Rise of the zombies
- or -
Low productivity firms: their causes, characteristics and consequences

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Abstract

This paper considers the decline in productivity growth in OECD economies by examining the least productive publicly listed firms. Using panel data across thousands of firms over three decades, so-called "zombie" firms are shown to be rising. They are becoming less financially healthy while at the same time facing reduced financial pressures. Relative to the number of firms in the economy they are largely over-represented in the agriculture sector. The purported reasons for zombies in previous papers are evidenced here, namely poor bank health and the lowering of interest rates. Zombie firms are shown to have knock-on effects to healthy firms by lowering capital spending and employment growth in the sectors where they are more prevalent. Finally, this paper considers some non-economic rationales for zombies, such as political and social factors.[1]

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Programmes used: R, LaTeX

To my Christ who raises the dead to life, 1 Corinthians 15 etc.

[1]I am extremely grateful to Dr Ryan Banerjee from the Bank of International Settlements for his kind correspondance and code.

1 Introduction and Motivation

The anaemic recovery following the Global Financial Crisis has renewed efforts to raise growth, as policy measures that used to be thought of as emergency have become the norm: ultra-low interest rates, extremely high levels of borrowing, inflated asset prices and large budget deficits (Summers, 2015). As time goes on, there is increasing concern that low growth rates are 'the new normal' and that policymakers need to address the 'post-growth challenge' (Jackson, 2019).

Traditional approaches have modelled growth in a macroeconomic framework, demonstrating that long run economic growth is underpinned by productivity growth.[2] However, pinning down the constituents of productivity growth and specifying them in an endogenous way has proven difficult.[3] Economics, just as physics, is often studied in two distinct but (ideally) complimentary scopes: the macro and the micro. This paper approaches the low productivity puzzle from a micro-empirical angle and, while *de facto* an academic exercise, its implications are not. Productivity growth, in supporting economic development, provides material security and other attendant benefits such as political stability, social cohesion and better quality of life. The lack of meaningful growth has proven fertile ground for populism which has erupted in the West, as dissatisfaction with the status quo is coalescing into political force. Not only are current generations becoming restless, but if productivity does not rise then our promises to future generations (most obviously in pensions) cannot be met.

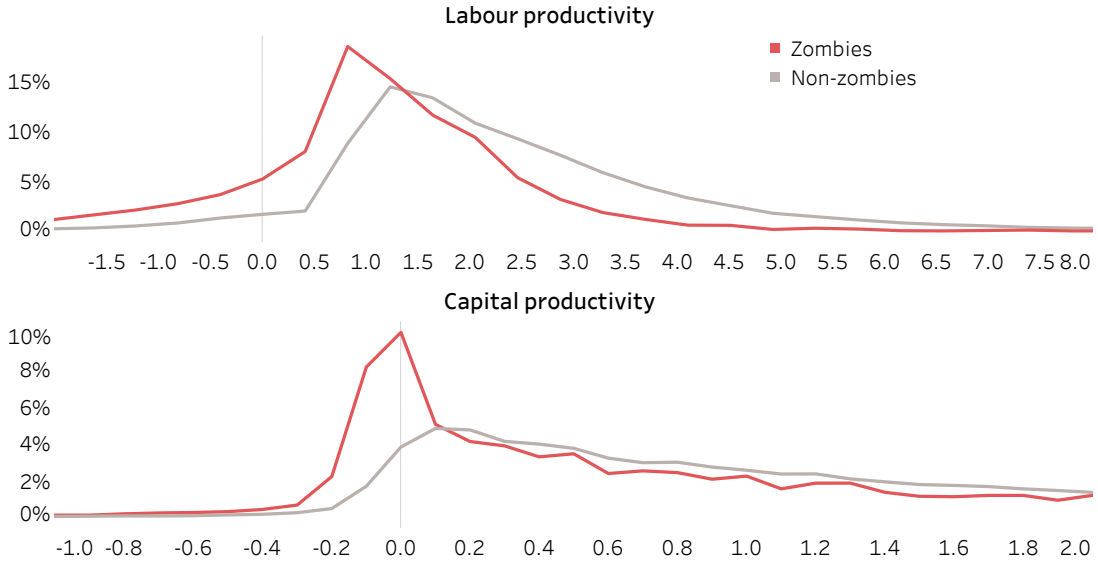
Thankfully economists have never been better-equipped to tackle and diagnose these issues. 20^{th} century economic hypotheses and statistical theory can now be combined with 21^{st} century data and computing power. This paper brings these modern advantages to bear on this most pressing of problems. The intuition is straightforward: it could be informative to look at firms which exhibit low productivity, and think about how they constitute parts of the whole economy. In keeping with the latest literature this paper focusses on so-called 'zombie firms', which economists can use to study low-growth environments. Building up from the micro-firm level allows us to interrogate which firms are not productive and probe more precisely why, gleaning plausible reasons for what we observe at the economy-wide level. In short, to understand why economies become less productive, it can help to examine the less productive firms that comprise them. While specificities are laid out in later sections, inspection of labour and capital productivity densities (Figure 1) shows that this could be a promising approach. Teasing out the low-productivity firms and exploring their characteristics, possible causes and consequences offers a novel approach to an old problem.

[2] See (Romer, 2012) ch1.

[3] See (Romer, 2012) chs.3-4 for an excellent discussion.

Figure 1: Density plots of labour and capital productivity

A firm is classified as a 'zombie' if over 10 years old, with an interest coverage ratio of less than one for at least three consecutive years and a Tobin's Q below the median firm in the sector in a given year. Labour productivity is given by a firm's wages and gross profit (i.e. gross value added) divided by staff costs. Capital productivity is given by a firm's wages and gross profit (i.e. gross value added) divided by total fixed capital. The graphs below have their axes tapered due to long tails. The data covers observations across the sample period.



2 Literature Review

'Zombies' first entered popular consciousness in William Seabrook's book on Haiti and voodoo cults, *The Magic Island*. Zombies lacked free will in slavish devotion to their masters, controlled by voodoo magic as human husks subject to another's bidding (Seabrook, 1931).[4] The break from Haitian folklore came from the film industry via George Romero's 1968 *Night of the Living Dead*. These zombies were the reanimated dead, moved by pure instinct. They attacked and devoured the living, often turning their victims into zombies too. This latter sense is closest to 'zombies' in an economics context.[5] Zombie firms are somehow "unnatural" in the standard economic environment: in a well-functioning market economy, creative-destruction compels firms to improve their efficiency or exit the market through competition.

Originally the literature examined the impacts of zombie firms on healthy firms, particularly in the context of Japanese macroeconomic stagnation in the 1990s (Caballero, Hoshi, & Kashyap, 2008). In Japan, the rise in zombies was due to weak banks using forbearance lending to otherwise insolvent firms.[6] Lending continued with the hope that defunct firms could be resurrected, preventing the realisation of balance sheet losses. Weak banks did this to prevent writing off non-performing loans which would push them up against minimum capital requirements. The moral hazard of anticipated government bailouts as well as political and social pressure to keep lending to struggling businesses also played a role. Thus, zombie firms were first diagnosed from perverse incentives for under-capitalised banks, combined with rigid resolution mechanisms which inhibited resource reallocation. The continued provision of subsidised credit kept zombies alive for longer, disincentivised them to improve their profitability and hurt healthier firms through credit and labour misallocation. Like their fictional counterparts, zombies harmed non-zombie firms and, in extreme cases, could turn healthy firms into zombies too, devouring scarce capital and labour (Hoshi, 2006).

Following the Global Financial Crisis, the literature and interest in zombie firms has extended considerably with renewed energies into bolstering productivity growth. Like the Japanese case, a study into the Outright Monetary Transactions (OMT) Program by the European Central Bank (ECB) found that it had indirectly recapitalised Euro periphery country banks, increasing their incentives to lend to zombie firms which, in turn, significantly increased credit misallocation and slowed economic recovery (Acharya, Eisert, Eufinger, & Hirsch, 2019). This was complimented by an impressive Organisation for Economic Co-operation and Development (OECD) study demonstrating a large rise in zombie firms between 2003-13. They showed how zombies stifled labour productivity, lowered investment and employment growth, and they also congested the labour and capital markets and so raised barriers to entry for new, younger firms (McGowan, Andrews, & Millot, 2017).

[4] See particularly chapter 2 *Dead men working in the cane fields*: 'The zombie, they say, is a soulless human corpse, still dead, but taken from the grave and endowed by sorcery with a mechanical semblance of life...'

[5] 'Zombies' is not yet commonplace to become jargon: a search of 'zombies' at http://citec.repec.org yields just 65 results as of September 2019.

[6] From here, any reference to 'zombies' is shorthand for zombie firms

Yet zombie growth is not just restricted to OECD economies. The International Monetary Fund (IMF) used survey data to show that zombie firms account for an increasing share of total corporate debt in China, and that they are closely linked with state-owned enterprises (SOEs), contributing to corporate debt vulnerabilities and low productivity (Lam, Schipke, Tan, & Tan, 2017).

While most studies focus on the role of inefficiencies in financial intermediation, perverse incentives and insolvency regimes, a new strand in the empirical literature focuses on the unintended consequences of loose monetary policy. While the empirics may be new, the economic theory is not new. The so-called Austrian School of Economists, sceptical about Keynes' demand-side focus, have long-argued that easy credit encourages misallocations of real resources ('malinvestment'), culminating in financial crisis. Tellingly, these more heterodox arguments have been dusted off as received wisdom and traditional policy levers have failed to deliver to expectations.

Central banks began to raise concerns that prolonging low interest rates helped bad firms subsist, holding back potential growth in the United Kingdom (Bank of England, 2013) and South Korea (Bank of Korea, 2013). The Bank of International Settlements (BIS) has used its empirical findings on zombie firms to encourage new thinking around macroeconomic policy, particularly with respect to the uninteded consequences of low interest rates (Borio, 2018).

3 Data

3.1 Source

This paper uses the *Worldscope* Database from Thomson Reuters, a source of detailed financial statement data on public companies domiciled outside the United States. It also contains complete coverage of US companies filing with the Securities Exchange Commission.[7] The database has been constructed to facilitate comparisons across industries and jurisdictions despite the variety of accounting standards, and so it is ideal for this large micro-level panel data approach. As of February 2018, it contains over 85,000 companies worldwide, 49,000 of which are currently active (Refinitiv, 2018). Any firm made extinct (i.e. when it has merged, liquidated or become privately held) remains in the database.

