years is required. Vertical lines indicate business cycle peaks according to ECRI and OECD classifications.

Sources: Datastream Worldscope; authors' calculations.

Moreover, our sample of listed firms misses the post-GFC increase in non-listed low-return borrowers in Japan that has been highlighted for example by the Bank of Japan (2019).

The vertical lines in Graph 3 highlight the frequent association of increases in the zombie share with business cycle peaks at the national level. In order to test the role of business cycle turning points more formally, we run a panel regression for the national zombie shares, assessing the impact of recession dates on zombie shares in subsequent years. The left-hand panel of Graph 4 shows the deviation of zombie shares in the cross section of 14 countries from their mean after business cycle peaks.⁶ The chart shows that in the wake of a recession, the zombie share rises by up to more than three percentage points two years later relative to the mean. Subsequently, the share recedes towards its average but still remains noticeably elevated four years after.

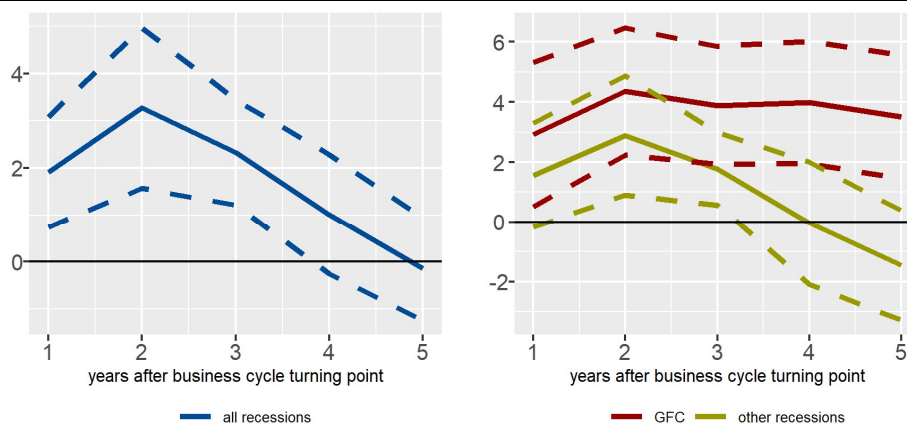
Zombies shares after recessions¹

In percentage points

Graph 4

All recessions²

GFC vs other recessions³



¹ Deviation of zombie share from country-specific mean in the years after a business cycle peak. Estimates based on panel regressions of the country zombie share on a country recession dummy, controlling for country fixed effects. The recession dummy takes the value one in years of business cycle peaks and zero otherwise. Business cycle peaks are based on classifications by ECRI and OECD composite leading indicators. Broken lines indicate 95% confidence bands based on standard errors clustered at the country level. Zombie firms defined as firms with both an interest coverage ratio of less than 1 and a Tobin's q below the median firm in the sector over two years. To be declassified as a zombie firm, an ICR larger than one or a Tobin's q above the sector median over two years is required.

Sources: Datastream Worldscope; ECRI, OECD, authors' calculations.

The right-hand panel of Graph 4 distinguishes between recessions associated with the GFC 2007-2009 and the recessions in the other years. The chart shows that the impact of the GFC on zombie shares was considerably larger and more persistent than that of other recessions, probably reflecting the fact that it was a

⁶ Business cycle peaks are based on classifications of the Economic Cycle Research Institute (ECRI) and the OECD composite leading business cycle indicators.

deeper recession and associated with a global financial crisis. The more persistent increase in the zombie share after the GFC may also reflect the unprecedented policy response with a massive and prolonged easing of monetary conditions. This may have helped zombie firms remain in operation, dampening the recession “cleansing effect” (Foster et al. (2017)).

Besides business cycles and financial crises, structural factors may explain cross-country differences in zombie shares and their evolution over time. One factor are differences in the propensity to list on stock markets across countries. As mentioned before, our dataset only includes listed corporates – as we make use of stock market valuations to identify zombie firms. However, the propensity of firms to list is very heterogeneous across economies. Anglo-Saxon economies tend to have more listed firms, including in particular also more listed SMEs.⁷ The share of SMEs (defined as firms with an annual turnover of less than 50 million US dollars)⁸ in all listed firms in 2017 was on average 50% in the four Anglo-Saxon countries, 28% in the nine continental European countries and just 15% in Japan.⁹ As SMEs are more likely to be zombies as we will show below, the higher zombie share in Anglo-Saxon economies reflects in part their higher share of SMEs among listed companies. Put differently, the underrepresentation of SMEs in the group of listed firms in continental Europe and Japan means that the true zombie share in these economies is probably higher than our estimates suggest. Our estimates of zombie shares for these countries, and therefore also for the aggregate reported in Graph 2, are therefore probably conservative lower bounds.

At the same time, tax and insolvency regimes play a role. As interest expenses are generally deductible from taxable profits, tax systems favour debt financing over equity financing, with higher corporate tax rates giving rise to greater incentives for firms to lever up. Indeed, empirical evidence suggests that leverage tends to be positively related to the corporate tax rate (Graham (2003), Feld et al. (2013)). Higher leverage would imply higher interest expenses and hence a lower

⁷ Kahle and Stulz (2017) show that over the past four decades, the number of publicly listed companies has decreased by about 20% and that the remaining public companies are much larger than in the past. A similar development is observed more generally across OECD countries (OECD (2019)).

⁸ This definition follows that adopted by the European Commission. Another criterion defining an SME is that the number of employees should be below 250. We do not use the employment criterion here as the reporting of employment numbers is somewhat less populated in the Worldscope database.

⁹ A similar picture emerges when looking at the share of listed companies in the non-financial corporate sector (NFC) gross value added. For instance, in the United States and the euro area, where data on NFC gross value added is available from the national accounts, the share of listed companies' value added in 2016 was 64% and 42%, respectively.

ICR which could also systematically affect the share of zombie firms in a country. At the same time, poorly designed insolvency regimes increase the cost and time of corporate bankruptcy or inhibit corporate restructuring, thus helping to create zombie firms. Andrews and Petroulakis (2017) present evidence suggesting that improvements in bank health are more likely to be associated with a reduction in the prevalence of zombie firms in countries with more efficient insolvency regimes.

Another factor influencing the country zombie shares are differences at the sectoral level. There is indeed considerable variation in zombie shares at the sectoral level (Graph 5). In particular, in 2017 commodity sectors are characterised by relatively high shares of zombie firms (40%), probably reflecting the aftermath of the commodity super cycle of the past two decades. The relatively high shares of zombie firms we find for Australia and Canada reflects in large part the relatively greater importance of the commodity sector in these economies. Indeed, more than two thirds of zombie firms in these countries in 2017 were commodity firms. That said, excluding the commodity sector does not qualitatively change the evolution over time of the national zombie shares.¹⁰

The second largest presence of zombie firms is in the healthcare sector. This might change in the wake of the Covid-19 shock, which could boost the profitability and stock valuations of these firms, just as it could dampen them in other sectors that used to be characterised by low degrees of zombification (e.g. retail and transportation). Finally, the printing and publishing sector also has relatively high shares. The structural challenges from digitisation could be one driver here.

The public debate usually focuses on the rising number of zombie companies as documented above. But how important are these zombie companies economically? In order to assess this question, we compute the share of zombie companies in the total assets, the capital stock, employment and sales of all listed non-financial corporates (i.e. total zombie assets/capital/employment/sales as a ratio of that of all firms).¹¹ Graph 6 (left-hand panel) shows that the economic weight of zombies is lower than their number. In 2017, our last data point, the share in assets, capital, employment and sales was 6%, 8%, 5% and 5%, respectively.

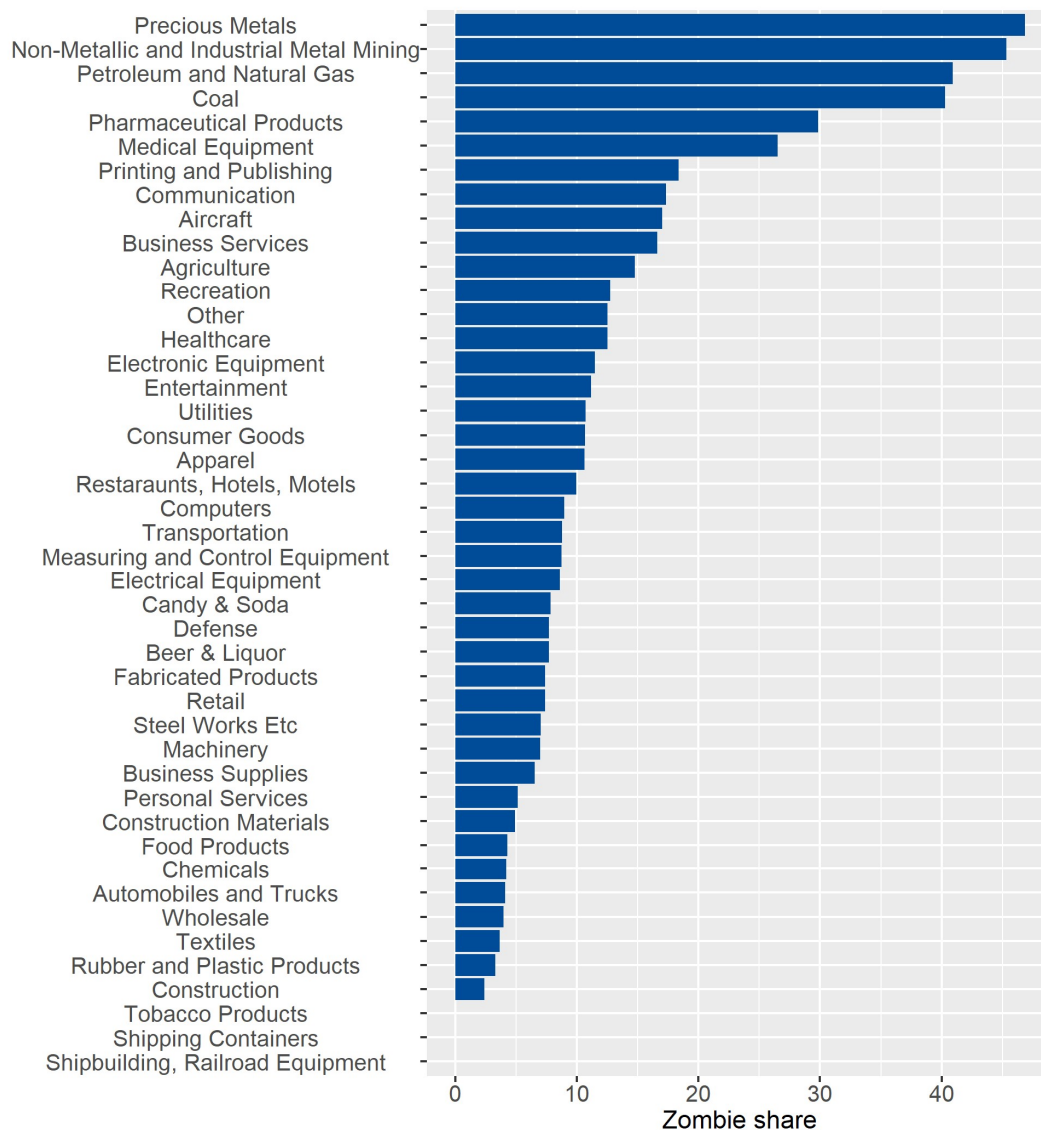
¹⁰ Results of the analysis excluding the commodity sector are available upon request.

¹¹ We do not report the share in employment as firm employment is less consistently reported in the Worldscope database, in particular for small firms.

Zombie shares by sector¹

In per cent, 2017 shares

Graph 5



¹ Sector definitions based on Fama-French 48 sectors. Zombie firms defined as firms with both an interest coverage ratio of less than 1 and a Tobin's q below the median firm in the sector over two years. To be declassified as a zombie firm, an ICR larger than one or a Tobin's q above the sector median over two years is required.

Sources: Datastream Worldscope; authors' calculations.

The upward trend in the zombie share since the late 1980s also holds in the weighted shares, although the increase is flatter in the employment and sales weighted shares. Interestingly, while the weighted shares have moved closely together pre-GFC, there has been a decoupling more recently, with the capital and asset shares rising while the employment and sales weighted shares moved sideways. This suggests that the role of zombie firms in economic activity has not increased recently. It also suggests, however, that a growing share of capital and assets is sunk in firms that contribute little to employment and growth.

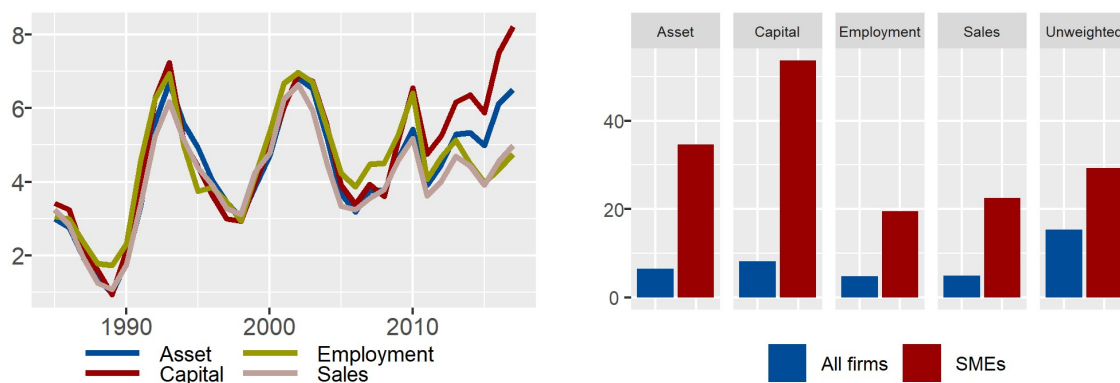
Weighted zombie shares

In percent

Graph 6

Total share of zombie firms¹

Share of zombie firms in SMEs in 2017²



¹ Zombie firms defined as firms with both an interest coverage ratio of less than 1 and a Tobin's q below the median firm in the sector over two years. To be declassified as a zombie firm, an ICR larger than one or a Tobin's q above the sector median over two years is required. ² SMEs defined as firms with an annual turnover of less than 50 million US dollars.

