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Centre for Economic Policy Research
33 Great Sutton Street, London EC1V 0DX, UK
187 boulevard Saint-Germain, 75007 Paris, France
Tel: +44 (0)20 7183 8801
www.cepr.org

# RESOLVING BAD LOANS AND ZOMBIE FIRMS: THE CASE OF GREECE


## Abstract

We analyze the negative externalities of “zombie” firms on investment, employment, and productivity in the context of the Greek crisis, during which the share of zombie firms and non-performing business loans peaked at 20% and 50% respectively. Using a panel dataset by firm size and sector during 2002-2021, we find a strong correlation between non-performing business loans and zombie firms. Empirical analysis reveals that zombie firms impact on the economy in several ways: (1) healthy firms outperform zombies in investment, employment, and productivity; (2) high zombie firm density hinders investment growth among healthy firms; (3) healthy firms must increase productivity to survive in zombie-dense sectors; and (4) zombie firms’ capital concentration limits resource reallocation to more productive uses. Younger and larger firms generally perform better across key metrics, also during crisis conditions. Resolving zombie firms and non-performing loans can enhance resource allocation, both within and across sectors of economic activity, boosting growth in the medium to long term.



JEL Classification: E22 , G20

Keywords: non-performing loans, zombie firms, growth, investment; productivity



Georgios Gatopoulos - Gatopoulos@iobe.gr
*Foundation for Economic and Industrial Research*

Alexandros Louka - louka@iobe.gr
*Foundation for Economic and Industrial Research*

Kostas Peppas - KPEPPAS@eurobank.gr
*Eurobank Research*

Nikolaos Vettas - nvettas@aueb.gr
*Athens University of Economics and Business and CEPR*



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This paper draws from and extends analysis previously circulated under the title of “Benefits for the Greek economy from resolving bad loans and zombie firms” (Bank of Greece Economic Bulletin No 59, July 2024).

# *Resolving bad loans and zombie firms: the case of Greece*[1]

Georgios Gatopoulos[2], Alexandros Louka[3], Kostas Peppas[4], Nikolaos Vettas [5]

**Abstract**

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[2] Foundation for Industrial and Economic Research - IOBE and American College of Greece

[3] Foundation for Industrial and Economic Research - IOBE

[4] Eurobank Research

[5] Athens University of Economics and Business, Foundation for Industrial and Economic Research - IOBE, and Centre for Economic Policy Research; corresponding author, email: nvettas@aueb.gr

# Introduction

A large number of "zombie" firms[6] and a high level of non-performing business exposures (NPEs),[7] either on or off bank balance sheets, can have significant side effects on the economy. Their delayed resolution has been shown to have a negative impact on investment, employment and competition in goods and services markets, as well as on average productivity across sectors and in the wider economy. The context of the Greek economy around the sovereign debt crisis offers a natural experiment with unique features in relation to studying the side-effects of overdue private debt on economic activity, for at least two reasons. Firstly, because the economy reached unprecedented shares of non-performing loans (50%) and "zombie" firms (20%) during the sovereign debt crisis. Secondly, because the economy faces significant investment and productivity gaps, for which overdue private debt acts as an amplifier and hence needs to be tackled so as to achieve a sustainable growth path (Pissarides et al., 2023).

Firms that have "weak" prospects for recovery, based on a number of alternative criteria, are labelled as "zombies". The criteria proposed for classifying firms as zombies vary, with many of them relating to ratios derived from financial statements, combined with firm age criteria (see e.g. De Jonghe et al., 2024). The prevalence of zombie firms appears to be related to the share of business Non-Performing Exposures (NPEs) in total loans for the Greek economy as a whole, as well as for individual sectors. It has occasionally been documented that banks may tend to support firms that do not service their loans. Such support may include offering favourable refinancing terms, reducing the interest rate on existing loans, extending new loans, etc. This practice is pursued when banks aim to avoid or postpone the recording of provisions or losses on their balance sheets, which, in turn, would affect their capital adequacy.

Keeping zombie firms in operation has been shown internationally to have a negative impact not only on macroeconomic aggregates, but also on the functioning of healthy firms, especially in sectors where the former are more prevalent. Channelling financial resources to zombie firms to prevent them from going out of business deprives other, healthy firms of resources, both financial and physical. It further has negative effects on employment, investment and productivity growth for the total economy. This is critical in the case of Greece for at least two reasons. On the one hand, large investment gap over recent decades, underutilised human resources due to high unemployment and low labour market participation, and adverse demographic trends, all imply a need to ensure the recovery of investment and employment rates. On the other hand, sustained long-term output growth requires productivity growth beyond investment in physical and human capital, which would be hard to achieve if resources are allocated to unproductive activities.

This paper assesses empirically the nature and magnitude of the externalities caused to a small open economy by keeping zombie firms in operation. It contributes to existing literature on two fronts: (a) it analyses the dynamics and impact of zombie firms both within and across

[6] Following criteria suggested by existing literature, we define a zombie firm as one which, in a given year, (a) is at least 10 years old; and (b) has an interest coverage ratio of less than 1 for the last three consecutive years.