3.2 Sample construction

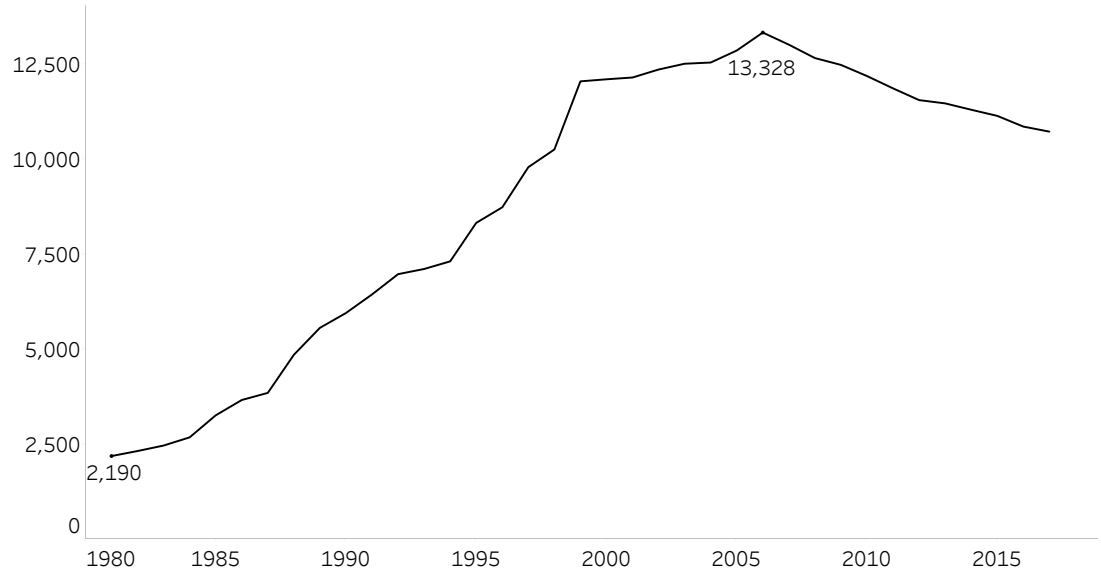
Our sample employs firm data between 1980 and 2018 from 14 advanced OECD economies: Australia, Belgium, Canada, Denmark, France, Germany, Italy, Japan, the Netherlands, Spain, Sweden, Switzerland, UK and USA. The query from *Worldscope* extracts all variables for all firms for all years, regardless of whether the firm existed or not at the time, so the first step is to subset observations where firms really exist (i.e. when data is held on them). We keep all observations on firms with positive total assets, net sales, and liabilities, and remove observations where certain key fields are missing: cash and equivalents, assets, revenue, common equity and liabilities.[8] To pin down genuinely unproductive firms, balance sheets should reflect the underlying viability of the firms in question. In two cases this is often not the case. For financial firms, the balance sheet is part of its business rather than a reflection of it. Utility firms' balance sheets can oscillate dramatically from commodity price shocks, while their prices are often state-controlled, and due to barriers to entry/exit, they can sustain many years of large profits or losses. Accordingly, any firms in these sectors are removed. In addition, we remove American Depositary Receipts (ADRs) from the US data to ensure the sample contains only US companies rather than other US financial instruments.[9]

Having restricted the domain of the sample to the countries, sectors and firm types needed, the next step ensures that each firm at each point in time can be categorised as zombies or not. To calculate the firm's age I use the 'founding year' field. Where this is missing I substitute with the 'date of incorporation'. If both fields are missing, I proxy the age by taking the year where the firm is first observed in the sample as its founding year. This is a conservative approach, treating the firm as if it came into existence when it first appeared on the public exchange. This ensures that the bias for estimating zombie shares etc. is downwards, and that it is more likely that zombies are wrongly identified as non-zombies, rather than non-zombie firms as zombies.

[7] Except for closed end investment companies.
[8] As we use these fields for denominators setting them to zero is not an option.
[9] The full cleaning process can be found in the code submitted with this paper.

Figure 2: The number of active firms over time

'Active' here means the firm i is publicly listed on an exchange in country c in year t.



Any firm which does not provide at least 3 consecutive observations of its interest coverage ratio (ICR, defined in the next subsection) is dropped, as well as any firm which has a missing Tobin's Q (again, defined below). We further restrict the analysis to between 1987 and 2018 to ensure a minimum quality of data coverage.[10] Finally, we augment the sample dataset with key macroeconomic statistics for each country, each year, such as interest rates, inflation, unemployment and gross domestic product (GDP). These are sourced from either the BIS or OECD (see Annex).

This leaves a sample comprising 30,511 unique firms across the time period. As shown in Figure 2, the number of firms starts from around 3,600 in 1987 and peaks at over 13,000 in 2007. In 2018 there are nearly 11,000 active firms. Having specified the sample, the next section sets out the identification strategy for 'zombie' firms.

3.3 Defining 'zombie'

There is no fixed definition of what a 'zombie' firm is. The OECD use two criteria to determine zombie status (McGowan et al., 2017). Firstly, the firm must be "old", i.e. at least 10 years old. This is because younger firms may be unprofitable for their early years as their investments and fixed costs take time to pay off. As well as the age criterion, there is also the profitability threshold, which uses the ratio of earnings before interest and tax (EBIT) divided by total interest paid. This ratio, the 'interest coverage ratio' (ICR), captures how well a firm's earnings cover its debt payments. If the ICR is below one, this implies that a firm pays more in interest

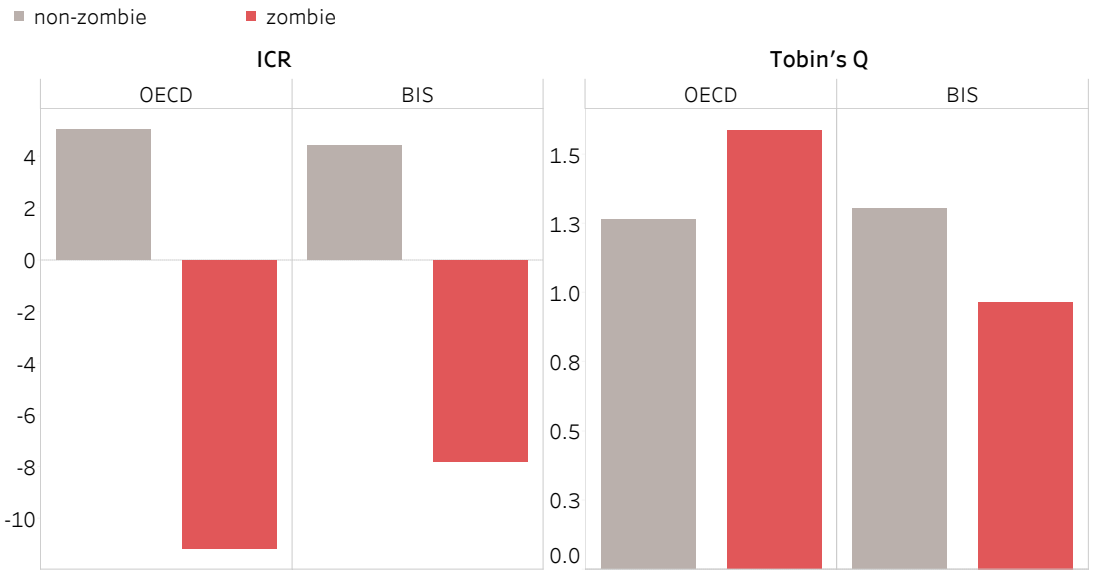
[10] According to the user guide, the *Worldscope* Database's coverage and quality improves markedly from 1985, so including the consecutive years needed for the ICR criterion, it makes sense to start the sample from 1987.

payments than it earns. An old firm which spends all its operating income on servicing its debts is clearly not particularly viable, and so accordingly, economists at the OECD define a zombie firm as one which is over 10 years old and has an ICR below one for at least 3 consecutive years (to capture persistent unprofitability).

Added to these criteria, the Bank of International Settlements (BIS) include a third criterion - that the 'Tobin's Q' is below the median in the firm's sector in a given year (Banerjee & Hofmann, 2018). The Tobin's Q is ratio of the market value of assets to the replacement value of the assets.[11] It provides information on how well a company's investments pay off, with values larger than one implying that investments have been good. If the market has low expectations for future profitability for a firm, its Tobin's Q is lower than the average in its cohort. The Tobin's Q takes advantage of the nature of the firms in the sample. As they are publicly listed it is possible to infer expectations about their future profitability and, hence, viability. The firm's sector in this paper is taken as its two-digit SIC code, a broad definition for its 'cohort'.

Figure 3: Median interest coverage ratios (ICR) and Tobin's Q by zombie definition

Sample medians based on data for 14 advanced economies over the period 1987-2018. Interest coverage ratio = ratio of earnings before interest and taxation to interest paid. Tobin's Q = the sum of the market value of equity and liabilities divided by the sum of the book value of equity and debt. The OECD definition of a 'zombie' is a firm over 10 years old and with an interest coverage ratio of less than one for at least three consecutive years. The BIS definition is the OECD definition with the added criterion that the firm has a Tobin's Q below the median firm in the sector in a given year.



Which definition one chooses produces very different results. While there is some difference under the two definitions with current profitability, the real difference comes when comparing the definitions in light of future profitability prospects (Figure 3). The future profitability of BIS zombies is significantly lower than with OECD zombies due to the Tobin's Q criterion.

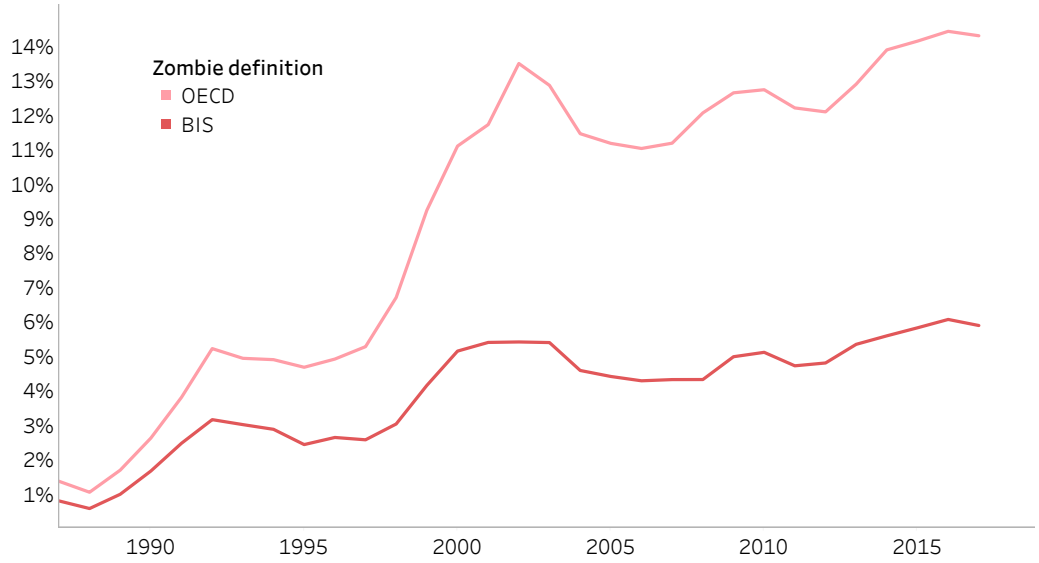
[11] or, on a macroeconomic level, the value of the stock market divided by corporate net worth.

This highlights that the OECD definition might capture so-called 'growth' stocks by treating all stocks as 'value' stocks. What this means is that the OECD definition is in danger of capturing firms whose *current* balance sheet fundamentals look poor but whose *prospects* might be excellent. Taking Tesla Inc. as an example, founded in 2003 it is now considered an 'old' firm. In 2018 it had an ICR of -0.48 as it is yet to make positive earnings: it pays more in interest than it earns. However, it has a Tobin's Q ratio much higher than its peers (the transportation equipment sector). Under the OECD definition, Tesla would count as a zombie, whereas under the BIS definition it would not, due to market expectations about future profitability.

Where the consequences of definition choice are most pronounced is shown by the proportion of firms which have zombie status over time (Figure 4). Clearly the BIS definition, because it uses the OECD definition plus a further narrowing condition, leads to a significantly lower proportion of zombie firms in the sample. By the last observation (2018), the average country's proportion of zombie firms reaches over 14% under the OECD definition compared with around 6% under the BIS.

Figure 4: Mean country zombie shares by definition

The OECD definition of a 'zombie' is a firm over 10 years old and with an interest coverage ratio of less than one for at least three consecutive years. The BIS definition is the OECD definition with the added criterion that the firm has a Tobin's Q below the median firm in the sector in a given year. The share of zombie firms is calculated for each country, each year and then averaged.



Having demonstrated that choosing between the definitions makes a material difference to the analysis, this paper opts for the BIS definition. The crucial factor in this decision is not empirical but conceptual: the BIS definition is more conceptually precise to the 'zombie' label. As the name suggests, 'zombie' firms should be dead.[12] The BIS definition better captures the dynamic element, as the OECD definition is restricted to current balance sheet fundamentals without taking into account future growth prospects. Accordingly, the BIS definition for

[12]More formally, in the long run they should be forced to exit the market due to competitive forces.