Sources: Datastream Worldscope; authors' calculations.

Overall, these numbers suggest that zombies tend to be smaller than non-zombie firms. More to the point, this seems to imply that zombies are probably economically less important. However, amongst listed SMEs (defined as described above), the share of zombie firms in assets, capital, employment and sales is substantially higher at around 20%-50% (Graph 6, right-hand panel).¹² If SMEs are more likely to be zombie firms, as our analysis suggests, the weight of zombie firms in the total economy, where unlisted SMEs in many countries play an important

¹² These relatively large number are not due to an adverse selection bias in our data of listed firms, merely capturing listed firms shrinking to SME status because of poor performance. Out of the listed SME zombies identified by our analysis, only a very small fraction, about 7 percent, were larger firms earlier in their life.

role, may well be larger than their weight in the population of companies listed on the stock market.¹³

3. Zombie anatomy

This section reports stylised facts about the anatomy of zombie companies. Specifically, we look at financial statements to flesh out the characteristics that distinguish them from other firms. In Table 1 we report sample averages with asterisks indicating whether the difference between the zombie and non-zombie means is statistically significant. We further report the median and the upper and lower quartiles of the distributions in order to get a better picture of the relevance of the tails of the distribution.

The statistics highlight a number of key facts about the anatomy of zombie firms. Zombie companies are much smaller than non-zombie firms. Assets, capital stock and employment of non-zombie firms are on average three times larger than those of zombie companies. This is consistent with the observation that we made in the previous section that the share of zombies is considerably higher amongst SMEs compared to the total population of firms.

Zombie firms are also less dynamic. They invest less, with capex about 0.5 percentage points of assets lower than that of non-zombies and investment in intangible capital (i.e. research and development (R&D) and organisational capital) about 2 percentage points of capital lower.¹⁴

Zombies are shrinking their operations, as reflected in higher asset disposal and declining employment. Their asset disposal (i.e. cash raised through asset sales) is roughly 0.5 percentage points higher than that of their non-zombie peers. At the same time, the number of employees in zombie firms on average fell by more than 7% per year, compared to employment growth of more than 3% in other firms.

¹³ Indeed, comparisons of public and private firms suggest that the latter are smaller in size (assets), have higher leverage, lower cashflow and grow at a slower pace (Brav (2009), Badertscher et al. (2019)). Badertscher et al. (2019) further find that default rates of private firms are significantly higher than those of public companies. This supports the notion that non-listed firms have overall weaker performance and more vulnerable balance sheets, putting them at greater risk of zombification. It further suggests that they may be more similar to listed SMEs than to the overall population of listed companies, or may be somewhere in between the two groups.

¹⁴ The definition follows Peters and Taylor (2017), who measure intangible investment as the sum of R&D expenditures plus 30% of selling, general and administrative expenditure to capture expenditures on organisational capital.

Zombie firms' anatomy¹

Means,¹ medians and quartiles

Table 1

	Mean		Median and quartiles					
	Non-zombie ¹¹	Zombie ¹¹	Non-zombie			Zombie		
			25th	50th	75th	25th	50th	75th
Total assets ²	23,244	7,361***	689	3,023	12,922	153	605	2,652
Capital stock ^{2,3}	16,468	6,173***	289	1,626	7,565	66	364	1,946
Employees	7,076	2,541***	305	1,123	4,470	78	314	1,300
Capex ⁴	5.59	5.14***	1.53	3.64	7.03	0.74	2.34	5.86
Intangible investment ⁵	10.09	8.01***	2.17	7.12	13.69	1.15	4.83	11.21
Asset disposal ⁴	1.18	1.92***	0	0.07	0.60	0	0.02	0.82
Employment growth ⁶	3.82	-7.24***	-3.39	1.54	9.46	-18.18	-4.83	3.23
Labour productivity ⁷	3.47	1.76***	1.45	2.22	3.42	0.03	1.08	1.94
TFP ⁷	7.02	3.68***	2.45	4.24	8.09	1.11	2.41	4.63
Cash flow ⁴	13.69	-3.45***	8.19	15.15	23.91	-10.16	0.42	8.25
Interest coverage ratio	16.09	-17.93***	1.17	4.79	18.78	-49.88	-7.54	-0.72
Tobin's q	2.24	1.13***	1.02	1.32	1.98	0.74	0.96	1.19
Dividends paid ⁴	1.36	0.17***	0	0.56	1.73	0	0	0
Interest paid ⁴	2.13	2.22	0.23	0.97	2.28	0.08	0.92	2.68
Book leverage ⁹	23.57	24.29***	5.08	19.80	35.21	0.18	18.08	39.96
Market leverage ⁹	18.3	23.82***	3.11	14.08	28.65	0.19	18.55	41.65
Debt growth ⁶	3.29	-4.27***	-17.58	-0.06	21.92	-27.38	-2.96	17.36
Equity Issuance ⁴	5.61	7.17***	0	0.05	1.08	0	0.01	4.97
Exit probability ¹⁰	0.04	0.09***						

¹ Units are in percentage points except for log assets where it is in percent and the ICR and Tobin's q are expressed as ratios. ***/**/* indicate significant difference in means at the 1/5/10% level relative to non-zombie firms after controlling for country, sector and time fixed effects. ² In thousands of 2010 US dollars. ³ Plant, property and equipment. ⁴ As a ratio of total assets (in percent). ⁵ As a ratio of capital stock (in percent). ⁶ Growth rate defined as $(x_t - x_{t-1}) / (0.5(x_t + x_{t-1})) * 100$. ⁷ Labour productivity is computed following Gopinath et al. (2017) as real output divided by the real wage bill. Real output is computed as nominal value added (wage bill plus gross profits) converted into US dollars divided by the US CPI deflator. For firms with missing wage bill we follow Imrohroglu and Tuzel (2013) and impute the wage bill using the number of employees in the firm multiplied by the average industry wage computed at the two digit SIC level. ⁸ TFP is the level of total factor productivity estimated using the semi-parametric estimator proposed by Levinsohn and Petrin (2003). Real value added and labour inputs are measured as for labour productivity. The real capital stock is the nominal value of fixed capital deflated by the CPI deflator. Material inputs as materials if available or operating expenses minus staff costs following Imrohroglu and Tuzel (2013). ⁹ Total debt at book/market value as a ratio of total assets. ¹⁰ Firm exit/death where Worldscope classifies the reason for exiting the database as either: "DEAD", "MERGER", "TAKEOVER" or "LIQUIDATED". ¹¹ Zombie firms defined as firms with both an interest coverage ratio of less than 1 and a Tobin's q below the median firm in the sector over two years. To be declassified as a zombie firm, an ICR larger than one or a Tobin's q above the sector median over two years is required.

In line with previous evidence, we find that zombies are less productive than non-zombie firms. Both their labour productivity and their total factor productivity

(TFP) are respectively only about half the level of that of other companies.¹⁵ Zombies are further characterised by negative cash flow and negative ICRs as well as a low Tobin's q , essentially reflecting the way they have been defined. At the same time, they pay out lower dividends, by more than 1 percentage point of total assets compared to other companies, reflecting their lower profitability. The median and quartiles of the distribution reveal that only very few zombie firms pay dividends at all. The median and also the upper quartile of the distribution of zombie dividends is exactly 0.

There is also evidence that zombie firms receive subsidised credit. While interest paid relative to total assets is 0.1 percentage points higher for zombie firms, the difference to non-zombie firms is not statistically significant despite their lower profitability and greater riskiness. The median zombie firm even pays slightly lower interest and the lower quartile of interest payment is below that of non-zombie companies. It would appear that properly taking into account the greater credit risk associated with lending to zombie firms should be reflected in significantly higher interest payments of these firms relative to non-zombie firms.

The table further shows that zombie companies are significantly more leveraged than other firms, both in terms of book leverage and market leverage. There is, however, substantial cross-sectional variation across firms, in particular for zombie firms. The interquartile range of the zombie leverage ratio is respectively 0.18 – 39.96 for book leverage and 0.19 – 41.64 for market leverage. This compares to ranges of 5.08 – 35.21 and 3.11 – 28.65 respectively for non-zombie firms.

While zombie firms are more leveraged, they are on average reducing their debt at an annual rate of 4%, probably reflecting efforts to reduce leverage or difficulties in obtaining credit despite being kept alive. However, also here the average number conceals considerable variation across firms, with an interquartile range of debt growth of -27.38% – 17.36%. At the same time, zombies issue significantly more equity than other firms do (relative to total assets). This result is consistent with the

¹⁵ Labour productivity is computed following Gopinath et al. (2017) as real output divided by the real wage bill. Real output is computed as nominal value added (wage bill plus gross profits). For firms with missing wage bill we follow Imrohorglu and Tuzel (2013) and impute the wage bill using the number of employees in the firm multiplied by the average industry wage computed at the two digit SIC level. To compute real variables, nominal values in local currency are first converted into US dollars and then divided by the US CPI deflator. TFP is the level of total factor productivity estimated using the semi-parametric estimator proposed by Levinsohn and Petrin (2003). Real value added and labour inputs are measured as above. The real capital stock is the nominal value of fixed capital deflated by the CPI deflator. Material inputs as materials if available or operating expenses minus staff costs following Imrohorglu and Tuzel (2013).

finding by Denis and McKeon (2018) that loss-making US corporates frequently issue equity through private placements, and use the funds raised to cover operating losses. That said, the mean equity issuance is driven by a few large issuances, reflected in mean issuance being higher than the upper quartile of the distribution.

Finally, the last row of Table 1 also reports average exit probabilities. The figures reveal that zombie firms face a probability of exiting the market in any given period (through bankruptcy, merger or take-over)¹⁶ that is more than twice as high as that of non-zombie firms: 9% vs. 4%. This raises the question how the exiting zombie firms compare to those staying on, and how the exiting non-zombies compare to the continuing zombies.

In order to address these questions, we report in Table 2 the same anatomy statistics as in Table 1, but with both zombie and non-zombie firms broken down into those that exited over the sample period and those that did not. In order to keep the table tractable we focus on averages, bearing in mind that the averages sometimes conceal significant cross-sectional variation as discussed above.

The statistics reported in Table 2 suggest that exiting zombie firms were, surprisingly, more productive and made smaller losses than zombie firms that stayed in the market. They were however more leveraged and paid higher interest expenses. Also non-zombie firms that exited were more leveraged and paid higher interest expenses than zombie firms that continued operation, while they were more productive and dynamic. This suggests that leverage and the interest paid on the debt rather than firm performance are key factors for firm exit, of both zombie and non-zombie companies.

¹⁶ We define a firm exit/death if Worldscope classifies the reason for exiting the database as either: “DEAD”, “MERGER”, “TAKEOVER” or “LIQUIDATED”. We do not classify a firm as having exited if it drops out of the database without one of these four reasons. In particular, delisting does not count as exit.

Anatomy of zombie firms: Exiters vs remainers¹

Means Table 2

	Non-zombie		Zombie ¹⁰	
	Exit ⁹	No exit	Exit ⁹	No exit
Total assets ²	14,645	28,088	6,486	7,970
Capital stock ^{2,3}	10,315	20,018	4,986	7,095
Employees	4,949	8,323	2,219	2,833
Capex ⁴	6.21	5.24	5.07	5.19
Intangible investment ⁴	10.55	9.84	8.45	7.68
Asset disposal ⁴	1.47	1.00	2.35	1.6
Employment growth ⁵	3.8	3.83	-8.01	-6.53
Labour productivity ⁶	3.27	3.56	2.25	1.5
TFP ⁷	6.49	7.33	4.04	3.39
Cash flow ⁴	15.15	12.86	-1.16	-5.06
Interest coverage ratio	12.65	18.02	-14.33	-20.43
Tobin's q	2.09	2.33	1.14	1.12
Dividends paid ⁴	1.33	1.38	0.18	0.16
Interest paid ⁴	2.45	1.95	2.68	1.91
Book leverage ⁸	24.53	23.02	28.76	21.09
Market leverage ⁸	19.08	17.85	27.89	20.91
Debt growth ⁵	3.71	3.05	-5.24	-3.49
Equity Issuance ⁴	5.31	5.77	5.95	8.02

¹ Units are in percentage points except for log assets where it is in percent and the ICR and Tobin's q are expressed as ratios. ² In thousands of 2010 US dollars. ³ Plant, property and equipment. ⁴ As a ratio of total assets (in percent). ⁵ Growth rate defined as $(x_t - x_{t-1}) / (0.5(x_t + x_{t-1})) * 100$. ⁶ Labour productivity is computed following Gopinath et al. (2017) as real output divided by the real wage bill. Real output is computed as nominal value added (wage bill plus gross profits) converted into US dollars divided by the US CPI deflator. For firms with missing wage bill we follow Imrohroglu and Tuzel (2013) and impute the wage bill using the number of employees in the firm multiplied by the average industry wage computed at the two digit SIC level. ⁷ TFP is the level of total factor productivity estimated using the semi-parametric estimator proposed by Levinsohn and Petrin (2003). Real value added and labour inputs are measured as for labour productivity. The real capital stock is the nominal value of fixed capital deflated by the CPI deflator. Material inputs as materials if available or operating expenses minus staff costs following Imrohroglu and Tuzel (2013). ⁸ Total debt at book/market value as a ratio of total assets. ⁹ Firm exit/death where Worldscope classifies the reason for exiting the database as either: "DEAD", "MERGER", "TAKEOVER" or "LIQUIDATED". ¹⁰ Zombie firms defined as firms with both an interest coverage ratio of less than 1 and a Tobin's q below the median firm in the sector over two years. To be declassified as a zombie firm, an ICR larger than one or a Tobin's q above the sector median over two years is required.