'zombie' is used for all analysis going forward: firm i is a zombie at year t if aged 10 years or older, has an interest coverage ratio less than one for at least three consecutive years, and has a Tobin's Q less than the median for its sector s in year t.

$$Zombie_{i,t} = \begin{cases} 1, & \text{if } age_{i,t} \geq 10 \text{ and } ICR_{i,t,t-1,t-2} < 1 \text{ and } \textit{Tobin's } Q_{i,t} < \textit{Tobin's } Q^{median}_{s \supset i,t} \\ 0, & \text{otherwise} \end{cases} \tag{1}$$

4 Analysis

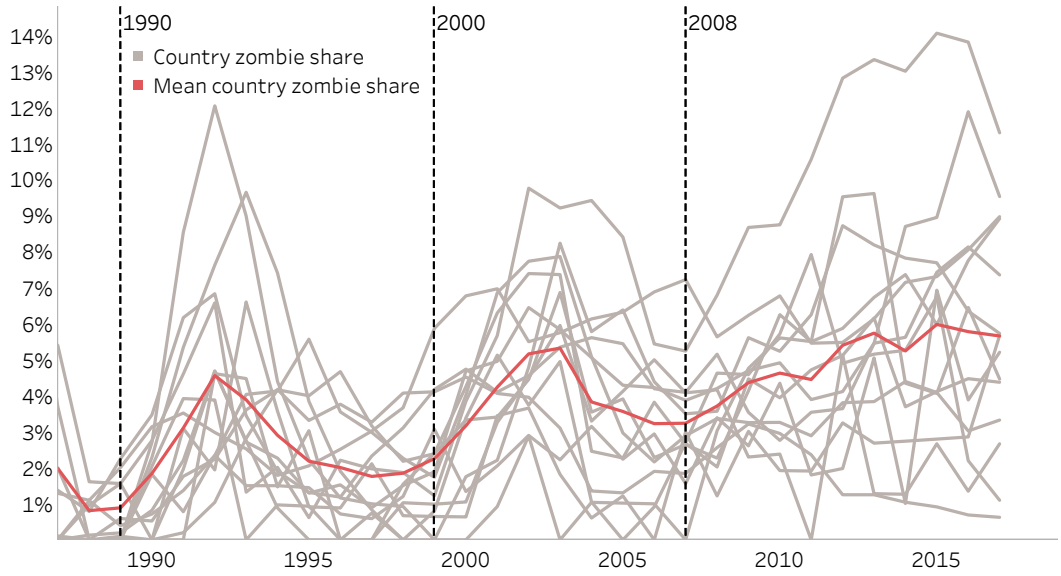
4.1 Stylised facts

4.1.1 Zombie shares by country

As shown by Figure 4 in the section above, there is a 'ratcheting' dynamic in the zombie share. There are steep rises following financial crises and though decreasing gently in the following years, the level never quite reduces to that before the rise. However, by splitting out the constiuent parts of the aggregate and looking at each country over time in Figure 5, we can enhance the picture. There is clearly some general co-movement of zombie shares. Zombie shares appear to rise following growth economic downturns and dip in the years afterwards, though the picture more recently is less clear. Following 2008, there has been a gentle rise in the share of zombie firms but this rise is not characterised by the monotonicity of the previous rises, nor the declines associated with recovery.

Figure 5: Country zombie shares against the average

A firm is classified as a 'zombie' if over 10 years old, with an interest coverage ratio of less than one for at least three consecutive years and a Tobin's Q below the median firm in the sector in a given year.



Despite this general co-movement, there remains considerable difference between countries. To take just one example, Figure 11 shows the zombie share of Japan against that of the UK (see Annex). Consistent with what we might expect, both countries begin the 90s with a sharp increase in their respective zombie shares. However, the UK's share recedes much throughout the mid and late 90s, while Japan's share remains stubbornly high. Following the so-called "lost decade" of the Japanese economy and the dot com bubble bursting, the Japanese share gradually falls, only briefly rising with the Global Financial Crisis (GFC). The UK's share on the other hand witnesses steep rises and persistently high levels: this certainly accords with the narrative of Japan's economic crisis in the 90s and the UK's productivity problem since the

GFC.

4.1.2 State transitions and financial health

We can intensify our focus by going from a country-level to firm-level. It will be instructive to track firms' zombification and recovery or exit over time. Specifically, if the general level of zombie firms is rising, perhaps we might expect zombie firms to remain as zombies for longer, or for fewer zombies to be exiting, or for more non-zombies to become zombies. To analyse this hypothesis we can treat the firm's state (zombie vs non-zombie) as a Markov Chain and use a transition matrix to construct the probability of each outcome at a given point in time. Consider a zombie firm in year t and its corresponding transition probabilities. It can either remain a zombie P_{zz}, transition to a non-zombie P_{zn}, or exit the sample P_{zexit} in the next period *t+1*. Likewise a non-zombie firm can remain healthy P_{nn}, become a zombie in the next period P_{nz} or, finally, exit the sample with probability P_{nexit}.[13] Thus we define the transition matrix as:

$$\underline{\mathrm{T}} = \begin{array}{c} \\ non-zombie_t \\ zombie_t \\ entry_t \end{array} \begin{array}{c} \begin{array}{ccc} non-zombie_{t+1} & zombie_{t+1} & exit_{t+1} \end{array} \\ \begin{pmatrix} P_{nn} & P_{nz} & P_{nexit} \\ P_{zn} & P_{zz} & P_{zexit} \\ 1 & 0 & 0 \end{pmatrix} \end{array}$$

Furthermore, if we define the state of the firm as

$$\underline{\mathrm{S}} = \begin{array}{c} \\ non-zombie_t \\ zombie_t \\ exit_t \end{array} \begin{array}{c} \begin{array}{c} t+1 \end{array} \\ \begin{pmatrix} P_n \\ P_z \\ P_{exit} \end{pmatrix} \end{array}$$

then from the initial state of each firm each year S_{i0}, the probability of a given state at time t is given by the average of $S_{it} = T^t \cdot S_{i0}$.

From Figure 6, it is clear that while most series remain stable, the probability of a zombie firm recovering (red) declines over time, going from around 60% down to 30%. By contrast the probability of a zombie remaining a zombie (dark red) notably increases from around 40% to 60%. Exits generally increase, peaking at around 2007, but since the GFC it appears that relatively fewer zombies are exiting the market.

This analysis demonstrates that while zombie shares vary considerably over time, on average zombie firms are becoming more prevalent over time. They appear to increase after economic downturns and, consistent with the BIS, there is a 'ratcheting dynamic' whereby the subsequent drops in zombie share do not offset the rise beforehand. Moreover, the probability of remaining a zombie has risen steeply and the chance of recovery for zombies has fallen. Moreover, the average (mean) time a firm is a zombie gently increases over time from 2 years in the late 1980s

[13] A firm can exit the sample through becoming privately held, merged or liquidated.

Figure 6: State transition probabilities of firm status

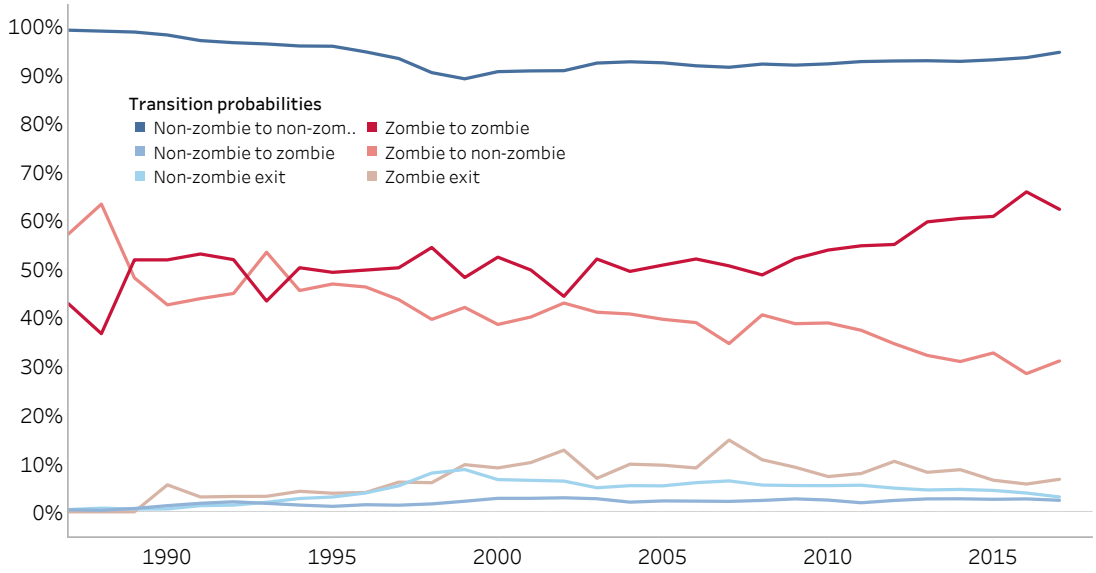
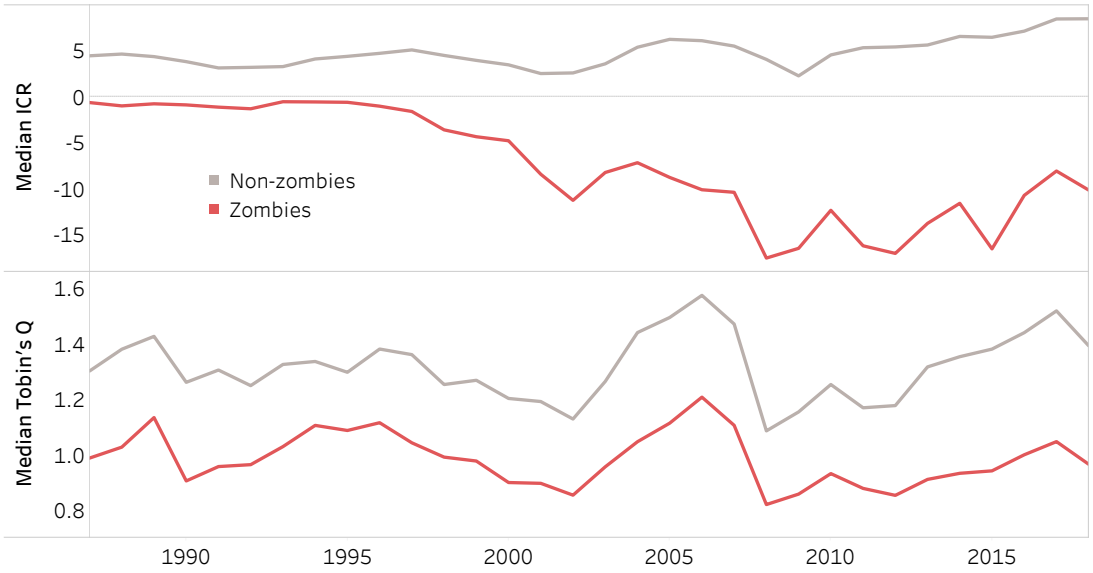


Figure 7: Zombies' relative financial health gets significantly worse over time

Sample medians based on data for 14 advanced economies over the period 1987-2018. Interest coverage ratio = ratio of earnings before interest and taxation to interest paid. Tobin's Q = the sum of the market value of equity and liabilities divided by the sum of the book value of equity and debt. A firm is classified as a 'zombie' if over 10 years old, with an interest coverage ratio of less than one for at least three consecutive years and a Tobin's Q below the median firm in the sector in a given year.



to 2.3 years by 2018.[14]

As well as remaining in a zombie state for longer, zombies' financial health relative to that of healthy firms gets worse over time. This is particularly pronounced in the gap in average interest coverage ratios, which increases from a little over 5 in the late 1980s to over 18 by 2018. The financial crisis in 2007 appears to have had a particularly bad effect on zombie firms' ability to cover their debt interest payments. In addition, zombies' relative future profitability has declined. Starting from a 0.3 gap in the Tobin's Q ratios with non-zombie firms in the late 1980s, by 2018 this has extended to over 0.4, a relative increase of over 33%. Not only are zombies becoming more prevalent but they are becoming less healthy too.