4. Zombie life cycle

As the next step, we document in this section stylised facts about the life cycle of zombie firms. How do these firms develop before morphing into a zombie? And how do they evolve afterwards? We shed light on these questions by analysing their performance around the year when they were first classified as a zombie firm, i.e. by looking at their dynamics around zombification. Moreover, we assess the survival probability a zombie company.

Zombification dynamics

In order to flesh out zombie life cycle dynamics, we run local linear projection regressions of the following form:

$$\begin{aligned} y_{i,c,s,t+h} &= \alpha_{c,s,t+h} + \beta_h D(\text{Enterzombie})_{i,c,s,t} \\ &+ \gamma_h D(\text{Prezombie})_{i,c,s,t} \\ &+ \theta_h X_{i,c,s,t-5} + \varepsilon_{i,c,s,t+h} \end{aligned}$$

for $h = \{-4, -3, -2, -1, 0, 1, 2, 3, 4\}$. $y_{i,c,s,t+h}$ is a measure of firm performance (e.g. capex) of firm i in country c and sector s in period $t+h$, $D(\text{Enterzombie})_{i,c,s,t}$ is a dummy variable that takes the value one if the firm became a zombie in period t . To compare newly minted zombies with healthy firms only we include as a control variable $D(\text{Prezombie})_{i,c,s,t}$ which is a dummy variable that takes the value one if the firm is a zombie in period t but did not enter in zombie status in this period. $X_{i,c,s,t-5}$ is the five year lagged log of total assets in constant US dollars to control for initial size in the year preceding the horizon of our life cycle analysis which ranges from $t-4$ to $t+4$.¹⁷ The regressions further include for country-sector-time fixed effects ($\alpha_{c,s,t+h}$) controlling for country-sector-specific business cycles. Standard errors are clustered at the country-sector level.

The coefficients β_h trace the dynamics of the firm balance sheet and profit account variables from four years before to four years after the year when a firm was classified as a zombie. The coefficients measure zombie performance relative to non-zombie firms, so that a value above (below) zero means that the realisation of that variable was higher (lower) for zombie firms than for the non-zombie benchmark, conditional on the control variables included. In the following, we report the point estimates together with 95% confidence bands (clustered at the country-sector level). We focus on those firms that are still alive in $t+4$ in order to avoid introducing a survivorship bias in the estimated trajectories that would arise if the worst firms drop out because of exit over time.

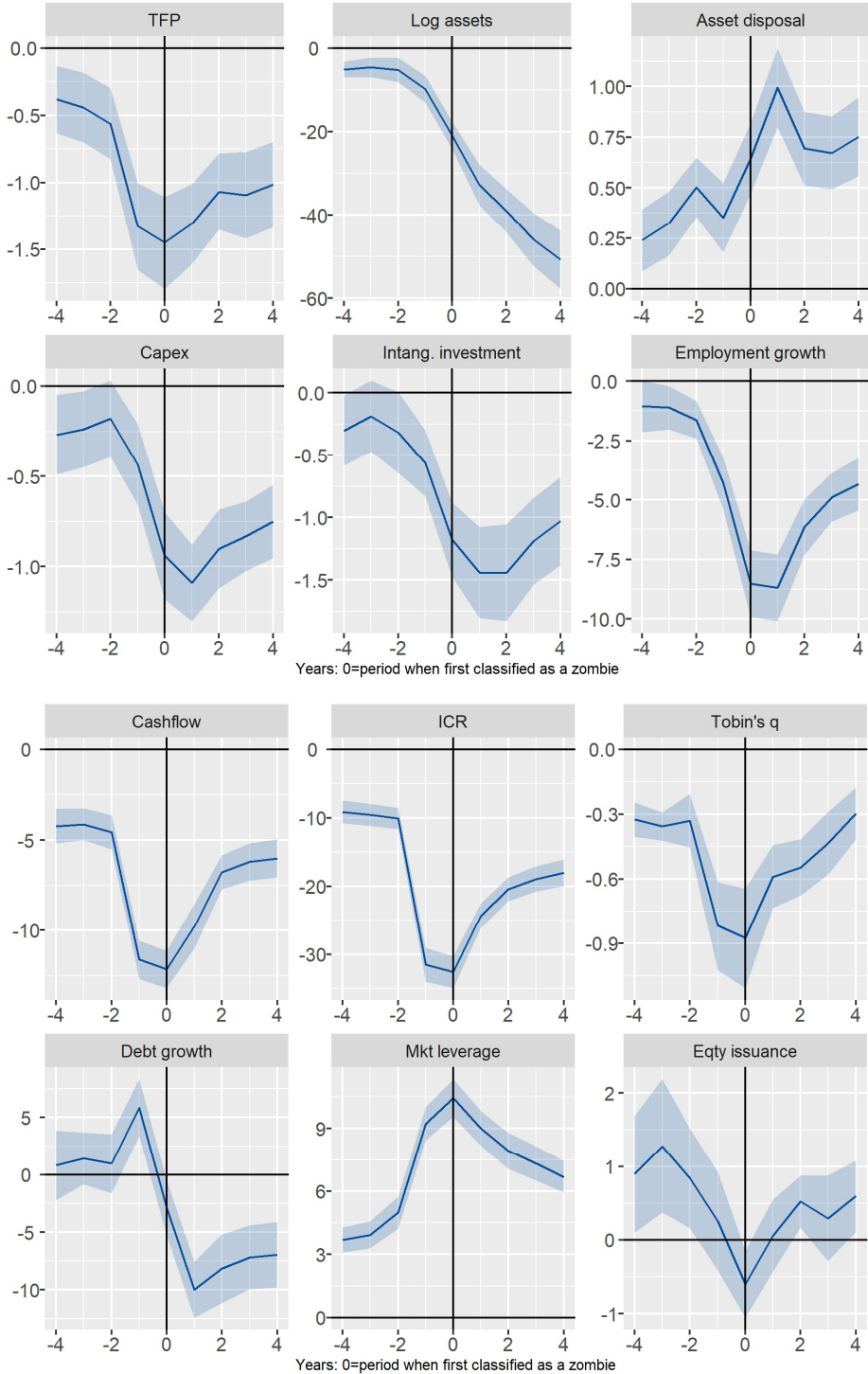
The results reported in Graph 7 suggest that the performance of zombie companies in terms of productivity, business activity and profitability is below that of non-zombie firms already four years before the date of zombification. A

¹⁷ Frank and Goyal (2009) show that firm size, alongside profitability and the market-to-book ratio, consistently correlates with many capital structure decisions. We only select firm size as this is not included in the zombie firm definition.

significant deterioration in the performance is registered in $t-2$ and $t-1$. Their productivity declines and their assets, capital and intangible investment and employment shrink. As a mirror image of shrinking asset size, zombie firms' asset disposal is significantly above that of non-zombies and rises steeply in the years before a company becomes a zombie. At the same time, their cash flow and ICR as well as their Tobin's q decline drastically relative to that of non-zombie companies. This deterioration in performance in the two years ahead of zombification reflects of course somewhat mechanically the way zombie firms are defined, namely by low profits and low Tobin's q over a two-year period.

After zombification, firms' performance improves, but still does not catch up with that of healthy firms. Also, four years after becoming a zombie firm, if still in operation, productivity, activity and profitability is significantly below that of non-zombie firms. In particular, their productivity remains more than 1 percentage point below that of the non-zombie benchmark in $t+4$. At the same time, in the post-zombification years, these firms continue to shrink significantly in terms of their asset size, partly reflecting rising asset disposal. They recover somewhat in terms of capex, intangible investment and employment growth. Also their cash flow and their Tobin's q improve, suggesting that markets increasingly seem to expect that the firms can recover the longer they survive. However, also in these dimensions, zombie firm performance remains well and significantly below the non-zombie benchmark in $t+4$.

The bottom panels of Graph 7 show the dynamics of debt and equity issuance of zombies around the date of zombification. The charts suggest that zombies stay afloat by issuing equity both before and after zombification, significantly more so than their profitable peers, except for the year they turn zombies when their equity issuance temporarily collapses. Up to two years before being classified as a zombie, a firm's indebtedness grows strongly relative to that of its non-zombie peers. Subsequently, debt accumulation drops significantly and continues to fall after the firm became a zombie. Leverage nevertheless rises all the way relative to non-zombies in the years before zombification as assets and their valuations fall at a faster rate than debt. After the date a firm has turned zombie, leverage starts to fall but stays significantly above that of profitable firms.



¹ Units are in percentage points except for log assets where it is in percent and the ICR and Tobin's q are expressed as ratios. Zombie firms defined as firms with both an interest coverage ratio of less than 1 and a Tobin's q below the median firm in the sector over two years. To be declassified as a zombie firm, an ICR larger than one or a Tobin's q above the sector median over two years is required. Shaded areas indicate the 95% confidence interval, standard errors clustered at the country industry level.

Sources: Datastream Worldscope; authors' calculations.

We also explored the role of recessions for the zombie life cycle. To this end, we estimated extended versions of the life cycle regressions including interaction terms with recession dummies. Details on these estimations and the results are reported in Annex 2. The results suggest that there is little difference in zombie dynamics around recessions compared to non-recession period. For the GFC, some differences emerge, however. Zombie firms that emerged around the GFC were less productive and made higher losses. They also had higher capex, while asset disposal after zombification was lower. At the same time, they were more leveraged and issued more equity. Overall, these results suggest that zombie firms around the GFC performed worse but at the same time faced less financial pressure to retrench. These findings are consistent with greater persistence in zombie firms after the GFC shown in Graph 4. They are also consistent with the notion of a slower allocation of resources in the wake of the GFC highlighted by Foster et al. (2017).

Zombie survival

We next explore the evolution and the determinants of zombie survival probability rates. To this end, we first calculate Kaplan-Meier (Kaplan and Meier (1958)) survival rate estimates. The Kaplan-Meier survival rate estimates are given by:

$$\hat{S}_t = \prod_{t_i < t} \left[1 - \frac{d_i}{n_i} \right]$$

where t_i is duration of study at point i , d_i is number of deaths up to point i and n_i is number of firms at risk just prior to t_i . S estimates the probability that a firm survives at the end of a time interval, on the condition that it was present at the start of the time interval. We estimate the survival probability of zombie and non-zombie firms as well as the survival probability of zombie firms in zombie state, i.e. the probability of persisting as a zombie firm rather than recovering.

The first panel in Graph 8 compares the survival curves for zombies and non-zombie firms. The charts show that zombies have a significantly lower survival probability. The difference in survival probabilities reaches about 7 percentage points after five years and then remains broadly constant. The median zombie firm exits after 12 years, while the median non-zombie after 15 years. Also the log-rank test shows that the differences between the two groups is statistically significant. The second panel shows the survival curve for a zombie remaining in a zombie state (after being classified as a zombie). It suggests that the median duration of firms in the zombie state is 7 years.

In order to assess the determinants of firms' survival time, we run a Cox (1972) proportional hazard model. To estimate the Cox proportional hazard model we

define a firm's survival time from the first year it enters our sample or is first classified as a zombie firm. The Cox model characterises the firm hazard function h , reflecting the risk of dying at time t , as follows:

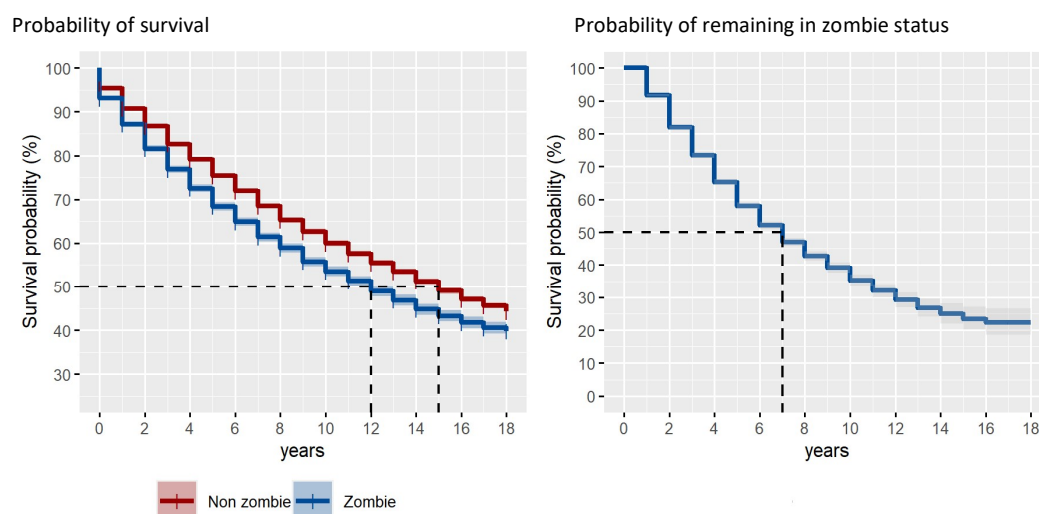
$$h(t, X_{i,c,s}) = h_0(t) \exp(\beta X_{i,c,s} + \gamma D(\text{Zombie})_{i,c,s} + \beta X_{i,c,s} \times D(\text{Zombie})_{i,c,s})$$

$h(t, X_{i,c,s})$ is the conditional hazard rate, i.e. the instantaneous probability of death conditional on surviving to year t and on covariates $X_{i,c,s}$. $h_0(t)$ is the baseline hazard and X is a vector of covariates that includes the log of firm total assets, EBIT scaled by total assets, the interest coverage ratio, Tobin's q and market leverage. $D(\text{Zombie})_{i,c,s}$ is as a dummy variable taking the value one when a firm is identified as a zombie company and zero otherwise.

Zombie survival and outlasting probabilities¹

In percentage points

Graph 8



¹ The charts show Kaplan-Meier estimates of survival probabilities. Zombie firms defined as firms with both an interest coverage ratio of less than 1 and a Tobin's q below the median firm in the sector over two years. To be declassified as a zombie firm, an ICR larger than one or a Tobin's q above the sector median over two years is required.

Sources: Datastream Worldscope; authors' calculations.

The results reported in Table 3 suggest that firm-level fundamentals significantly influence the firm hazard rate. Higher productivity (TFP), higher profits and a higher Tobin's q lower the hazard rate, while smaller size (lower assets), higher interest payments and higher leverage significantly increase it (column (1)). Except for size, these effects are statistically significant. Independent from the influence of these fundamental factors, zombie companies face a significantly higher hazard rate than non-zombie firms (column (2)). At the same time, firm fundamentals do not seem to affect zombie hazard rates in different ways,

as reflected in the coefficient of the interaction terms in column (3) which are all statistically insignificant.

Zombie death: Cox proportional hazard model estimates			Table 3
	(1)	(2)	(3)
log(total assets)	-0.006 (0.007)	-0.010 (0.007)	-0.004 (0.008)
TFP	-0.006*** (0.002)	-0.005*** (0.002)	-0.006*** (0.002)
Cash flow/Total assets	-0.002*** (0.0004)	-0.002*** (0.0004)	-0.002*** (0.0004)
Int expenses/Total assets	0.003* (0.002)	0.003** (0.002)	0.004*** (0.002)
Tobin's q	-0.017*** (0.003)	-0.015*** (0.003)	-0.015*** (0.003)
Market leverage	0.006*** (0.001)	0.006*** (0.001)	0.005*** (0.001)
D(zombie)		0.120*** (0.026)	0.218* (0.110)
log(total assets) x D(zombie)			-0.019 (0.014)
TFP x D(zombie)			0.005 (0.004)
Cash flow/Total assets x D(zombie)			0.0002 (0.001)
Int. expenses/Total assets x D(zombie)			-0.005 (0.004)
Tobin's q x D(zombie)			-0.019 (0.058)
Market leverage x D(zombie)			0.002 (0.001)
Observations	27,816	27,451	27,451
R ²	0.009	0.010	0.010
Score (Logrank) Test	245.016***	264.337***	270.415***

Note: The dependent variable is the hazard of firm death. A positive coefficient indicates that the risk of firm exiting is increasing in that variable. Sample stratified by industry, country and year. Significance at the 1, 5 and 10% levels denoted by *, ** and***.

5. Recovered zombies

When looking at the total number of zombie cases since the mid-1980s and classifying them into recovered, deaths and active cases, we see that the majority of zombie firms recover (Graph 9, left-hand panel). Out of a total of 12,727 zombie cases, about 60% (8,060) have recovered, while a quarter (2,955) have died through

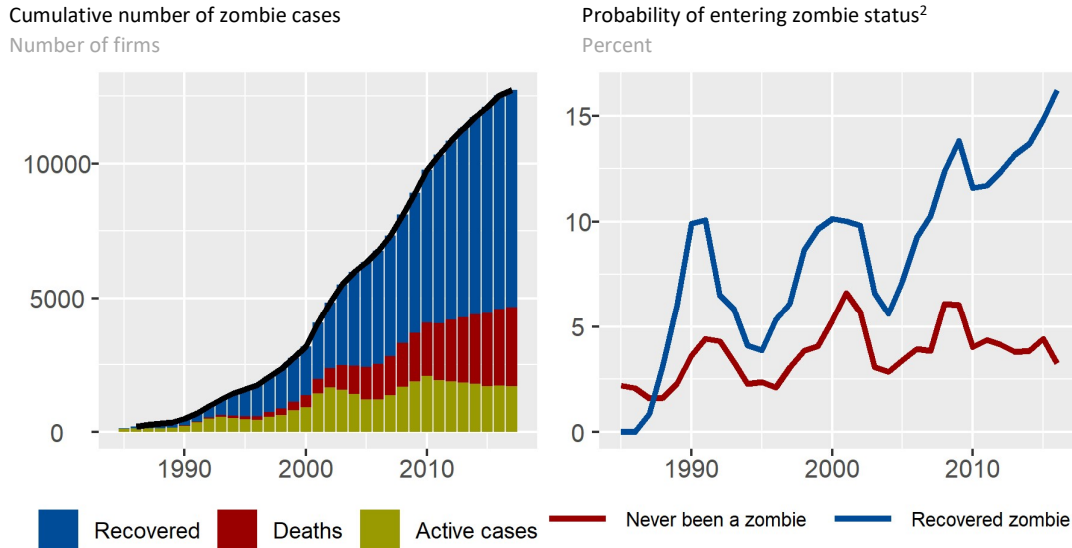
market exit. The number of active cases has remained relatively stable since the GFC at around 1,800.

Does this observation mean that the zombie problem is just an illusion? Are zombies just firms that experience temporary hardship but can ultimately fully recover? In order to address this question, we have to zoom in on these recovered zombies to get an idea about their longer term “health” status.

As a first step, we assess how sustained the recovery of former zombie firms is. To this end, we first compare the likelihood that they return to zombie status from one period to the next with that of firms that have never been classified as zombies before (Graph 9, right-hand panel). The probability of a recovered zombie being classified as a zombie firm in period T is calculated as the number of firms that have recovered at least once from zombie state in years $t < T$ but were classified as a zombie in year T divided by the number of firms that have recovered at least once from being a zombie. The probability that a firm is classified as a zombie that has never been a zombie is calculated by the number of firms that have never been classified as a zombie in periods $t < T$ but were classified as a zombie firm in period T , divided by the number of firms that have never been classified as a zombie in period $t < T$.

It turns out that recovered zombie firms face a high probability of relapse and that this probability has increased considerably over recent years. In 2017, our last data point, a recovered zombie firms faced a probability of becoming a zombie firm in the next period of about 17% (blue line), up from a probability of about 5% in 2005. This compares to a probability of turning zombie in the next period of about 3% for firms that were never zombies before, essentially unchanged compared to the probabilities over the past two decades (red line). This steep increase in relapse probability suggests that the GFC probably had a major scarring effects on the corporate sector, making firms that were zombie at some point in the past more fragile and more prone to relapse.

More generally, the relapse probability of recovered zombie firms displays a much more pronounced and increasing procyclicality compared to the probability of healthy firms to turn zombie. The relapse probability spiked around the recessions in the early 90s, early 2000s and in particular in the wake of the GFC. This suggests increasing recession scarring effects over time. Indeed, 13% of the firms that turned zombie in the wake of the GFC had already been classified as zombie firms in earlier periods, a rate which is fully consistent with the relapse probabilities shown in Graph 9.



¹ Zombie firms defined as firms with both an interest coverage ratio of less than 1 and a Tobin's q below the median firm in the sector over two years. To be declassified as a zombie firm, an ICR larger than one or a Tobin's q above the sector median over two years is required. ² "Never been a zombie" are firms which in period T have not been classified as a zombie firm in periods $t < T$. "Recovered zombie" are firms which in period T have been classified as a zombie at least once in periods $t < T$.

Sources: Datastream Worldscope; authors' calculations.

As the next step, we explore the anatomy of recovered zombies similar to the way we assessed the anatomy of zombies before, focusing on a number of key performance indicators. The reference point is again firms that have never been zombie firms.

We find that, as well as being more likely to relapse into zombie status, recovered zombie firms are also systematically weaker than firms that have never been zombies (Table 4). They are significantly smaller in terms of assets, capital stock and employment. More importantly, they are also less dynamic and productive. Recovered zombies invest significantly less in physical and intangible capital and the number of their employees expands at less than half the rate of firms that were not previously classified as a zombie. At the same time, their productivity, both labour productivity and TFP, is significantly lower than that of their immaculate peers.

Overall, these results suggest that there seems to be a growing corporate precariat characterised by mediocre performance and a material risk of relapsing into zombie status. The headline figures of zombie firms reported above may therefore understate the true extent of weaknesses and risks present in advanced economy corporate sectors.

Recovered zombie firms' anatomy

Means¹ and tests of differences in distribution

Table 4

	Never zombie firms ⁸	Recovered zombie firms ⁹	Kolmogorov-Smirnoff stat ¹⁰
Total assets ²	25,023	14,418***	0.16
Capital stock ²	17,536	10,934***	0.12
Employees	7,542	4,754***	0.12
Capex ³	5.73	5.02***	0.12
Intangible investment ⁴	10.53	8.13***	0.09
Employment growth ⁵	4.37	1.45***	0.09
Labour productivity ⁶	3.53	3.11***	0.09
TFP ⁷	7.32	5.6***	0.26

¹ ***/**/* indicate significant difference in means at the 1/5/10% level of zombie firms relative to non-zombie firms after controlling for country, sector and time fixed effects. ² In thousands of 2010 US dollars. ³ As a ratio of total assets. ⁴ As a ratio of capital stock. ⁵ Growth rate defined as $(\text{Employment}_t - \text{Employment}_{t-1}) / (0.5 * (\text{Employment}_t + \text{Employment}_{t-1})) * 100$. ⁶ Labour productivity is computed following Gopinath et al. (2017) as real output divided by the real wage bill. Real output is computed as nominal value added (wage bill plus gross profits) converted into US dollars divided by the US CPI deflator. For firms with missing wage bill we follow Imrohorglu and Tuzel (2013) and impute the wage bill using the number of employees in the firm multiplied by the average industry wage computed at the two digit SIC level. ⁷ TFP is the level of total factor productivity estimated using the semi-parametric estimator proposed by Levinsohn and Petrin (2003). Real value added and labour inputs are measured as for labour productivity. The real capital stock is the nominal value of fixed capital deflated by the CPI deflator. Material inputs as materials if available or operating expenses minus staff costs following Imrohorglu and Tuzel (2013). ⁸ Firms that have never previously been classified as a zombie. ⁹ Firms that have recovered at least once from zombie status in years $t < T$. ¹⁰ Kolmogorov-Smirnoff test of differences in distributions relative to non-zombie firms. All tests reject the null hypothesis that the data are drawn from the same distribution. The 1% critical value of the test is 0.008 so that all tests reject the null hypothesis that the data are drawn from the same distribution.

6. Zombie congestion and aggregate productivity

Why should we care about zombie firms? Previous studies have found that zombie companies weaken economic performance (Caballero et al. (2008) and Adalet McGowan et al. (2017)). Zombies are less productive and crowd out growth in more productive firms by locking resources (so-called “congestion effects”). Specifically, they may depress the prices of those firms’ products, raise their wages and their funding costs, by creating excess capacity in a sector.

In order to test whether zombie firms identified according to our definition also give rise to such congestion effects, and thus to test the plausibility of the definition from another angle assuming that only true zombies would give rise to such effects, we run the following panel regression

$$y_{i,c,s,t} = \alpha_{c,s,t} + \beta_1 D(\text{nonzombie firm})_{i,c,s,t} + \beta_2 D(\text{nonzombie firm})_{i,c,s,t} \times \text{zombie share}_{s,t-1} + \beta_3 \log(\text{size}_{i,c,s,t}) + \beta_4 \text{firm age}_{i,c,s,t} + \varepsilon_{i,c,s,t}$$

The dependent variable $y_{i,c,s,t}$ is either capital expenditures as a ratio lagged physical capital, employment growth or debt growth defined as $\frac{x_{it} - x_{it-1}}{0.5(x_{it} + x_{it-1})}$ and

equity issuance as a ratio of lagged total assets in firm i in sector s of country c in year t . The variable $D(\text{non zombie firm})$ is a dummy variable taking the value of one if the firm is not a classified as a zombie. zombie share is the share of total assets in zombie firms in a given sector in a year. $\alpha_{c,s,t}$ are country-sector-year fixed effects, respectively. Standard errors are clustered at the country-sector level.

The results suggest that zombie firms give rise to significant congestion effects (Table 5). This is reflected in a negative and statistically significant coefficient for the interaction term between non-zombies and the zombie share. Specifically, the estimation results suggest that a 1 percentage point increase in the zombie share in a sector lowers the capital expenditure (capex) rate of non-zombie firms by around 0.5 percentage point, a 5 per cent reduction relative to the mean investment rate. Similarly, employment growth is 0.14 percentage points lower, a 5 per cent reduction. However, we also find that non-zombie companies invest more, have higher employment growth (first row in Table 5), consistent with the results we reported in Table 1. We also find evidence that zombie firms impair new firm formation. In particular, the share of young non-zombie firms is lower when the share of zombie firms is higher.

Zombie firms are therefore not only less productive, but also hinder the growth of more productive firms. However, from these findings we can still not infer the wider effect of zombie firms on productivity growth. They may be significantly less productive and give rise to significant congestion effects, but the effects may quantitatively still be too small to affect aggregate productivity growth.