4.1.3 Structural transformation

An advantage of using a sample spanning 30 years is that it might be possible to observe the structural transformation of economies. Specifically, it could be instructive to check if there is a significant reallocation of economic activity across broad sector groups. Accordingly, this paper groups firms into either agriculture, manufacturing or services.[15] As these are publicly listed firms in advanced OECD economies, we would expect *ex ante* to see a declining share of manufacturing relative to services since the 1980s. We would also not expect agriculture to play a significant role. These expectations are largely confirmed by the data.

The share of firms in each large sector group changes significantly. While the agriculture share of firms remains modest and grows in later years, services firms rise from 30% in the late 1980s to 45% in 2018. Manufacturing firms decrease from a share of 64% to 46% over the same period.

Assets (a useful proxy for firm size) and capital share a similar story. Manufacturing declines by around a 13% share of assets and an 8% share of capital, substituted for larger shares in services. Notably the rise of services firms' shares broadly stops around 2001, plateauing thereafter. Agriculture remains broadly stable, but intriguingly sees increase in the share of firms, assets and capital from about 2007, perhaps confounding *ex ante* expectations.

In contrast with the previous three measures, structural transformation in employment are more straightforward. Agriculture's share of employment declines from over 3% in the late 1980s to under 2% by 2018. These shares are also well below equivalent shares in firm numbers, assets or capital, implying a shift in production away from labour and towards capital.

Starting at 34% in 1987, services firms have a broadly monotonic increase in their employment share, reaching 54% by 2018: there is no peak in 2002. By contrast, manufacturing begins

[14] See Figure 12. However, this rise is by no means monotonic (the short run interest rate follows a similar path so is included for comparison).

[15] 'Agriculture' captures any firm with a 2 digit SIC code from 01 to 14. 'Manufacturing' includes all firms with SIC codes from 15 to 39. 'Services' captures all firms with SIC codes between 40 and 98. Any firm with a SIC code 99 i.e. unclassifiable has been dropped, as well as financial firms and utility firms.

Figure 8: Structural transformation over time

'Agriculture' captures any firm with a 2 digit SIC code from 01 to 14. 'Manufacturing' includes all firms with SIC codes from 15 to 39. 'Services' captures all firms with SIC codes between 40 and 98. Any firm with a SIC code 99 i.e. unclassifiable has been dropped.

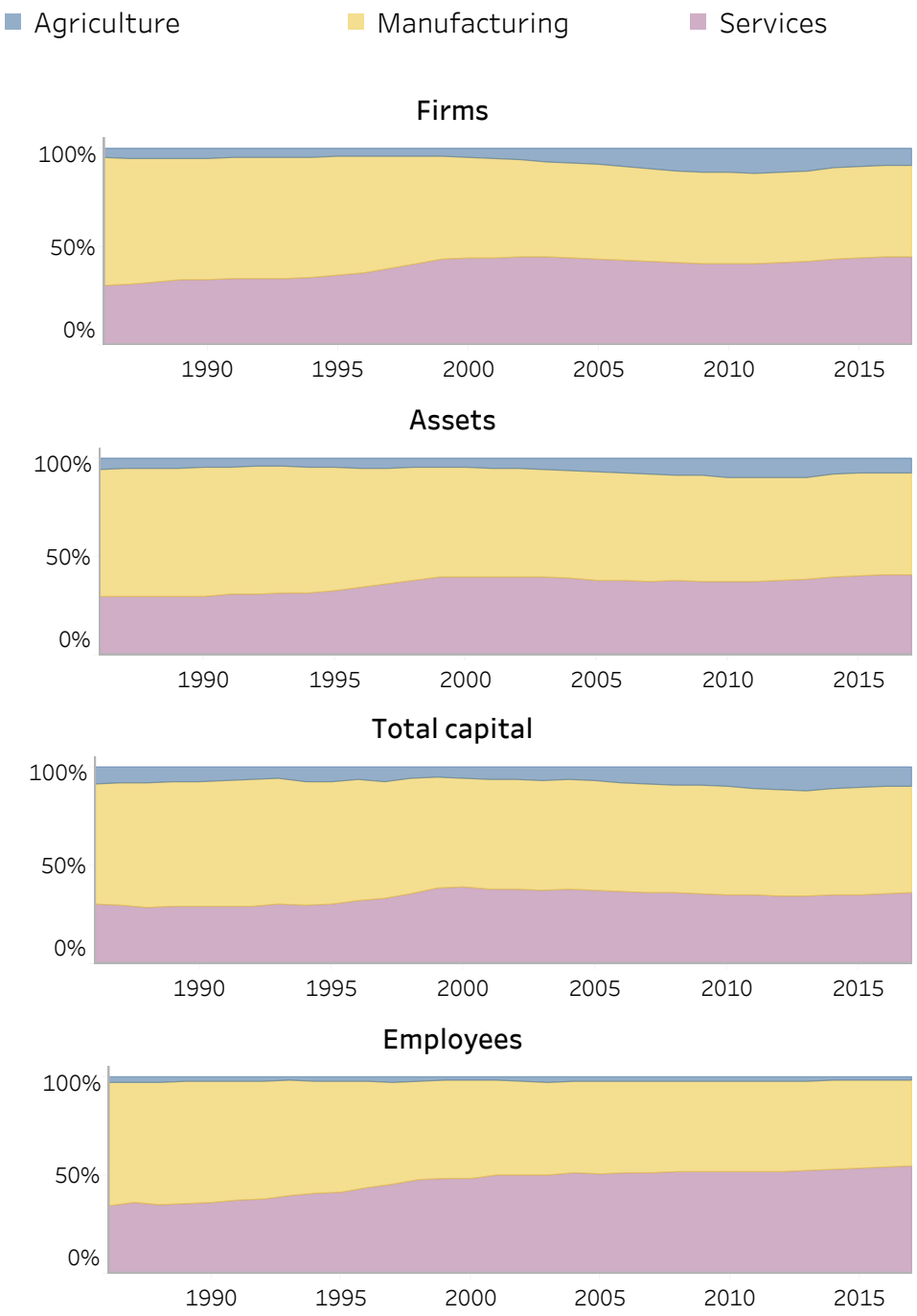
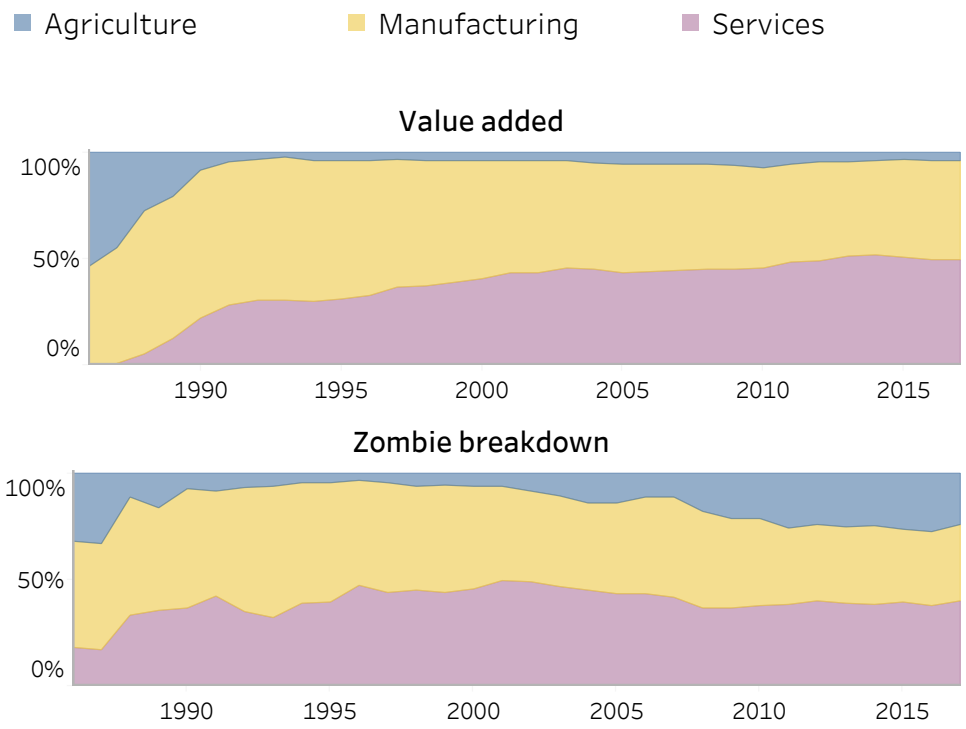


Figure 9: Productivity measures by sector

'Agriculture' captures any firm with a 2 digit SIC code from 01 to 14. 'Manufacturing' includes all firms with SIC codes from 15 to 39. 'Services' captures all firms with SIC codes between 40 and 98. Any firm with a SIC code 99 i.e. unclassifiable has been dropped. 'Value added' is the sum of staf wages and gross profit.



with the lion's share of employment (63%) which declines steadily to 44% by the end of the sample.

The persistence and stability of the agriculture sector over the decades requires further investigation. In particular, the recent growth of firms, assets and capital in agriculture firms is surprising. From standard theories of comparative advantage there seems little reason why developed OECD economies should be investing much resource into domestic agriculture. Away from economic theory, however, there are reasons why a state might want to prop up agriculture. Perhaps it is prudent to guarantee food security by ensuring *de minimis* domestic production in case of trade disruption. Alternatively, perhaps agriculture is a well-recognised sector with political weight and social standing, and so there are state subsidies to support the industry (this is particularly true in countries such as France and the USA).

Since the late 1980s the agriculture sector has seen a sharp decline in its share of value added. With no notable increase in productivity, it is unsurprising that given the increase in firms, assets and capital in agricultural firms, the share of zombie firms in agriculture has increased markedly. In 2007 agriculture firms accounted for just 11% of zombie firms (still higher than their equivalent shares in other measures), but by 2018 they account for nearly 25% of all zombies.

4.2 Have zombies changed their behaviour?

Faced with financial difficulties, we might expect zombie firms to cut back debt (deleverage) and/or increase asset disposal to improve the balance sheet. However, the increase in zombie firms implies that, somehow, these firms are facing less financial pressure than they did before. Therefore, there are two questions to ask:

(i) Do zombies deleverage/ dispose of assets more than their non-zombie peers? *(we might expect so)*

(ii) Does the intensity of this activity reduce over time? *(possible given the rise in zombies over time)*

Both these questions can be answered by the following econometric model computed by ordinary least squares (OLS):

$$\begin{aligned} y_{isct} =& \beta_1 D(zombie_t) + \beta_2 D(zombie_t) * D(post2000) + \beta_3 D(zombie_t) * D(post2009) \\ &+ \gamma Controls_{isct} + \alpha_{st} + \delta_{ct} + \varepsilon_{isct} \end{aligned} \tag{2}$$

The variable y_{isct} stands for either change in total debt over total assets (i.e. change in leverage[16]) or asset disposal over total assets for firm i, member of sector s, in country c, at year t. $D(zombie_t)$ is a dummy variable assuming 1 if the firm is a zombie at year t and zero otherwise.

[16] All short and long-term obligations expected to be satisfied by the company.