Zombie congestion effects on non-zombie firms¹

Table 5

	Capex	Employment growth	Young firm indicator ²
D(Non zombie firm)	0.414*** (0.023)	0.084*** (0.006)	-0.008 (0.006)
D(Non zombie firm) x zombie share	-0.530** (0.262)	-0.144*** (0.048)	-0.173* (0.095)
Firm size controls	Yes	Yes	Yes
Firm age controls	Yes	Yes	No
No of observations	240,342	232,187	257,223
R ²	0.317	0.135	0.182

¹ Significance at the 1/5/10% level denoted by ***/**/*; standard errors are clustered by country*sector. Zombie firms defined as firms with both an interest coverage ratio of less than 1 and a Tobin's q below the median firm in the sector over two years. To be declassified as a zombie firm, an ICR larger than one or a Tobin's q above the sector median over two years is required. ² A firm is classified as young if its age is less than 8 years.

Sources: Datastream Worldscope; authors' calculations.

We further assess the economy wide impact on productivity from the rise in zombie firms using a Bartik/shift-share instrument. In particular, to assess the productivity impact, we isolate the rise in a country's zombie share only due to the exposure of its asset stock to the global industry trends in zombification to reduce potential endogeneity issues related to domestic factors. To this end, we run the following instrumental variable panel regression

$$TFP\ growth_{c,t} = \alpha_c + \alpha_t + \beta_1 zombie\ share_{c,t-1} + \beta_2 output\ gap_{c,t-1} + \beta_3 TFP\ growth_{c,t-1} + \varepsilon_{c,t}.$$

The asset weighted $zombie\ share_{c,t}$ in country c in year t is instrumented with a shift-share instrument which measures zombie exposure of a country to the global zombie share, i.e. $\sum_{i=1}^I assetshare_{i,c,t} zombiesshare_{i,t}$, where $assetshare_{i,c,t}$ is the share of total assets in industry i in country c in year t and $zombiesshare_{i,t}$ is the zombie share in industry i across all 14 economies in our sample in year t . α_c and α_t are country and year fixed effects, respectively.

We find that when the zombie share increases, productivity growth declines significantly (Table 6). The estimates indicate that an increase in the zombie share in an economy by one percentage point lowers productivity growth by around 0.1 percentage points in the long run. A back-of-the-envelope calculation suggests that the increase in the share of zombie firms by about 10 percentage points since the late 1980s may have depressed aggregate productivity growth by about 1 percentage point, about half of the overall slowdown registered over the period. We also estimate its effect on the level of TFP. Here we find that a 1 percentage point increase in the zombie share lowers to level of TFP by 2.2 percentage points in the long run.¹⁸

¹⁸ The rise in the share of zombie firms could also be a factor behind the slowdown in the speed of post-recession output recovery found by Galí et al. (2012) and Graetz and Michaels (2017) as well as the slow pace of reallocation of resources in the wake of the GFC highlighted by Foster et al. (2017).

Zombie firms and aggregate productivity¹

Table 6

	TFP growth ²	Log TFP ²
Zombie share	-0.074* (0.035)	-0.069* (0.037)
Lagged TFP growth	0.290*** (0.083)	
Lagged log TFP		0.969*** (0.023)
Long-run effect	-0.104** (0.052)	-2.213 (1.821)
Country, year fixed effects	Yes	Yes
No of observations	377	377

¹ Significance at the 1/5/10% level denoted by ***/**/*; standard errors are double clustered by country and year. Zombie firms defined as firms with both an interest coverage ratio of less than 1 and a Tobin's q below the median firm in the sector over two years. To be declassified as a zombie firm, an ICR larger than one or a Tobin's q above the sector median over two years is required.

Sources: OECD; Datastream Worldscope; Penn World Tables; authors' calculations.

7. Reduced financial pressure on zombies?

How have corporate zombies arisen and become more persistent, in particular since the 2000s, as suggested by Graph 2? One reason could be that they have improved their performance, and another could be that they have faced less pressure to cut back their debt and activities. In order to assess this point, we run the following regression:

$$y_{i,c,s,t} = \beta_1 D(\text{Zombie}_{i,c,s,t}) + \beta_2 D(\text{Zombie}_{i,c,s,t}) \times D(\text{post 2000}) + \gamma \text{Controls}_{i,c,s,t} + \alpha_{c,s,t} + \varepsilon_{i,c,s,t}$$

where $D(\text{Zombie}_t)$ is a dummy variable indicating whether firm i is classified as a zombie in period t , $D(\text{post 2000})$ takes a value of 1 for years after 2000. For the firm-level dependent variable y_{isct} we select a number of variables that would likely reflect enhanced performance or reduced financial pressure, i.e. profitability, interest payments, change in leverage, asset disposal as well as TFP growth and capex. The set of control variables includes those commonly used in corporate finance studies on investment and cash holdings (e.g. Almeida and Campello (2007)), namely the ratio of fixed assets over total assets, the firm's Tobin's q, log total assets and the ratio of capital expenditures to total assets. The regressions

include again country-sector-time fixed effects and standard errors are clustered at the country-sector level.

Change in zombie anatomy post-2000

Table 7

	$EBIT_t/TA_{t-1}$	ΔTFP_t	$Interest\ paid_t/TA_{t-1}$	$\Delta leverage_t$	$Asset\ disposal_t/TA_{t-1}$	$CAPEX_t/TA_{t-1}$
	(1)	(2)	(3)	(4)	(5)	(6)
$D(Zombie)_t$	-10.208*** (0.397)	-0.248** (0.093)	0.850*** (0.064)	-0.014*** (0.002)	0.013*** (0.001)	-2.135*** (0.149)
$D(Zombie)_t \times$	2.232*** (0.625)	-0.796*** (0.140)	-0.740*** (0.080)	0.013*** (0.003)	-0.008*** (0.001)	0.680*** (0.163)
Observations	260,798	228,094	260,798	260,798	217,424	260,798
R ²	0.324	0.573	0.170	0.131	0.122	0.370

¹ Significance at the 1, 5 and 10% levels denoted by *, ** and ***, standard errors are double-clustered by country and sector. Control variables: ratio of fixed assets to total assets, market-to-book value, logarithm of total assets (TA) in constant 2010 US dollars, ratio of capital expenditures and intangible investments to total assets, dummy variable indicating whether the firm pays a dividend as well as country-sector-time fixed effects

Sources: Worldscope, BIS calculations.

The regression estimates reported in Table 7 support the notion that it was mainly reduced financial pressure that has helped sustain zombie firms in recent years rather than enhanced performance. While zombies have improved their profitability relative to that of profitable firms after 2000, they are still making heavy losses post 2000. At the same time, their productivity growth has even significantly deteriorated over this period. The zombie productivity growth gap with respect to non-zombies has widened from -0.2 to -1.0 percentage points. Both interest payments and deleveraging of zombie firms have fallen relative to non-zombies post-2000, suggesting reduced financial pressure. In particular, pre-2000, zombies interest payments exceeded those of other firms by 0.85 per cent of assets and they cut debt at a rate of just under 1.5 per cent of total assets per year relative to non-zombie firms. Post-2000, however, the two groups have become indistinguishable in these respects. At the same time, zombies have been locking in more resources, hindering reallocation. Specifically, they have significantly slowed down their asset disposals relative to those of their more profitable peers and their capex has increased relative to non-zombie firms.

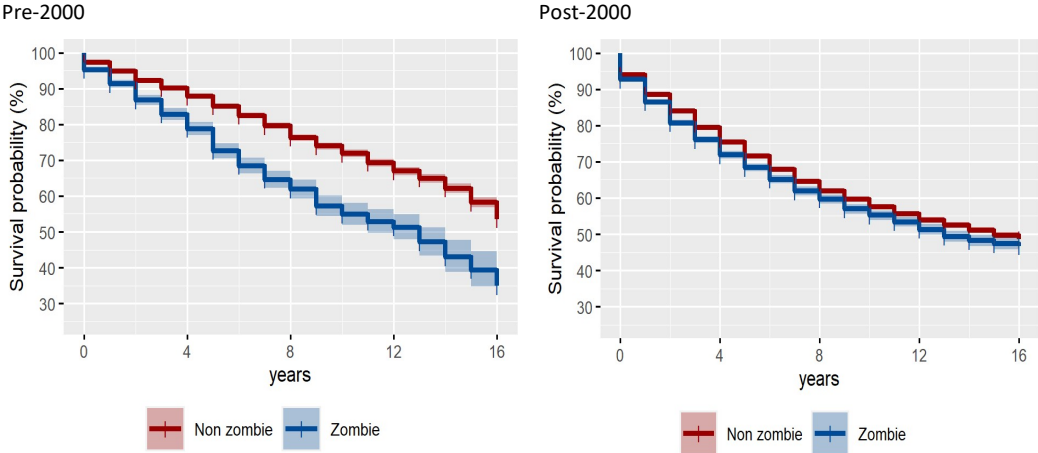
Reduced pressure on zombie firms is reflected in their survival probabilities (Graph 10). Re-estimating the Kaplan-Meier survival probabilities for the pre- and post-2000 period suggest that the differences between zombie and non-zombie firms have largely disappeared over the more recent period. While survival probabilities of non-zombie firms were much higher than those of zombies between

1985 and 2000, they are almost identical since 2000. This is due to both a higher survival probability of the zombie firms and a lower survival probability of the non-zombie firms. At the same time, the analysis in Annex 2 suggests that, while the survival probability of zombie firms has increase, their life cycle has remained fairly stable over time.

Zombie survival probabilities¹

In percentage points

Graph 10



¹ The charts show Kaplan-Meier estimates of survival probabilities. Zombie firms defined as firms with both an interest coverage ratio of less than 1 and a Tobin's q below the median firm in the sector over two years. To be declassified as a zombie firm, an ICR larger than one or a Tobin's q above the sector median over two years is required.

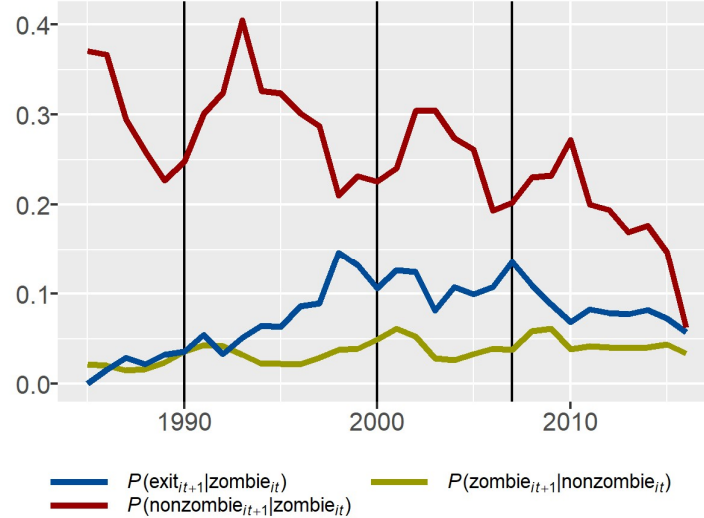
Sources: Datastream Worldscope; authors' calculations.

There is also evidence of a reduced probability of market exit of zombie firms over time (Graph 11), consistent with the notion of reduced financial pressure. The probability of a firm transitioning from zombie status in period t to market exit in t+1 (blue line) has fallen from around 15% in the late 1990s to 5% recently. This drop has mostly occurred after the GFC. The chart also shows that the probability of recovery from zombie status from one year to the next has declined (red line), while at the same time the probability for a healthy firm to enter zombie status from one year to the next has increased (green line). The increase in the zombie share over time is therefore driven by a combination of a lower probability of exit and recovery for zombie firms and a higher probability of a healthy firm becoming a zombie firm.

Zombie entry and exit probabilities over time¹

In percent

Graph 11



¹ The chart shows the evolution over time of the probability of a firm transitioning from zombie status in period t to market exit in $t+1$ (blue line), the probability of a firms transitioning from nonzombie status in period t to zombie status in period t (green line) and the probability of a firm transitioning from zombie status in period t to nonzombie status in period $t+1$ (red line). Vertical lines indicate business cycle peaks according to ECRI and OECD classifications.

Sources: Datastream Worldscope; authors' calculations.

Why did zombie firms face less financial pressure since the early 2000s? The literature has identified weak banks as a potential key factor the financial pressure faced by zombie firms (Caballero et al. (2008), Storz et al. (2017), Schivardi et al. (2017), Andrews and Petroulakis (2017)). When banks' balance sheets are impaired, banks have incentives to roll over loans to non-viable firms rather than writing them off. Another potential, more general, factor is the downward trend in interest rates (Borio and Hofmann (2017), Banerjee and Hofmann (2018)). Mechanically, lower rates should reduce our measure of zombie firms as they improve ICRs by reducing interest expenses, all else equal. However, low rates can also reduce the pressure on creditors to clean up their balance sheets and encourage them to “evergreen” loans to zombies or more generally to step up risk-taking by lending to or investing in risky zombie firms.

In order to assess the role of these factors, we assess whether weaker bank health or lower interest rates affects sectoral zombie shares considering the Fama-

French 48 industries. We identify the effect using sectoral dependence on external funding as a measure of the sector’s sensitivity to changes in financial conditions.¹⁹

Specifically, we run the following panel regression:

$$\begin{aligned} \text{Zombie share}_{c,s,t} = & \beta_1(\text{External finance dependence}_s \times \\ & \text{Interest rate}_{c,t-1}) + \beta_2(\text{External finance dependence}_s \times \\ & \text{Bank health}_{c,t-1}) + \alpha_{c,s,t} + \varepsilon_{c,s,t}. \end{aligned}$$

The dependent variable, *Zombie share*_{s,c,t} is the share of assets in zombie firms in sector *s* in country *c* in year *t*; *External finance dependence*_s in sector *s* is measured as the median firm’s share of capital expenditures that are not financed from operating income. *Interest rate* refers to the nominal short-term interest rate. *Bank health* is the banking sector price-to-book ratio in country *c* in year *t* – 1 as a proxy for bank health.²⁰ $\alpha_{c,s,t}$ are country-sector-year fixed effects.