As such, β_1 will address the first question above. $D(post2000)$ is a dummy variable with value 1 if year t is 2000 or after, and 0 otherwise, and likewise for $D(post2009)$. This means that β_1, β_2 and β_3 will help answer the second question above. A vector of control variables is added to account for other possible balance sheet variables that might affect the outcome variable(s). These are: the logarithm of ratio of fixed assets to total assets; logarithm of market-to-book value; logarithm of total assets in constant 2012 US dollars; the logarithm of the ratio of capital expenditures to total assets; the logarithm of ratio of research and development (R&D) to sales; and a dummy variable indicating whether a firm pays a dividend that year. α_{st} and δ_{ct} are sector-year and country-year dummy variables respectively to control for changes to sectors and countries across time: this is a fixed effects model to control for time-invariant unobserved idiosyncratic firm heterogeneities.[17]

Throughout this paper, fixed effects estimators are used rather than random effects estimators. This is because it is highly doubtful that the time-invariant idiosyncratic unobserved effects are orthogonal to the regressors in this data: i.e. it is reasonable to expect that balance sheet data reflect the particulars of a firm. Moreover, with a large number of observations the fixed effects estimator produces a consistent estimator against the random effects model and so is unbiased. The cost is losing some precision in the variance-covariance matrix.[18]

Consistent with the BIS, I find that zombie firms cut debt at a rate of just under 1% of total assets a year than non-zombie firms. However, after 2000 this relatively higher rate of deleveraging becomes statistically insignificant. This reveals that while zombie firms used to deleverage at a faster rate than non-zombies, post-2000 their behaviour is no different to non-zombies. This implies that the pressure to cut back on their debt has decreased over time.

How leverage is defined is important here. This first regression has taken a simple ratio of total liabilities to total assets. However, a more nuanced view might be 'net leverage', which is the short term debt and current portion of long-term debt[19] added to long term debt[20] minus cash and short-term investments. This takes into account the dynamics of when the debt is payable and the means of the firm to pay the short term debt. If we regress onto net leverage (divided by total assets) rather than simple leverage, we get a slightly different picture.

Now we see that before 2000, zombie firms had little difference in net leverage than non-zombie firms. However, after 2000 their net leverage increased by over 3% relative to total assets, and after 2009 by 3%. While the differing definitions of leverage lead to slightly different conclusions, the message from both regressions is that zombies appear to have experienced less pressure to cut their debts as the years have gone on.

[17] I also subset to firms with an absolute deleverage amount to less than 40% (so not to capture liquidating firms) and where the firm has negative earnings limited to equal the value of its total assets. These subsets are reasonable to remove a few strange observations that don't fall under what I try to measure in this context.

[18] See (Wooldridge, 2010), chapter 10.7.2 for a detailed discussion.

[19] Representing that portion of debt payable within one year including current portion of long term debt and sinking fund requirements of preferred stock or debentures.

[20] All interest bearing financial obligations, excluding amounts due within one year, net of premium or discount.

Table 1: Zombies' action following financial pressures over time

	Measures to improve balance sheet health		
	$\Delta\frac{leverage}{totalassets}$	$\Delta\frac{netleverage}{totalassets}$	$\Delta\frac{assetdisposal}{totalassets}$
$D(zombie_t) * D(pre2000)$	-0.0127^{**}	-0.0064	1.0103^{***}
	(0.0058)	(0.0055)	(0.2022)
$D(zombie_t) * D(pre2009)$	-0.0014	0.0333^{***}	0.4555^{***}
	(0.0027)	(0.0054)	(0.0630)
$D(zombie_t) * D(post2009)$	0.0028	0.0288^{***}	0.3389^{***}
	(0.0026)	(0.0079)	(0.0853)
$\ln(\frac{fixedassets}{totalassets})$	-0.0047^{***}	0.0153^{***}	-0.1027^{***}
	(0.0008)	(0.0022)	(0.0203)
$\ln(\frac{marketcapitalisation}{bookvalue})$	-0.0062^{***}	-0.0538^{***}	-0.2126^{***}
	(0.0009)	(0.0031)	(0.0281)
$\ln(totalassets_{t,2012USD})$	0.0019^{***}	-0.0001	0.0650^{***}
	(0.0002)	(0.0005)	(0.0103)
$\ln(\frac{capex}{totalassets})$	0.0088^{***}	0.0132^{***}	0.0921^{***}
	(0.0008)	(0.0013)	(0.0118)
$\ln(\frac{R\&Dexpenses}{sales})$	0.0009^{**}	0.0042^{***}	-0.0557^{***}
	(0.0004)	(0.0011)	(0.0118)
$D(dividend_t)$	-0.0135^{***}	-0.0275^{***}	0.2358^{***}
	(0.0013)	(0.0055)	(0.0351)
*Sector * year fixed effects*	Yes	Yes	Yes
*Country * year fixed effects*	Yes	Yes	Yes
R^2	0.09195	0.08865	0.06916
Observations	100,436	109,606	95,508

Significance at the 1,5,10% level is denoted by ***/**/* respectively.

Running the same model but with asset disposal (divided by total assets) on the left hand side shows more evidence that zombie firms are facing less financial pressure. Though the sign of the beta coefficients matches expectations (that zombie firms dispose of assets at a relatively higher rate than non-zombies), the difference between zombies and non-zombies shrinks from over 1% pre-2000 to under 0.3% post-2010.

This reduced financial pressure on zombies has not been matched with a corresponding meaningful improvement in their profitability. As financial pressure on zombie firms has reduced, these firms lock in more resources better-allocated for more profitable firms, having a knock-on effect to healthier firms.[21]

[21] See section 4.4

4.3 Causes

As previously discussed, the literature identifies two potential causes of zombie firms: weak banks and low interest rates. To proxy bank health I use banking sector price-to-book ratios.[22]. For interest rates I take the policy rate, but for robustness testing also use the short run 3 month central bank offer rate where I get the same results.[23] A crude inspection of the zombie share against the (inverted) interest rate/ bank price-to-book ratio reveals there could possibly be a relationship.

One way to explore this relationship in a robust way is to look at the difference in zombie shares across sectors. Specifically, we can assess whether the effect of weaker bank health or lower interest rates affects those sectors that are relatively more dependent on external funding sources. The intuition would be that these firms are more likely to face financial pressure for given changes in financing conditions. This approach is well-suited to address concerns about omitted variable bias and reverse causality because we can fully control for the influence of unobserved macroeconomic factors at the country level in any year.

$$\begin{aligned} ZombieK_{sct} =& \beta_1(ExternalFinancialDependence_s) * (InterestRate_{c,t-1}) \\ &+ \beta_2(ExternalFinancialDependence_s) * (BankHealth_{c,t-1}) \\ &+ \alpha_{st} + \gamma_{ct} + \varepsilon_{sct} \end{aligned} \tag{3}$$

$ZombieK_{sct}$ is the share of physical capital in zombie firms in sector s in country c at year t; $ExternalFinancialDependence_s$ is the median firm's share of capital expenditures not financed by their operating income in sector s; $InterestRate_{c,t-1}$ is the previous period's policy rate for country c; $BankHealth_{c,t-1}$ is the banking sector's price-to-book ratio in country c in year *t-1*. α_{st} and γ_{ct} are sector and country*year fixed effects respectively. Standard errors are clustered by sector-year and country-year.

Unlike the BIS, I find that both banking sector health and the interest rate have a significant effect on the zombie shares in sectors more dependent on external financing.[24] Consistent with the hypothesis, lower nominal rates/ weakening banks push up zombie shares in those sectors where firms depend more heavily on external sources of financing.

[22] See (Bogdanova, Fender, & Takats, 2018). Data are taken from *Thomson Reuters Datastream*. For Spain 1987-9, France in 1987 and the Netherlands between 1987-91 there are data missing. I interpolate by employing the annual growth rate of the average PB ratio of the remaining countries with full data series.

[23] Sourced from the OECD Economic Outlook database.

[24] (Banerjee & Hofmann, 2018) only find the latter.

Figure 10: Potential drivers of country zombie shares

Price-to-book ratios, policy rates (central bank 3 month nominal rate) and zombie shares are simple averages from Australia, Belgium, Canada, Denmark, France, Germany, Italy, Japan, the Netherlands, Spain, Sweden, Switzerland, UK and USA.

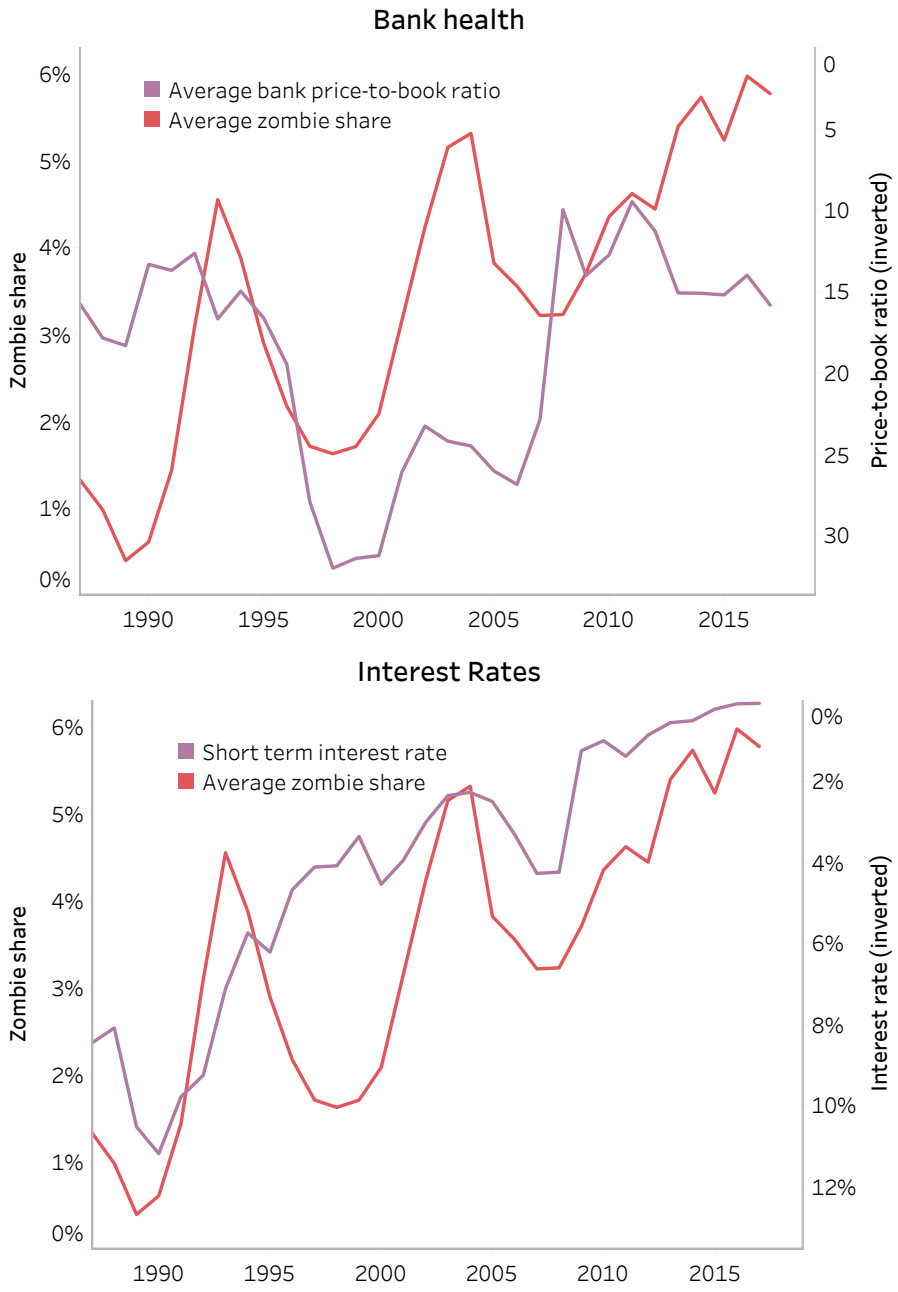


Table 2: Financial pressures, bank health and policy rates

	1	2	3
$ExternalFinancialDependence_s * InterestRate_{c,t-1}$	-0.0360^{**}		-0.0380^{***}
	(0.0146)		(0.01476)
$ExternalFinancialDependence_s * BankHealth_{c,t-1}$		-0.2132^{***}	-0.1689^{***}
		(0.0633)	(0.0618)
Sector fixed effects	Yes	Yes	Yes
*Country * year fixed effects*	Yes	Yes	Yes
R^2	0.1999	0.2100	0.2064
Observations	19,932	16,488	19,348

Significance at the 1,5,10% level is denoted by ***/**/* respectively.