Interest rates, bank health and zombie shares¹

Table 8

	(1)	(2)	(3)
<i>External finance dependence</i> _s × <i>Interest rate</i> _{c,t-1}	-0.165*** (0.039)		-0.171*** (0.039)
<i>External finance dependence</i> _s × <i>Bank health</i> _{c,t-1}		-0.101 (0.167)	-0.086 (0.170)
Observations	14,133	14,418	14,418
R ²	0.111	0.108	0.109

¹ Significance at the 1/5/10% level denoted by ***/**/*; standard errors are clustered by sector-year and country-year.

Sources: Datastream; Datastream Worldscope; authors’ calculations.

The results reported in Table 8 suggest that lower nominal interest rates go hand in hand with a higher zombie share in sectors where firms depend more heavily on external funding. The relationship is statistically significant and the effects appear material.²¹ Our estimates suggest that the roughly 10 percentage point decline in nominal interest rates across advanced economies since the mid-1980s can account

¹⁹ This is an application of the difference-in-difference method popularised by Rajan and Zingales (1998).

²⁰ For a more detailed discussion of bank PBRs and why they are useful proxies for bank health, see Bogdanova et al. (2018).

²¹ These results are also robust to removing the commodity sectors. Firms in this sector depend greatly on external funding, but may also experience swings in commodity prices related to global economic activity.

for around 17 percent of the rise in the zombie share when evaluated at the average industry external finance dependency ratio. The interaction between external finance dependence and bank health is generally statistically insignificant, suggesting that the link that has been highlighted in previous studies could be more anecdotal, playing out in periods of banking sector stress.

8. Conclusions

Our analysis suggests that the share of zombie companies has increased considerably over the past three decades, rising from 4% in the late 1980s to 15% in 2017. The increase was not steady but occurred in the form of upward level shifts linked to major business cycle turning points and financial crises. In terms of economic weight, zombie firms account for about 8% of all listed companies' capital and for about 4% of their employment and sales. This does not, however, mean that the zombie problem is negligible from an economy-wide point of view. As our study aims to cover a longer sample time period and to identify firms also based on their expected profitability reflected in stock market valuation, it covers only listed companies, missing out in particular on the population of unlisted SMEs which in some countries is large. If small firms are more likely to be zombified, as our analysis suggests, then the economic weight of zombies may be greater than indicated by our analysis. Indeed, amongst listed SMEs, the share of capital and employment sunk in zombie firms is 50% and 20%, respectively. Moreover, our findings point to a growing army of enfeebled recovered zombies who underperform compared to healthy firms as a so far unrecognised consequence of the rise of zombie firms over the past three decades.

Our analysis also suggests that, while the general indication of an upward trend in the prevalence of zombie firms is robust, there is uncertainty with respect to the quantification of the zombie problem across different definitions. In other words, the extent of the zombie problem and the assessment whether any given firm is a zombie company depends to some extent on the definition chosen, but there is agreement across definitions that the prevalence of zombie firms has grown over time.

The results of the analysis of the zombie anatomy and life cycle indicate that zombie firms are significantly smaller as well as less productive and dynamic than other firms. However, our analysis also shows that the majority of these firms manage to recover, rather than exiting the market or remaining in zombie status. Yet, closer inspection shows that those firms that do recover from zombification remain weak and a drag on economic dynamics. They have a high probability of

relapsing into zombie status and their dynamism and productivity is significantly lower than that of firms that have never been zombies in their life. In other words, the zombie disease seems to cause long-term damage also on those that recover from it. The weakness and risks in advanced economy corporate sectors may therefore not be fully captured by headline figures of the number of zombie firms.

The findings in this paper also have implications for the debate about the causes and consequences of zombie firms. With respect to the causes, our analysis suggests that zombies often emerge in the wake of business cycle downturns and financial crises, implying that smoothing the cycle and avoiding financial crises through effective macroeconomic stabilisation policy would also help mitigate corporate zombification. At the same time, we find that financial pressure on zombies has dropped since the early 2000s, in part reflecting the easing effects of lower interest rates on financial conditions. This suggests a tricky trade-off for monetary policy between avoiding the genesis of new zombie firms in a downturn through easy monetary policy and sustaining zombie firms through low interest rates.

With respect to the consequences of zombie firms, our findings point to congestion effects on non-zombie firms and adverse effects on aggregate productivity undermining the long-run growth potential of the economy. This could in turn depress equilibrium real interest rates, giving rise to a vicious cycle between low rates, low growth and a rising prevalence of zombie firms. The combination of low growth, low interest rates and a rising share of debt sunk in zombie companies could also raise macroeconomic and financial fragility. Recent studies suggest that corporate credit booms have generally not impaired growth outcomes but that their economic costs rise when inefficient debt restructuring and liquidation foster the genesis and survival of zombie firms (Jordà et al 2020), Schularick (2021)).

Finally, our results underline the challenge the authorities have been facing when taking measures to contain the impact of the coronavirus recession on firms. The delicate task is to seek to shore up companies that would be viable in less extreme circumstances while at the same time not excessively dampening corporate dynamism by protecting already weak and unproductive ones. A firm's viability should therefore be an important criterion for its eligibility for government and central bank support.²² Whether the Covid recession will be followed by another

²² One possible way to address this issue is to make government support dependent on the profitability of a firm, e.g. by following the proposal by Carstens (2020) to link tax deferral loans to a firm's profitability in the previous year.

ratcheting up of share of zombie firms, similar to previous major recessions, remains to be seen.

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Annex 1: Alternative zombie definitions

In order to check the robustness of our results, we replicate the core empirical exercises for alternative zombie definitions. First, we consider two variations to our zombie definition: (i) we lengthen the horizon over which the ICR and Tobin's q condition for a zombie firm has to be fulfilled from two to three years; (ii) we evaluate the Tobin's q criterion for each firm with respect to the median of firms in the same country rather than the same sector; and (iii) profitability measured by EBITDA as opposed to EBIT. We also consider robustness of our results with respect to large equity markets, specifically with respect to the exclusion of the United States and United Kingdom and high-zombie share sectors (commodities and mining).

We further consider two alternative zombie firm definitions that have been used in previous studies: (i) an age-based definition, defining a zombie as having an $ICR < 1$ for at least three years and at least ten years of age following Adalet McGowan et al. (2018); and (ii) a subsidised credit-based definition, defining a zombie firm as having an $ICR < 1$ and interest paid on the debt below that of AAA rated firms, following Acharya et al. (2019, 2020).

The pattern of the development of the zombie share over time is broadly consistent across all these variations, with a ratcheting up of the share in the wake of major business cycle turning points (Graph A1). There are, however, notable quantitative differences. For the three variations to our baseline Tobin's q-based definition (left-hand panel), the lengthening of the window for entry into and exit from zombie status smoothes the zombie share and lowers it somewhat overall, as does the use of EBITDA to measure profitability. In 2017, the zombie share defined in these two alternative ways is about 3 percentage points lower than under our baseline definition. Using the country-based benchmark for the Tobin's q criterion of our definition hardly affects the resulting zombie share compared to the baseline that was shown in Graph 2.

Excluding large equity markets which may dominate our sample and high-zombie share sectors from the analysis does also not change the finding of an upward secular trend in the zombie share (middle panel), but changes the pattern over time somewhat. When the commodities and mining sectors are excluded, the zombie share is about 4 percentage points lower at the end of the sample period (11%).

Share of zombie firms under alternative definitions

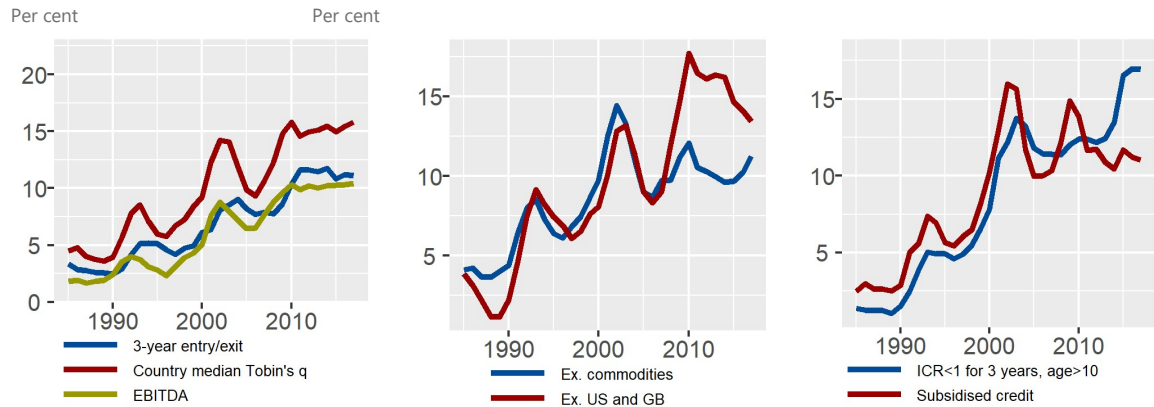
In percent

Graph A1

Robustness of baseline zombie definition¹

Excluding sector and countries²

Alternative zombie firm definitions³



¹ Robustness of zombie firm definition based on interest coverage ratios (ICR) and Tobin's q. 3-year entry/exit: a firm is defined a zombie if it has an ICR < 1 and Tobin's q is below the industry median for three consecutive years and only exits zombie state if either the firm's ICR >= 1 or its Tobin's q is above the industry median for three consecutive years. Country median Tobin's q: a firm is defined a zombie if it has an ICR < 1 for two consecutive years and its Tobin's q is below the country median. A firm only exits zombie state if either the firm's ICR >= 1 for two consecutive years or if its Tobin's q is above the country median for two consecutive years. EBITDA based interest coverage ratio: Same baseline zombie firm definition except that income defined as EBITDA instead of EBIT in the interest coverage ratio. ² Robustness to excluding key sectors and countries with baseline zombie firm definition.. ³ Alternative definitions of zombie firms. ICR < 1 for 3 years, and age > 10: a firm is classified as zombie if its ICR < 1 for 3 years, and age > 10 years following the definition in Adalet McGowan et al. (2018). Subsidised credit: a firm is defined a zombie if its ICR < 1 and the average interest rates on debt in non-AAA firms is less than that of AAA-rated firms based on their ICR. Following Acharya et al (2019) we split firms into those with short-term debt above and below 50% of total debt when comparing a firm's average interest rate to AAA firms.

Sources: Datastream Worldscope; authors' calculations.

The evolution of the zombie shares under the age-based and subsidised credit-based definitions is very similar to that of our baseline up to the GFC (right-hand panel). After that, there is a notable divergence. The age-based definition rises significantly after 2012, reaching a level of about 17% in 2017. The subsidised credit-based zombie share by contrast falls somewhat after the GFC and then moves sideways at a level of just above 10%. There are therefore qualitative differences in the indications of these alternative zombie definitions, between each other and also with respect to our baseline definition. These discrepancies suggest that the specific criteria used to identify a zombie firm make a difference in particular in recent years, raising in turn the question which criteria are better able to identify unviable firms.

We aim to address this question by replicating the zombie anatomy and life cycle analysis of sections 3 and 4 to shed light on the similarities and differences in firms identified by alternative zombie definitions (Table A1 and Graphs A2-A5).