4.4 Consequences

Previous papers have found evidence of "congestion effects" whereby zombie firms lock in resources (capital and labour) from healthier firms, raising costs through resource competion, and lowering prices by raising the supply of goods (Caballero et al., 2008). This paper's findings are consistent with these earlier studies. We can estimate the effects of zombies on non-zombies in both capital and labour with the following econometric model:

$$\begin{aligned} y_{isct} =& \beta_1 D(nonzombiefirm)_{isct} + \beta_2 D(nonzombiefirm)_{isct} * zombieshare_{s,t-1} \\ &+ \beta_3 log(size_{isct}) + \beta_4 firmage_{isct}) + \alpha_{st} + \gamma_{ct} + \varepsilon_{isct} \end{aligned} \tag{4}$$

The dependent variable y_{isct} is either capital expenditures as a ratio of lagged physical capital or employment growth[25] in firm i in sector s in year t. α_{st} and γ_{ct} are sector*year and country*year fixed effects respectively. The dummy variable $D(nonzombiefirm)$ adopts a value of 1 if the firm is not a zombie and 0 otherwise. *zombieshare* is the share of total assets in zombie firms in a given sector for the previous year. Standard errors are double-clustered by country and sector. From theory, we expect that non-zombie firms would have positive coefficients on their dummy variables i.e. that non-zombies exihibit higher capital spending and employment growth than the set of zombies and non-zombies. The congestion effects would be evidenced by significant negative coefficients on the interaction term β_2 which would show that sectors with a greater zombie presence (by assets/size) weigh on capital and labour growth more than in other sectors.

The results from the interaction term suggest that a 1% increase in the zombie share in a given sector will lower the capital expenditure (capex) rate of non-zombie firms in that same sector by about 1% too. Likewise, employment growth is a little over 0.3% lower. In addition, the first dummy term demonstrates that non-zombie companies invest more and have higher

[25] defined as $0.5 * \frac{employment_{it} - employmenti,t-1}{employment_{it} + employmenti,t-1}$

Table 3: Zombie congestion effects on non-zombies

	$\frac{capex}{capital}$	$EmploymentGrowth$
$D(nonzombiefirm)_{isct}$	0.6375^{***}	0.1069^{***}
	(0.0171)	(0.0069)
$D(nonzombiefirm)_{isct} * zombieshare_{s,t-1}$	-0.8727^{**}	-0.3224^{***}
	(0.04221)	(0.1081)
$Sector * year$and$country * year$ fixed effects	Yes	Yes
R^2	0.2054	0.0669
$Observations$	$290,576$	$261,174$

Significance at the 1,5,10% level is denoted by ***/**/* respectively.

employment growth, consistent with our intuition. Therefore, while we know in abstract that, *ex hypothesi* zombie firms will lower aggregate productivity in an economy, their impact is clearly not just an arithmetic truism. They have real impacts on other firms in their sector, clogging up resources and worsening capital spending and employment growth. Does this imply that zombies are unambiguously a bad thing?

5 Discussion: should all zombies be killed?

Throughout this paper we have employed the term "zombie" which, though being technically specified through a set of criteria, captures a broad pejorative implication, that these firms somehow *ought* not to exist. It is worth briefly reflecting on this by examining some example of zombies to caveat and contextualise the analysis above.

- **Eurotunnel**: the financial troubles of the Eurotunnel are well-documented.[26] Prime Minister Margaret Thatcher agreed to permit a privately financed project but the construction bill for the two 31 mile tunnels came in way over budget at £9.5 billion. It opened a year late and in its first year of operation made a loss of £925 million; interest payments at one point reached £2 million per day and the UK's Department of Transport had to intervene to guarantee the company's debt when difficulties arose. A decade after opening in 2009 it was forced to restructure to wipe more than €5 billion in debt from its books in loan for equity swaps. In the late 1990s and mid 2000s it is classified as a zombie in our sample. Though treated as a textbook case of overoptimistic infrastructure projects, it is unclear that the Channel Tunnel, in retrospect, "shouldn't exist". In particular, the political support for the project is an important dimension to consider when thinking outside its balance sheets, as well as the sunk costs once the project had begun.

- **Egdon Resources PLC**: another factor which might cause us pause is future uncertainty. Egdon Resources is a UK oil and gas exploration firm. It was a zombie in 2009 as well as between 2015-18. Egdon stands to gain significantly if shale and fracking becomes more liberalised in the UK.[27] At present it owns a lot of land but is not permitted to drill. Should the UK regulatory environment change, the finances of this moribund company may well recover with ease: it is again not clear that this firm is necessarily unproductive.

- **American Airlines Group Inc**: a huge firm but often with shaky finances, American Airlines became a zombie in the mid-1990s and 2000s. It appears to have quite a volatile cashflow and, though its debt burden is still heavy, its balance sheet has improved lately.[28] Consider the consequences of American Airlines going bust after prolonged balance sheet weakness. It would mean that US commerical flights would suffer enormously in the short run and the potential for people to be stranded.[29] However, allowing large airline firms to zombify could be a painful long-term policy move. It could introduce moral hazard to other firms by encouraging a "too big to fail" attitude. It also ignores market solutions to these problems, such as most travellers having travel insurance and that other airlines would be able to buy up parts that can be turned around.

This paper makes no prescription about what should be done about zombie firms. However, it is only appropriate that in considering zombies' negative impacts on the economy

[26] See (Times, 2019) for a recent summary.
[27] See (ProactiveInvestors, 2019)
[28] For more details see (Finance, 2019)
[29] Thomas Cook has a similar problem as this paper is being written, requesting £200 million from the UK Government. A collapse would leave 150,000 UK holidaymakers stranded (BBC, 2019).

as a whole and other firms in their sector, that the counterfactual of them going bust is also reckoned with, and that there are often non-financial considerations required before any normative pronouncement or policy. These examples acknowledge the complexity and nuance of each situation, and so caution against any crude or simplistic solution to the growing zombie problem.

Conclusion

It is no exaggeration to say that addressing the productivity malaise is key to the future of humanity's material prosperity. This paper has used tens of thousands of firms across several decades to establish that there is indeed a growing incidence of low-productivity firms. They are characterised by being old, persistently unprofitable and having bad future prospects. Across the sample, zombies are "living" for longer, becoming relatively less healthy and having a knock-on impact on healthy firms. There appears to be good evidence that the suspected causes, poor bank health and, more recently, the low interest rate environment, are contributory factors. Despite this, a policy measure is not forthcoming. Any proponent of "creative destruction" and allowing these firms to go bust will need to consider the wider impacts, be they social, political, prudential or ethical. This is not to say that such an approach would be unwarranted, but rather to highlight that, as with any serious matter of economic policy, trade-offs are inevitable.

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Appendices

Figure 11: Japan and the UK's zombie shares over time

A firm is classified as a 'zombie' if over 10 years old, with an interest coverage ratio of less than one for at least three consecutive years and a Tobin's Q below the median firm in the sector in a given year.

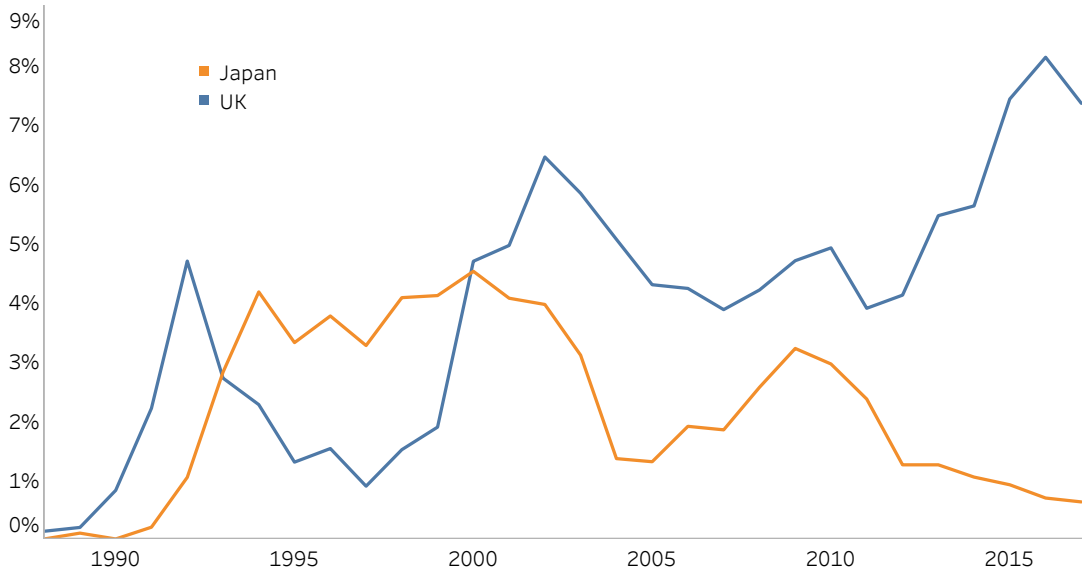

Figure 12: The average zombie duration gets longer across the sample

A firm is classified as a 'zombie' if over 10 years old, with an interest coverage ratio of less than one for at least three consecutive years and a Tobin's Q below the median firm in the sector in a given year.The short run interest rate is the country average of the 3 month central bank offer rate

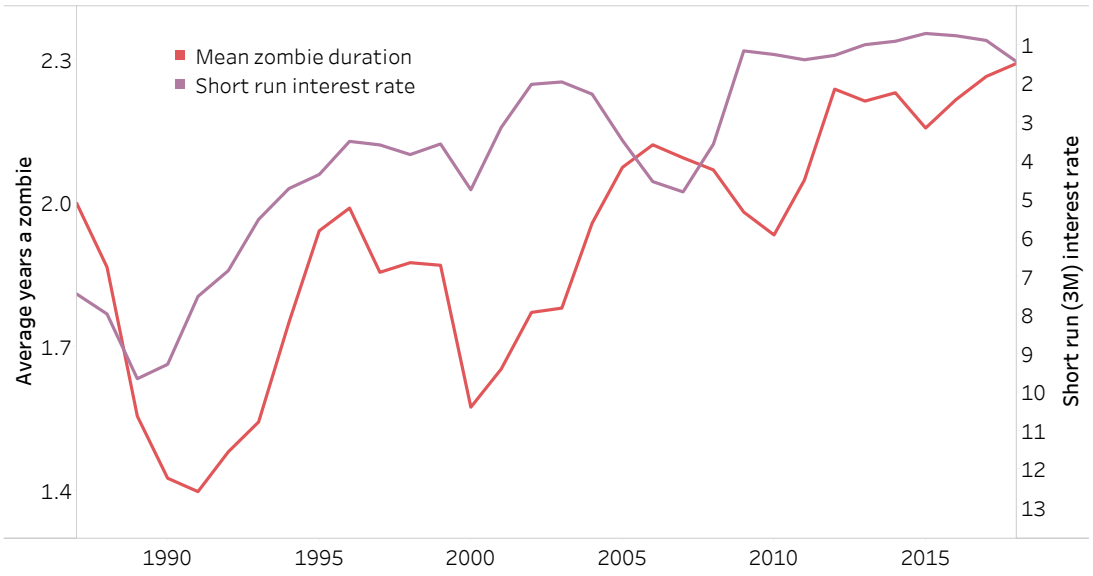

Table 4: Country-year statistics on firms and zombies

country	year	firms	zombies	percent_zombies
Australia	1987	67	0	0
Australia	1988	66	0	0
Australia	1989	104	1	0.96
Australia	1990	128	2	1.56
Australia	1991	145	4	2.76
Australia	1992	152	7	4.61
Australia	1993	152	10	6.58
Australia	1994	151	2	1.32
Australia	1995	149	3	2.01
Australia	1996	162	1	0.62
Australia	1997	181	4	2.21
Australia	1998	203	4	1.97
Australia	1999	214	4	1.87
Australia	2000	245	3	1.22
Australia	2001	312	12	3.85
Australia	2002	476	27	5.67
Australia	2003	799	78	9.76
Australia	2004	901	83	9.21
Australia	2005	934	88	9.42
Australia	2006	1035	87	8.41
Australia	2007	1140	62	5.44
Australia	2008	1183	62	5.24
Australia	2009	1266	86	6.79
Australia	2010	1326	115	8.67
Australia	2011	1292	113	8.75
Australia	2012	1278	135	10.56
Australia	2013	1178	151	12.82
Australia	2014	1155	154	13.33
Australia	2015	1053	137	13.01
Australia	2016	1038	146	14.07
Australia	2017	948	131	13.82
Australia	2018	938	106	11.3
Belgium	1987	27	1	3.7
Belgium	1988	37	2	5.41
Belgium	1989	62	1	1.61
Belgium	1990	64	1	1.56
Belgium	1991	64	0	0
Belgium	1992	65	0	0
Belgium	1993	65	3	4.62