Zombie firms' anatomy for alternative zombie definitions

Means¹ and tests of differences

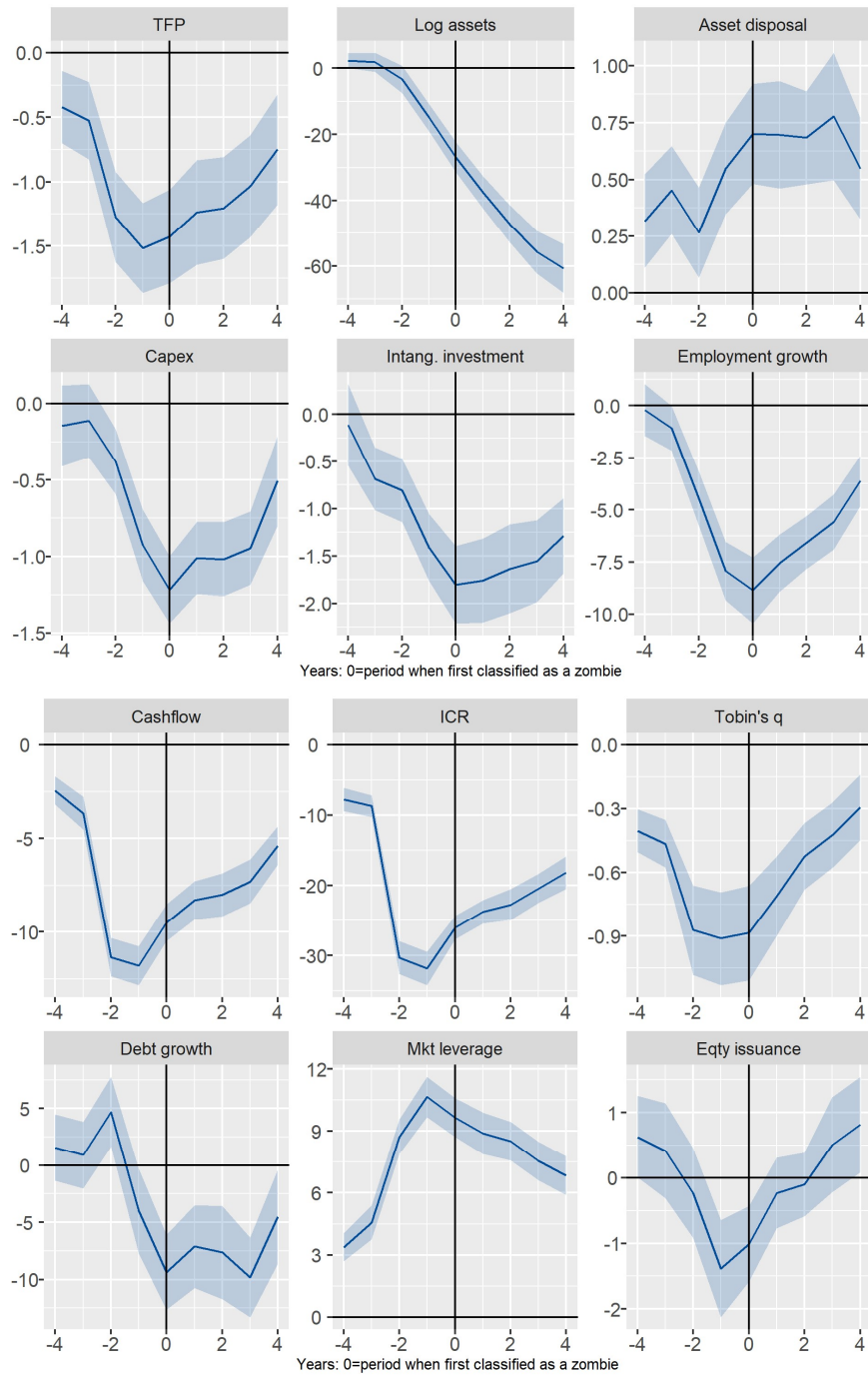
Table A1

	3 year entry/exit ¹¹		National Tobin's q benchmark ¹²		ICR<1 for 3 years and age >10 ¹³		Subsidised credit ¹⁴	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Non-zombie	Zombie	Non-zombie	Zombie	Non-zombie	Zombie	Non-zombie	Zombie
Total assets ²	23379	7129***	23120	8204***	23334	4594***	26769	8077***
Capital stock ^{2,3}	16637	6259***	16361	7016***	16541	3915***	19369	6711***
Employees	7111	2441***	7037	2886***	7124.05	1568***	7983	2226***
Capex ⁴	5.52	4.84***	5.59	5.13***	5.62	4.88***	5.51	5.59*
Intangible investment ⁵	9.74	6.99***	10.16	7.42***	9.63	12.06	8.81	11.1**
Asset disposal ⁴	1.19	1.7***	1.17	1.68***	1.21	1.61***	1.26	1.44**
Employment growth ⁶	3.39	-6.57***	3.87	-7.8***	3.51	-5.11***	3.42	-2.03***
Labour productivity ⁷	3.47	1.85***	3.43	1.92***	3.44	1.43***	3.64	1.83***
TFP ⁸	7.01	3.78***	6.98	4.05***	6.99	3.49***	7.27	3.77***
Cash flow ⁴	1.89	-11.18	1.25	-13.13**	3.19	-31.87***	4.78	-24.82***
Interest coverage ratio	15.83	-14.23***	15.87	-16.53***	16.2	-23.16***	14.37	-18.59***
Tobin's q	2.1	1.07***	2.24	1.07***	1.91	3.9***	1.74	3.15***
Dividends paid ⁴	1.36	0.16***	1.36	0.2***	1.36	0.1***	1.34	0.18***
Interest paid ⁴	2.07	2.13	2.1	2.44	1.87	4.53**	2.28	2.76
Book leverage ⁹	23.67	23.78	23.42	25.44*	23	29.38***	26.65	37.83***
Market leverage	18.73	23.67***	18.18	24.86***	18.91	19.09***	21.68	27.79***
Debt growth ⁶	3.05	-5.55***	3.29	-4.17***	2.76	0.05	2.6	14.77***
Equity Issuance ⁴	5.06	6.14*	5.74	5.97*	4.32	17.93***	3.13	10.95***
Exit probability ¹⁰	0.04	0.09***	0.04	0.09***	0.04	0.07***	0.04	0.09***

¹ ***/**/* indicate significant difference in means at the 1/5/10% levels of zombie firms relative to non-zombie firms after controlling for country, sector and time fixed effects. ² In thousands of 2010 US dollars. ³ Plant, property and equipment. ⁴ As a ratio of total assets (in percent). ⁵ As a ratio of capital stock (in percent). ⁶ Growth rate defined as $(x_t - x_{t-1}) / (0.5(x_t + x_{t-1})) * 100$. ⁷ Labour productivity is computed following Gopinath et al. (2017) as real output divided by the real wage bill. Real output is computed as nominal value added (wage bill plus gross profits) converted into US dollars divided by the US CPI deflator. For firms with missing wage bill we follow Imrohorglu and Tuzel (2013) and impute the wage bill using the number of employees in the firm multiplied by the average industry wage computed at the two digit SIC level. ⁸ TFP is the level of total factor productivity estimated using the semi-parametric estimator proposed by Levinsohn and Petrin (2003). Real value added and labour inputs are measured as for labour productivity. The real capital stock is the nominal value of fixed capital deflated by the CPI deflator. Material inputs as materials if available or operating expenses minus staff costs following Imrohorglu and Tuzel (2013). ⁹ Total debt at book/market value as a ratio of total assets. ¹⁰ Firm exit/death where Worldscope classifies the reason for exiting the database as either: "DEAD", "MERGER", "TAKEOVER" or "LIQUIDATED". ¹¹ Zombie firms defined as firms with both an interest coverage ratio of less than 1 and a Tobin's q below the median firm in the sector over three years. To be declassified as a zombie firm, an ICR larger than one or a Tobin's q above the sector median over three years is required. ¹² Zombie firms defined as firms with both an interest coverage ratio of less than 1 and a Tobin's q below the median firm in the country over two years. To be declassified as a zombie firm, an ICR larger than one or a Tobin's q above the country median over two years is required. ¹³ Zombie firms defined as firms with ICR<1 for three years and age >10 following the definition in Adalet McGowan et al. (2018). ¹⁴ Zombie firms defined as firms with ICR<1 and average interest rate on debt less than that of AAA-rated firms based on their ICR. Following Acharya et al (2019) we split firms into those with short-term debt above and below 50% of total debt when comparing a firm's average interest rate to AAA firms.

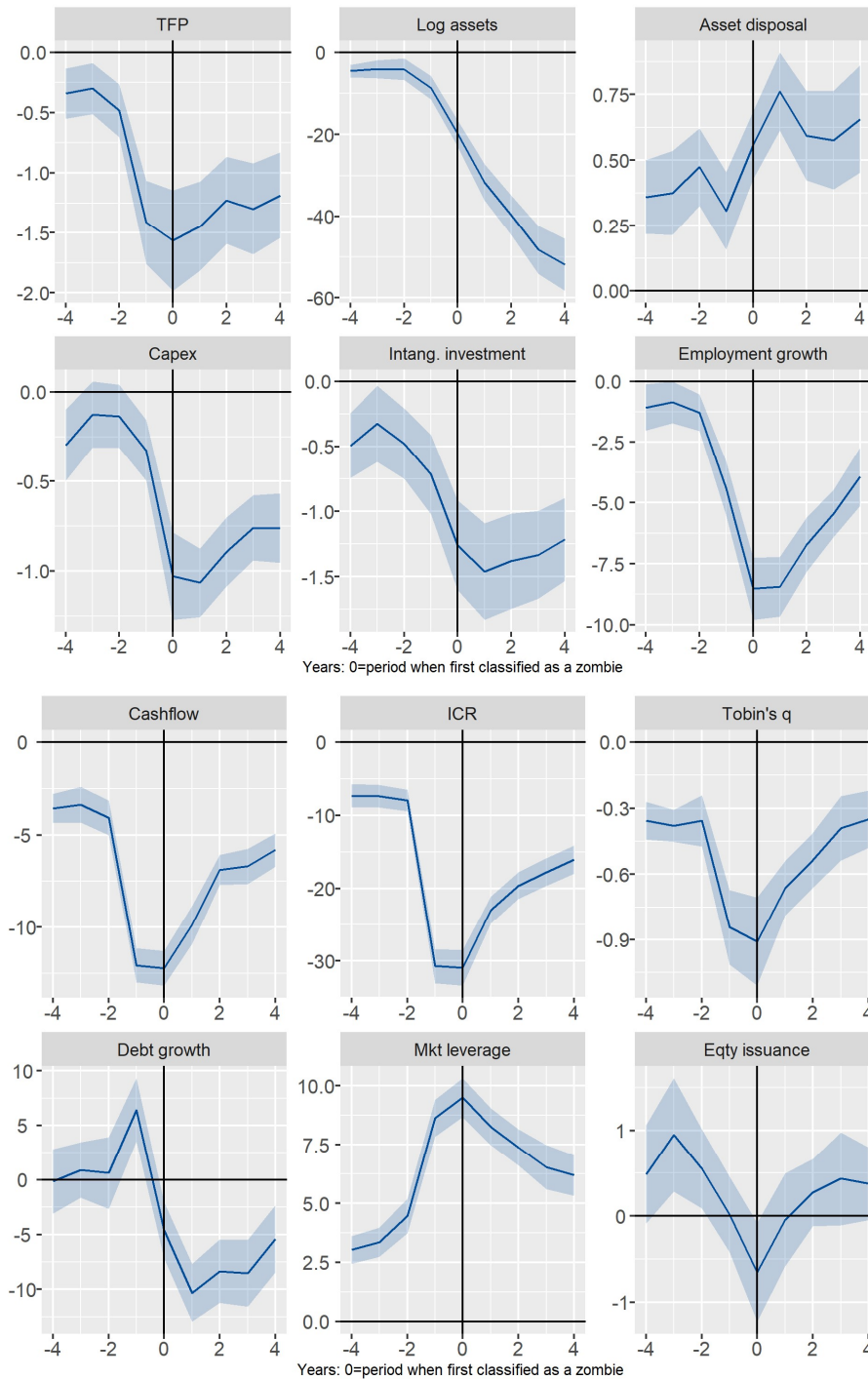
There is essentially no difference between the characteristics and life cycle of zombie firms under the baseline definition and the firms classified as zombie under the variations to the baseline definition (columns (1) and (2) in Table A1 and Graphs A2 and A3). With respect to the alternative age-based and subsidised credit-based definitions, important similarities but also important differences emerge (columns (3) and (4) and Graphs A4 and A5). Note that the zombie anatomy and life cycle results can differ somewhat from each other because the latter are regression based, controlling for sector and country fixed effects.

Zombie firms across all definitions share the common characteristics of being smaller, making losses, paying smaller or no dividends, being less productive and shrinking assets and employment. Zombie firms under the age- and subsidised-credit-based definitions however have significantly higher Tobin's q than non-zombie firms. This suggests that markets do not see these firms as unviable. Consistent with this notion, the zombie firms under these two definitions also have significantly higher equity issuance. This suggests that these firms are, on average, not seen as unviable by stock market investors.



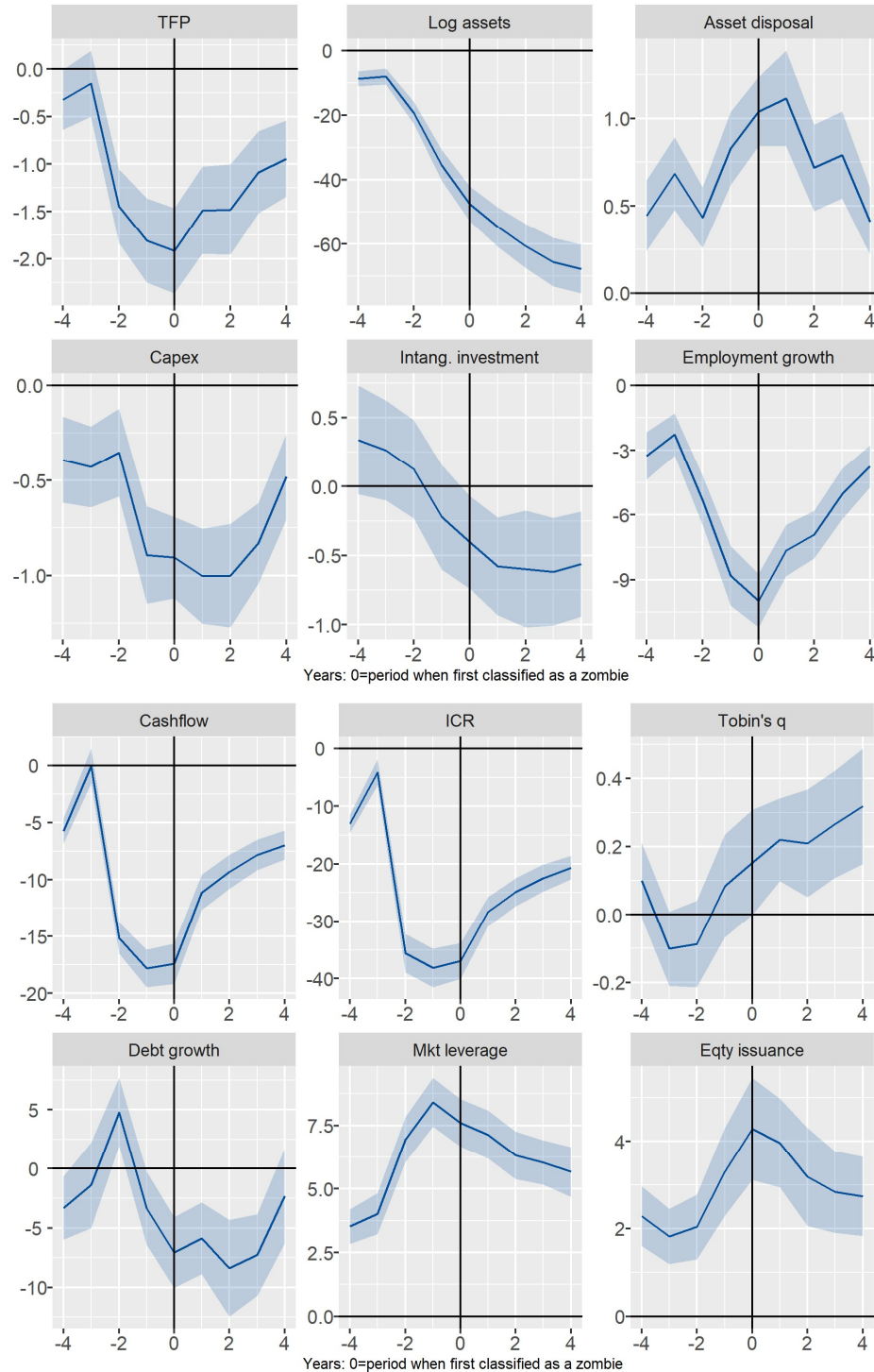
¹ Units are in percentage points except for log assets where it is in percent and the ICR and Tobin's q are expressed as ratios. Zombie firms defined as firms with both an interest coverage ratio of less than 1 and a Tobin's q below the median firm in the sector over three years. To be declassified as a zombie firm, an ICR larger than one or a Tobin's q above the sector median over three years is required. Shaded areas indicate the 95% confidence interval, standard errors clustered at the country industry level.