Table 4: Country-year statistics on firms and zombies

country	year	firms	zombies	percent_zombies
Belgium	1994	67	3	4.48
Belgium	1995	68	1	1.47
Belgium	1996	66	2	3.03
Belgium	1997	62	0	0
Belgium	1998	78	0	0
Belgium	1999	97	1	1.03
Belgium	2000	101	1	0.99
Belgium	2001	95	1	1.05
Belgium	2002	92	3	3.26
Belgium	2003	89	4	4.49
Belgium	2004	84	5	5.95
Belgium	2005	91	3	3.3
Belgium	2006	97	4	4.12
Belgium	2007	100	5	5
Belgium	2008	98	4	4.08
Belgium	2009	96	4	4.17
Belgium	2010	87	2	2.3
Belgium	2011	84	2	2.38
Belgium	2012	81	0	0
Belgium	2013	78	4	5.13
Belgium	2014	78	1	1.28
Belgium	2015	79	1	1.27
Belgium	2016	75	2	2.67
Belgium	2017	74	1	1.35
Belgium	2018	75	2	2.67
Canada	1987	200	1	0.5
Canada	1988	218	3	1.38
Canada	1989	254	2	0.79
Canada	1990	266	6	2.26
Canada	1991	288	10	3.47
Canada	1992	308	19	6.17
Canada	1993	322	22	6.83
Canada	1994	319	11	3.45
Canada	1995	316	6	1.9
Canada	1996	304	4	1.32
Canada	1997	337	4	1.19
Canada	1998	344	8	2.33
Canada	1999	354	11	3.11
Canada	2000	479	20	4.18
Canada	2001	612	29	4.74

Table 4: Country-year statistics on firms and zombies

country	year	firms	zombies	percent_zombies
Canada	2002	658	27	4.1
Canada	2003	680	31	4.56
Canada	2004	748	40	5.35
Canada	2005	766	43	5.61
Canada	2006	808	44	5.45
Canada	2007	1049	44	4.19
Canada	2008	1050	43	4.1
Canada	2009	1009	52	5.15
Canada	2010	1017	36	3.54
Canada	2011	1014	28	2.76
Canada	2012	960	34	3.54
Canada	2013	906	33	3.64
Canada	2014	862	47	5.45
Canada	2015	816	71	8.7
Canada	2016	782	70	8.95
Canada	2017	732	87	11.89
Canada	2018	745	71	9.53
Denmark	1987	28	0	0
Denmark	1988	28	0	0
Denmark	1989	40	0	0
Denmark	1990	76	0	0
Denmark	1991	98	2	2.04
Denmark	1992	102	4	3.92
Denmark	1993	103	4	3.88
Denmark	1994	105	0	0
Denmark	1995	103	1	0.97
Denmark	1996	107	1	0.93
Denmark	1997	107	0	0
Denmark	1998	135	1	0.74
Denmark	1999	132	0	0
Denmark	2000	125	1	0.8
Denmark	2001	118	4	3.39
Denmark	2002	117	6	5.13
Denmark	2003	107	4	3.74
Denmark	2004	101	5	4.95
Denmark	2005	95	1	1.05
Denmark	2006	96	0	0
Denmark	2007	109	1	0.92
Denmark	2008	111	3	2.7
Denmark	2009	108	5	4.63

Table 4: Country-year statistics on firms and zombies

country	year	firms	zombies	percent_zombies
Denmark	2010	109	5	4.59
Denmark	2011	105	6	5.71
Denmark	2012	101	8	7.92
Denmark	2013	102	5	4.9
Denmark	2014	97	5	5.15
Denmark	2015	95	5	5.26
Denmark	2016	89	6	6.74
Denmark	2017	91	2	2.2
Denmark	2018	91	1	1.1
France	1987	131	1	0.76
France	1988	139	0	0
France	1989	278	0	0
France	1990	337	2	0.59
France	1991	382	2	0.52
France	1992	397	7	1.76
France	1993	402	9	2.24
France	1994	388	14	3.61
France	1995	384	16	4.17
France	1996	375	15	4
France	1997	364	17	4.67
France	1998	537	17	3.17
France	1999	596	13	2.18
France	2000	627	15	2.39
France	2001	631	21	3.33
France	2002	616	21	3.41
France	2003	584	26	4.45
France	2004	568	39	6.87
France	2005	564	20	3.55
France	2006	588	23	3.91
France	2007	613	14	2.28
France	2008	605	16	2.64
France	2009	573	13	2.27
France	2010	556	23	4.14
France	2011	544	34	6.25
France	2012	509	28	5.5
France	2013	511	30	5.87
France	2014	520	35	6.73
France	2015	516	38	7.36
France	2016	519	31	5.97
France	2017	503	39	7.75

Table 4: Country-year statistics on firms and zombies

country	year	firms	zombies	percent_zombies
France	2018	471	42	8.92
Germany	1987	111	1	0.9
Germany	1988	114	0	0
Germany	1989	184	2	1.09
Germany	1990	253	1	0.4
Germany	1991	279	2	0.72
Germany	1992	292	4	1.37
Germany	1993	299	7	2.34
Germany	1994	322	13	4.04
Germany	1995	363	15	4.13
Germany	1996	359	20	5.57
Germany	1997	366	13	3.55
Germany	1998	469	14	2.99
Germany	1999	574	13	2.26
Germany	2000	633	11	1.74
Germany	2001	622	25	4.02
Germany	2002	583	40	6.86
Germany	2003	543	42	7.73
Germany	2004	534	42	7.87
Germany	2005	531	27	5.08
Germany	2006	573	17	2.97
Germany	2007	601	13	2.16
Germany	2008	588	17	2.89
Germany	2009	564	19	3.37
Germany	2010	553	18	3.25
Germany	2011	552	18	3.26
Germany	2012	519	15	2.89
Germany	2013	499	19	3.81
Germany	2014	469	18	3.84
Germany	2015	455	20	4.4
Germany	2016	440	18	4.09
Germany	2017	430	13	3.02
Germany	2018	421	14	3.33
Italy	1987	37	0	0
Italy	1988	50	1	2
Italy	1989	113	0	0
Italy	1990	124	0	0
Italy	1991	131	3	2.29
Italy	1992	131	7	5.34
Italy	1993	118	9	7.63

Table 4: Country-year statistics on firms and zombies

country	year	firms	zombies	percent_zombies
Italy	1994	114	11	9.65
Italy	1995	108	8	7.41
Italy	1996	104	4	3.85
Italy	1997	105	2	1.9
Italy	1998	120	1	0.83
Italy	1999	121	0	0
Italy	2000	147	0	0
Italy	2001	171	3	1.75
Italy	2002	181	4	2.21
Italy	2003	167	8	4.79
Italy	2004	170	14	8.24
Italy	2005	173	10	5.78
Italy	2006	188	12	6.38
Italy	2007	205	9	4.39
Italy	2008	200	7	3.5
Italy	2009	196	7	3.57
Italy	2010	196	11	5.61
Italy	2011	191	10	5.24
Italy	2012	176	11	6.25
Italy	2013	172	15	8.72
Italy	2014	171	14	8.19
Italy	2015	179	14	7.82
Italy	2016	182	14	7.69
Italy	2017	189	12	6.35
Italy	2018	192	11	5.73
Japan	1987	874	0	0
Japan	1988	915	1	0.11
Japan	1989	944	0	0
Japan	1990	1012	1	0.1
Japan	1991	1132	0	0
Japan	1992	1508	3	0.2
Japan	1993	1825	19	1.04
Japan	1994	1882	53	2.82
Japan	1995	1966	82	4.17
Japan	1996	2051	68	3.32
Japan	1997	2125	80	3.76
Japan	1998	2174	71	3.27
Japan	1999	2209	90	4.07
Japan	2000	2920	120	4.11
Japan	2001	2921	132	4.52

Table 4: Country-year statistics on firms and zombies

country	year	firms	zombies	percent_zombies
Japan	2002	2977	121	4.06
Japan	2003	3157	125	3.96
Japan	2004	3158	98	3.1
Japan	2005	3243	44	1.36
Japan	2006	3297	43	1.3
Japan	2007	3365	64	1.9
Japan	2008	3311	61	1.84
Japan	2009	3202	82	2.56
Japan	2010	3140	101	3.22
Japan	2011	3114	92	2.95
Japan	2012	3090	73	2.36
Japan	2013	3115	39	1.25
Japan	2014	3115	39	1.25
Japan	2015	3158	33	1.04
Japan	2016	3169	29	0.92
Japan	2017	3183	22	0.69
Japan	2018	3197	20	0.63
Netherlands	1987	47	1	2.13
Netherlands	1988	47	0	0
Netherlands	1989	89	0	0
Netherlands	1990	103	0	0
Netherlands	1991	110	2	1.82
Netherlands	1992	128	1	0.78
Netherlands	1993	128	3	2.34
Netherlands	1994	133	2	1.5
Netherlands	1995	133	2	1.5
Netherlands	1996	138	2	1.45
Netherlands	1997	139	1	0.72
Netherlands	1998	170	1	0.59
Netherlands	1999	166	2	1.2
Netherlands	2000	163	5	3.07
Netherlands	2001	149	2	1.34
Netherlands	2002	146	3	2.05
Netherlands	2003	138	4	2.9
Netherlands	2004	135	3	2.22
Netherlands	2005	127	4	3.15
Netherlands	2006	134	3	2.24
Netherlands	2007	136	4	2.94
Netherlands	2008	128	2	1.56
Netherlands	2009	118	4	3.39

Table 4: Country-year statistics on firms and zombies

country	year	firms	zombies	percent_zombies
Netherlands	2010	115	3	2.61
Netherlands	2011	115	5	4.35
Netherlands	2012	111	2	1.8
Netherlands	2013	101	2	1.98
Netherlands	2014	99	5	5.05
Netherlands	2015	99	1	1.01
Netherlands	2016	101	7	6.93
Netherlands	2017	103	4	3.88
Netherlands	2018	96	5	5.21
Spain	1987	21	2	9.52
Spain	1988	27	1	3.7
Spain	1989	53	0	0
Spain	1990	70	0	0
Spain	1991	74	2	2.7
Spain	1992	82	7	8.54
Spain	1993	83	10	12.05
Spain	1994	89	8	8.99
Spain	1995	91	4	4.4
Spain	1996	90	2	2.22
Spain	1997	86	1	1.16
Spain	1998	100	1	1
Spain	1999	108	1	0.93
Spain	2000	108	0	0
Spain	2001	110	0	0
Spain	2002	108	1	0.93
Spain	2003	104	3	2.88
Spain	2004	105	0	0
Spain	2005	96	1	1.04
Spain	2006	98	1	1.02
Spain	2007	100	1	1
Spain	2008	100	0	0
Spain	2009	99	3	3.03
Spain	2010	105	5	4.76
Spain	2011	107	6	5.61
Spain	2012	109	6	5.5
Spain	2013	105	10	9.52
Spain	2014	104	10	9.62
Spain	2015	115	5	4.35
Spain	2016	123	5	4.07
Spain	2017	124	8	6.45

Table 4: Country-year statistics on firms and zombies

country	year	firms	zombies	percent_zombies
Spain	2018	112	5	4.46
Sweden	1987	45	0	0
Sweden	1988	42	0	0
Sweden	1989	61	0	0
Sweden	1990	68	0	0
Sweden	1991	84	0	0
Sweden	1992	102	2	1.96
Sweden	1993	107	5	4.67
Sweden	1994	109	3	2.75
Sweden	1995	113	1	0.88
Sweden	1996	119	0	0
Sweden	1997	121	0	0
Sweden	1998	174	0	0
Sweden	1999	194	3	1.55
Sweden	2000	208	5	2.4
Sweden	2001	235	10	4.26
Sweden	2002	254	16	6.3
Sweden	2003	257	19	7.39
Sweden	2004	258	19	7.36
Sweden	2005	244	6	2.46
Sweden	2006	264	6	2.27
Sweden	2007	314	12	3.82
Sweden	2008	336	9	2.68
Sweden	2009	346	7	2.02
Sweden	2010	358	16	4.47
Sweden	2011	355	14	3.94
Sweden	2012	339	16	4.72
Sweden	2013	332	17	5.12
Sweden	2014	341	21	6.16
Sweden	2015	379	14	3.69
Sweden	2016	413	17	4.12
Sweden	2017	447	20	4.47
Sweden	2018	480	21	4.38
Switzerland	1987	36	0	0
Switzerland	1988	52	0	0
Switzerland	1989	86	0	0
Switzerland	1990	93	0	0
Switzerland	1991	95	0	0
Switzerland	1992	97	3	3.09
Switzerland	1993	103	2	1.94

Table 4: Country-year statistics on firms and zombies

country	year	firms	zombies	percent_zombies
Switzerland	1994	106	7	6.6
Switzerland	1995	112	4	3.57
Switzerland	1996	109	1	0.92
Switzerland	1997	113	1	0.88
Switzerland	1998	142	3	2.11
Switzerland	1999	149	1	0.67
Switzerland	2000	154	1	0.65
Switzerland	2001	157	1	0.64
Switzerland	2002	174	6	3.45
Switzerland	2003	164	6	3.66
Switzerland	2004	165	3	1.82
Switzerland	2005	165	1	0.61
Switzerland	2006	164	2	1.22
Switzerland	2007	173	0	0
Switzerland	2008	167	5	2.99
Switzerland	2009	164	2	1.22
Switzerland	2010	166	5	3.01
Switzerland	2011	156	3	1.92
Switzerland	2012	157	3	1.91
Switzerland	2013	154	5	3.25
Switzerland	2014	149	4	2.68
Switzerland	2015	146	4	2.74
Switzerland	2016	143	4	2.8
Switzerland	2017	140	4	2.86
Switzerland	2018	141	8	5.67
UK	1987	373	0	0
UK	1988	414	0	0
UK	1989	766	1	0.13
UK	1990	1027	2	0.19
UK	1991	1096	9	0.82
UK	1992	1088	24	2.21
UK	1993	1087	51	4.69
UK	1994	1068	29	2.72
UK	1995	1058	24	2.27
UK	1996	1079	14	1.3
UK	1997	1048	16	1.53
UK	1998	1234	11	0.89
UK	1999	1194	18	1.51
UK	2000	1112	21	1.89
UK	2001	1109	52	4.69

Table 4: Country-year statistics on firms and zombies

country	year	firms	zombies	percent_zombies
UK	2002	1130	56	4.96
UK	2003	1132	73	6.45
UK	2004	1148	67	5.84
UK	2005	1206	61	5.06
UK	2006	1258	54	4.29
UK	2007	1253	53	4.23
UK	2008	1188	46	3.87
UK	2009	1118	47	4.2
UK	2010	1043	49	4.7
UK	2011	997	49	4.91
UK	2012	950	37	3.89
UK	2013	923	38	4.12
UK	2014	916	50	5.46
UK	2015	907	51	5.62
UK	2016	902	67	7.43
UK	2017	873	71	8.13
UK	2018	843	62	7.35
USA	1987	1667	21	1.26
USA	1988	1702	22	1.29
USA	1989	1820	20	1.1
USA	1990	1941	39	2.01
USA	1991	1974	62	3.14
USA	1992	1988	70	3.52
USA	1993	2180	65	2.98
USA	1994	2257	57	2.53
USA	1995	2346	42	1.79
USA	1996	3259	67	2.06
USA	1997	3579	90	2.51
USA	1998	3908	118	3.02
USA	1999	4145	152	3.67
USA	2000	5023	295	5.87
USA	2001	4857	329	6.77
USA	2002	4634	323	6.97
USA	2003	4435	244	5.5
USA	2004	4433	255	5.75
USA	2005	4305	264	6.13
USA	2006	4256	269	6.32
USA	2007	4170	287	6.88
USA	2008	3945	285	7.22
USA	2009	3798	214	5.63

Table 4: Country-year statistics on firms and zombies

country	year	firms	zombies	percent_zombies
USA	2010	3706	231	6.23
USA	2011	3558	241	6.77
USA	2012	3480	190	5.46
USA	2013	3375	185	5.48
USA	2014	3389	208	6.14
USA	2015	3301	236	7.15
USA	2016	3161	231	7.31
USA	2017	3018	243	8.05
USA	2018	2920	262	8.97

Table 5: Sector-year statistics on firms and zombies

sector	year	firms	zombies	percent_zombies
Agriculture	1987	186	9	4.84
Agriculture	1988	200	10	5
Agriculture	1989	259	3	1.16
Agriculture	1990	293	9	3.07
Agriculture	1991	312	7	2.24
Agriculture	1992	328	13	3.96
Agriculture	1993	348	15	4.31
Agriculture	1994	348	13	3.74
Agriculture	1995	340	10	2.94
Agriculture	1996	377	9	2.39
Agriculture	1997	393	8	2.04
Agriculture	1998	412	11	2.67
Agriculture	1999	423	20	4.73
Agriculture	2000	510	28	5.49
Agriculture	2001	565	38	6.73
Agriculture	2002	629	39	6.2
Agriculture	2003	759	55	7.25
Agriculture	2004	880	73	8.3
Agriculture	2005	939	81	8.63
Agriculture	2006	1047	79	7.55
Agriculture	2007	1284	63	4.91
Agriculture	2008	1376	64	4.65
Agriculture	2009	1451	99	6.82
Agriculture	2010	1530	133	8.69
Agriculture	2011	1526	134	8.78
Agriculture	2012	1534	144	9.39
Agriculture	2013	1412	132	9.35
Agriculture	2014	1349	154	11.42
Agriculture	2015	1149	156	13.58
Agriculture	2016	1077	171	15.88
Agriculture	2017	948	181	19.09
Agriculture	2018	932	153	16.42
Manufacturing	1987	2353	14	0.59
Manufacturing	1988	2447	15	0.61
Manufacturing	1989	3012	15	0.5
Manufacturing	1990	3409	26	0.76
Manufacturing	1991	3637	55	1.51
Manufacturing	1992	3934	78	1.98
Manufacturing	1993	4253	126	2.96
Manufacturing	1994	4333	132	3.05

Table 5: Sector-year statistics on firms and zombies

sector	year	firms	zombies	percent_zombies
Manufacturing	1995	4449	118	2.65
Manufacturing	1996	4949	113	2.28
Manufacturing	1997	5106	113	2.21
Manufacturing	1998	5516	129	2.34
Manufacturing	1999	5564	149	2.68
Manufacturing	2000	6218	248	3.99
Manufacturing	2001	6155	297	4.83
Manufacturing	2002	6080	286	4.7
Manufacturing	2003	6029	284	4.71
Manufacturing	2004	6018	282	4.69
Manufacturing	2005	6018	232	3.86
Manufacturing	2006	6161	240	3.9
Manufacturing	2007	6271	258	4.11
Manufacturing	2008	6050	261	4.31
Manufacturing	2009	5844	245	4.19
Manufacturing	2010	5733	260	4.54
Manufacturing	2011	5596	251	4.49
Manufacturing	2012	5412	197	3.64
Manufacturing	2013	5273	196	3.72
Manufacturing	2014	5217	218	4.18
Manufacturing	2015	5183	231	4.46
Manufacturing	2016	5124	220	4.29
Manufacturing	2017	5017	229	4.56
Manufacturing	2018	4940	223	4.51
Services	1987	1111	5	0.45
Services	1988	1189	5	0.42
Services	1989	1552	9	0.58
Services	1990	1823	19	1.04
Services	1991	1961	36	1.84
Services	1992	2136	66	3.09
Services	1993	2326	76	3.27
Services	1994	2381	68	2.86
Services	1995	2471	81	3.28
Services	1996	2942	79	2.69
Services	1997	3176	107	3.37
Services	1998	3799	110	2.9
Services	1999	4202	139	3.31
Services	2000	5235	217	4.15
Services	2001	5296	281	5.31
Services	2002	5350	320	5.98

Table 5: Sector-year statistics on firms and zombies

sector	year	firms	zombies	percent_zombies
Services	2003	5480	322	5.88
Services	2004	5525	312	5.65
Services	2005	5503	256	4.65
Services	2006	5568	241	4.33
Services	2007	5691	243	4.27
Services	2008	5503	232	4.22
Services	2009	5277	197	3.73
Services	2010	5133	224	4.36
Services	2011	4981	233	4.68
Services	2012	4828	212	4.39
Services	2013	4782	219	4.58
Services	2014	4820	234	4.85
Services	2015	4885	240	4.91
Services	2016	4854	254	5.23
Services	2017	4803	245	5.1
Services	2018	4759	249	5.23
Unclassified	1987	14	0	0
Unclassified	1988	15	0	0
Unclassified	1989	31	0	0
Unclassified	1990	37	0	0
Unclassified	1991	42	0	0
Unclassified	1992	42	1	2.38
Unclassified	1993	47	2	4.26
Unclassified	1994	48	0	0
Unclassified	1995	50	0	0
Unclassified	1996	54	0	0
Unclassified	1997	58	1	1.72
Unclassified	1998	61	0	0
Unclassified	1999	64	1	1.56
Unclassified	2000	82	5	6.1
Unclassified	2001	83	5	6.02
Unclassified	2002	87	9	10.34
Unclassified	2003	88	6	6.82
Unclassified	2004	85	6	7.06
Unclassified	2005	80	4	5
Unclassified	2006	80	5	6.25
Unclassified	2007	82	5	6.1
Unclassified	2008	81	3	3.7
Unclassified	2009	85	4	4.71
Unclassified	2010	81	3	3.7

Table 5: Sector-year statistics on firms and zombies

sector	year	firms	zombies	percent_zombies
Unclassified	2011	81	3	3.7
Unclassified	2012	86	5	5.81
Unclassified	2013	84	6	7.14
Unclassified	2014	79	5	6.33
Unclassified	2015	81	3	3.7
Unclassified	2016	82	2	2.44
Unclassified	2017	87	2	2.3
Unclassified	2018	91	5	5.49