Sources: Datastream Worldscope; authors' calculations.



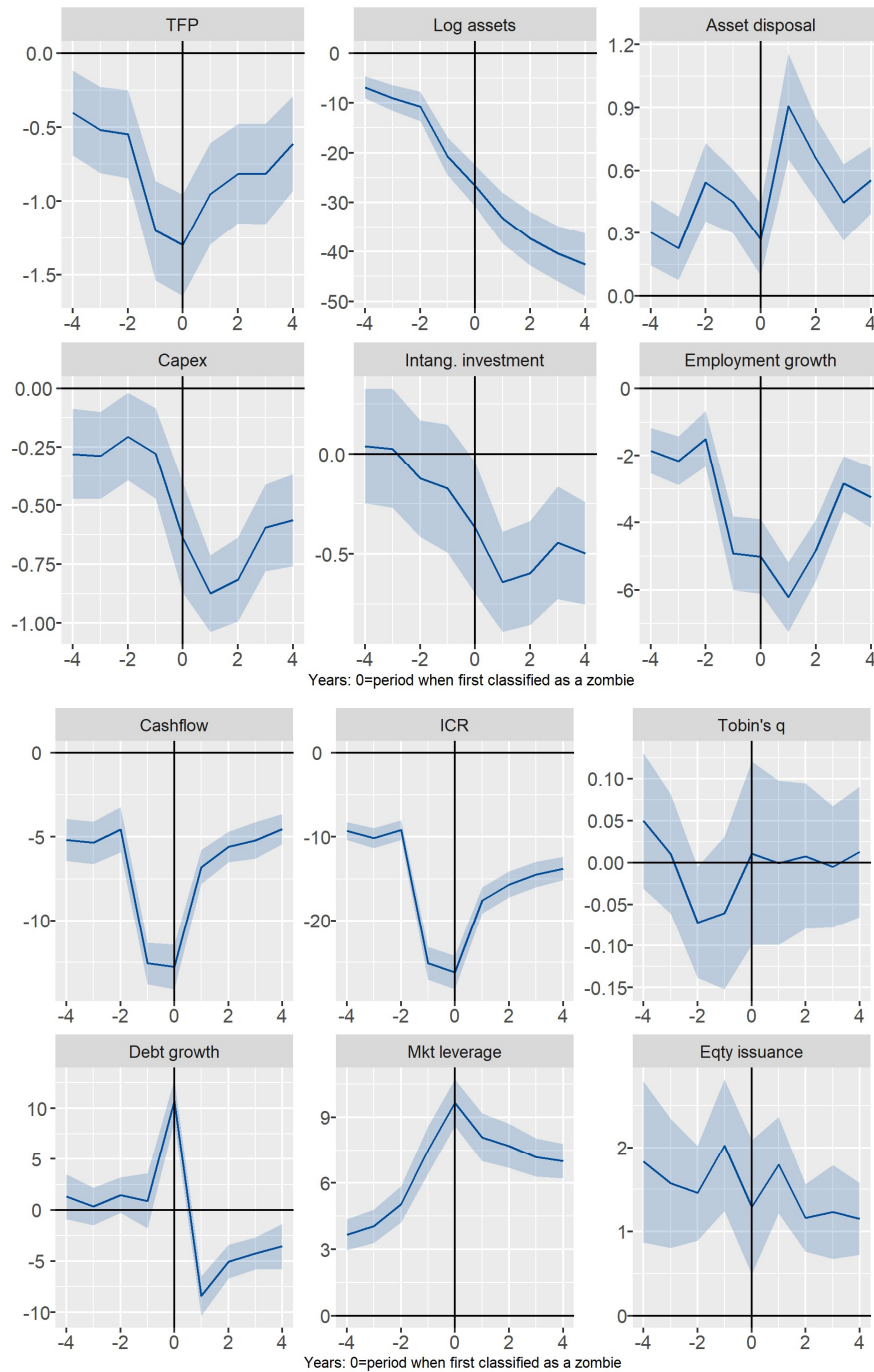
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¹ Units are in percentage points except for log assets where it is in percent and the ICR and Tobin's q are expressed as ratios. Zombie firms defined as firms with ICR<1 and average interest rate on debt less than that of AAA-rated firms based on their ICR. Following Acharya et al. (2019) we split firms into those with short-term debt above and below 50% of total debt when comparing a firm's average interest rate to AAA firms. Shaded areas indicate the 95% confidence interval, standard errors clustered at the country industry level.

Sources: Datastream Worldscope; authors' calculations.

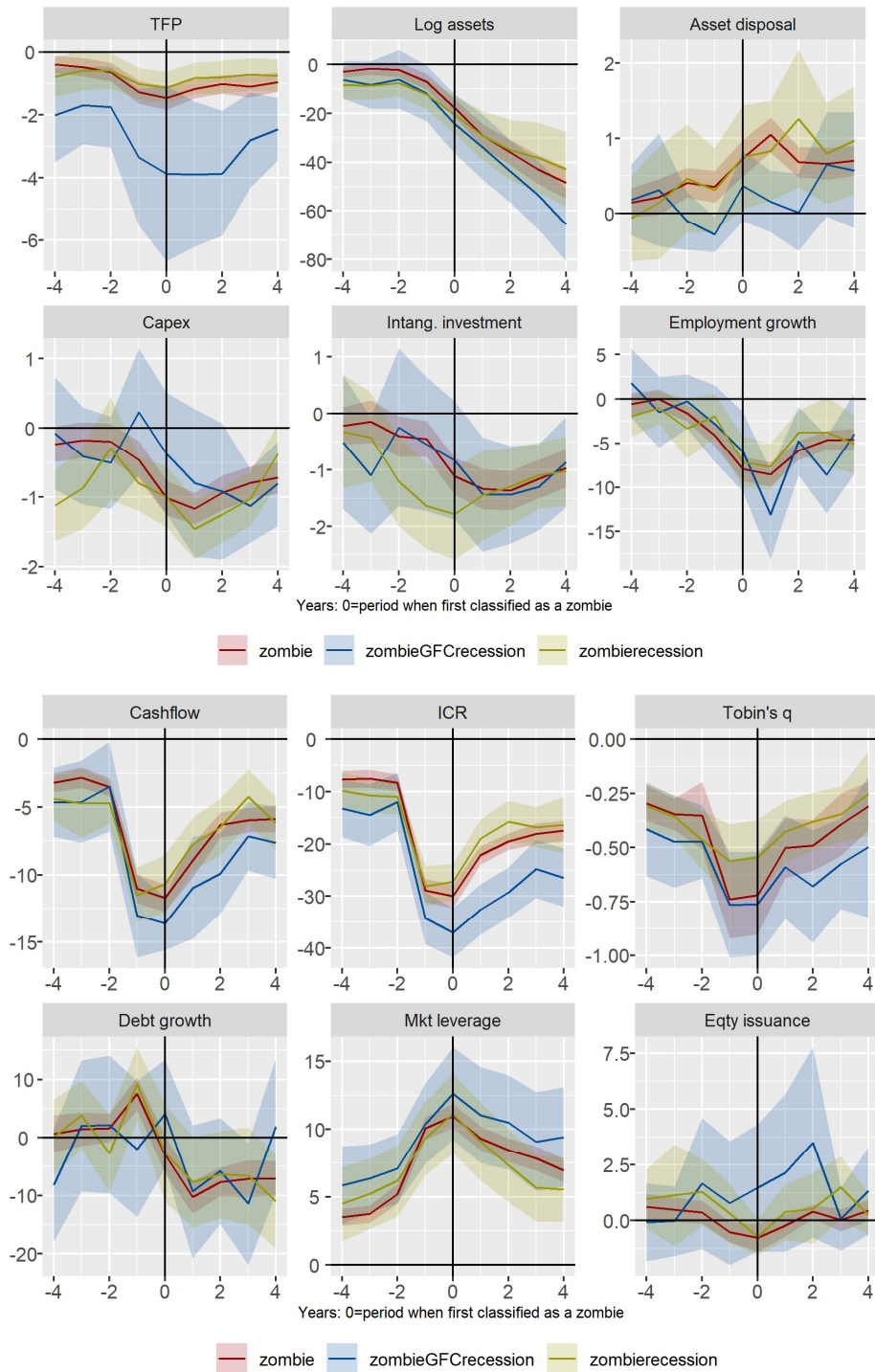
Annex 2: Zombie life cycle and recessions

In order to assess the role of recessions for zombie life cycle dynamics, we run local linear projection regressions of the following form:

$$\begin{aligned}
 y_{i,c,s,t+h} &= \alpha_{c,t+h} + \alpha_{s,t+h} + \beta_h D(Enterzombie)_{i,c,s,t} \\
 &+ \beta_{h,r} D(Enterzombie)_{i,c,s,t} \times D(recession)_{c,t} \\
 &+ \beta_{h,GFC} D(Enterzombie)_{i,c,s,t} * D(recession)_{c,t} \times D(GFC)_t \\
 &+ \gamma_h D(Prezombie)_{i,c,s,t} \\
 &+ \theta_h X_{i,c,s,t-5} + \varepsilon_{i,c,s,t+h}
 \end{aligned}$$

for $h = \{-4, -3, -2, -1, 0, 1, 2, 3, 4\}$. This is the same life cycle regression as before, with $y_{i,c,s,t+h}$ being a measure of performance (e.g. Capex) of firm i in country c and sector s in period $t+h$ and $D(Enterzombie)_{i,c,s,t}$ being a dummy variable that takes the value one if the firm became a zombie in period t . In order to test the role of recessions for zombie life cycle dynamics, the equation includes two additional interactions, one interacting the zombie dummy with $D(recession)_{c,t}$ which is a dummy variable that takes the value one when there was a business cycle peak in country c and zero otherwise. The other interaction term includes in addition the dummy $D(GFC)_t$ which takes the value of one for the periods 2007-2009, identifying recessions linked to the GFC. As before, $D(Prezombie)_{i,c,s,t}$ is a dummy variable that takes the value one if the firm is a zombie in period t but did not enter in zombie status in this period, making sure we compare zombies with healthy firms. $X_{i,c,s,t-5}$ is the five year lagged log of total assets in constant US dollars and we include country-time fixed effects ($\alpha_{c,t+h}$), sector-time fixed effects ($\alpha_{s,t+h}$).

Graph A6 reports the coefficients β_h (red lines) tracking the zombie life cycle in non-recession years. The charts further show $\beta_h + \beta_{h,r}$ tracking life cycle dynamics around recessions excluding the GFC (yellow lines) and $\beta_h + \beta_{h,r} + \beta_{h,GFC}$ tracking zombie life cycle around the GFC related recessions (blue lines). The coefficients measure zombie performance relative to non-zombie firms, so that a value above (below) zero means that the realisation of that variable was higher (lower) for zombie firms than for the non-zombie benchmark. We report the point estimates together with 95% confidence bands (clustered at the country-sector level).



¹ Units are in percentage points except for log assets where it is in percent. Zombie firms defined as firms with both an interest coverage ratio of less than 1 and a Tobin's q below the median firm in the sector over two years. To be declassified as a zombie firm, an ICR larger than one or a Tobin's q above the sector median over two years is required. Shaded areas denote 95% confidence intervals, standard errors clustered at the country sector level.

Sources: Datastream Worldscope; authors' calculations.

The results suggest that there is little difference in zombie dynamics around recessions compared to non-recession periods. For the GFC, some differences emerge, however. Zombie firms that emerged around the GFC were less productive and made higher losses. They also had higher capex their asset disposal after zombification was lower. At the same time, they were more leveraged and issued more equity. Overall, these results suggest that zombie firms around the GFC performed worse but at the same time faced less financial pressure to retrench. However, the confidence bands of the estimated effects often overlap, suggesting that the differences are not statistically significant.

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