[7] NPEs are defined by supervisory authorities as exposures (loans) which are more than 90 days past due, as well as exposures unlikely to pay, regardless of the number of days past due.

sectors of economic activity, (b) it focuses on a country of particular interest, as it went through a major crisis during which both NPEs and zombie firms peaked at unprecedent levels (PwC 2015; IMF 2021), while it still suffers from significant productivity and investment gaps.

The analysis focuses on three research questions. The first one attempts to estimate the number and share of zombie firms in the Greek economy, by sector of economic activity, and their correlation with the trend in NPEs. The second question examines the direct effects of zombie firms on the Greek economy, with a focus on investment, employment and productivity, and assesses whether these effects vary by sector of activity. The third question investigates the indirect economic impact of zombie firms, for example through their side effects on existing healthy firms.

The paper is structured in six sections. Section 2 provides a literature review, presenting various empirical models that have been used in the literature for the classification of zombie firms and econometric findings about their economic effects. Section 3 provides a description of the data available to carry out the descriptive and quantitative analyses. The descriptive analysis in Section 4 assesses the evolution of zombie firms in the Greek economy over time and highlights recent trends in NPEs at the sectoral level. Section 5 deals with the quantitative assessment of the direct and indirect effects of maintaining zombie firms in the Greek economy. Section 6 summarises the main findings of the descriptive and quantitative analyses, while linking them to policy priorities.

## Literature review

The literature on the impact of zombie firms on productivity, investment, and employment is relatively recent. It began in the early 1990s, following the prolonged stagnation and low productivity of the Japanese economy after its credit and real estate bubbles. Peek and Rosengren (2005) noted that during Japan's "lost decade," authorities exercised loose banking supervision, discouraged strict measures against overindebted firms, and encouraged banks to provide more credit to such firms. This practice, known as evergreening loans, postponed bankruptcies and prevented banks from recording losses that would reduce their capital adequacy. These firms were termed zombie firms by Kane (1987). According to Caballero et al. (2008) and da Silva and Gonçalves (2022), zombies exhibit poor financial performance, rely heavily on bank lending and government grants, and cannot meet financial obligations without concessions.

Ahearne and Shinada (2005) were among the first to validate the "zombie hypothesis" in Japan. They found that during the 1990s, inefficient zombie firms in non-tradeable sectors gained market share at the expense of productive firms due to bank support. Their results showed a stronger decline in Total Factor Productivity (TFP) in non-tradeable compared to tradable sectors. They noted that from 1980–1990, there was a positive correlation between market share changes and outstanding loans in tradeable sectors, which turned negative in 1991–2001, while remaining positive for non-tradeable sectors.

Caballero et al. (2008) further analyzed the effects of zombies on employment, investment, and productivity in Japan from 1981–2002. They defined zombies as firms unable to service loans but kept alive by banks through favorable interest rates. Their study showed that a rising share of zombies significantly reduced investment and employment growth rates for healthy firms. Furthermore, the productivity gap widened as healthy firms faced higher entry barriers. Their findings persisted even when sales growth was included as an explanatory variable.

Balgova et al. (2017) examined non-performing loans (NPLs) and their economic effects across 194 countries during 1990–2016. High NPL episodes lasted about six years, and once the average NPL ratio reached 21%, it declined, positively affecting economic growth. They found that reducing NPLs was most effective with asset management companies and bailout programs, which accelerated reductions two to three times faster than asset management companies alone. A sharp reduction in NPL ratios correlated with annual GDP growth exceeding 1.5 percentage points. Positive effects were strongest in investment, followed by consumption and, to a lesser extent, exports.

Fukuda and Nakamura (2011) focused on why zombie firms recovered in Japan in the early 2000s. They critiqued Caballero et al.'s (2008) definition of zombies and proposed additional criteria: the "profitability criterion," defining zombies by earnings lower than hypothetical risk-free interest payments, and the "evergreening criterion," based on high leverage and increasing debt levels.

Schivardi et al. (2017) studied zombie financing by banks with low capital adequacy in Italy from 2004–2013. They defined zombies using profitability and leverage thresholds and an interest coverage ratio (EBITDA to interest expenses). They found that low-capital banks financed zombies more than healthy firms, constraining the latter's growth. Increased zombie shares in sectors led to wider TFP dispersion, benefiting zombies and disadvantaging healthy firms, particularly in industries with high zombie prevalence.

Adalet McGowan et al. (2018) analyzed zombie firms' impact on productivity across 12 countries (2003–2013). Zombies were defined as firms with an interest coverage ratio below one for three consecutive years and more than ten years old. They observed that large, older firms were more likely to be zombies. An increase in zombie prevalence negatively impacted non-zombie firms' investment and employment growth. As in Caballero et al. (2008), the productivity gap widened due to market distortions caused by zombies. These firms also hindered efficient capital allocation and created entry barriers, requiring new firms to achieve higher productivity to compete.

Hallak et al. (2018) investigated zombie firms in 19 European countries (2010–2013) using three definitions of zombies: (i) interest coverage ratio ≤1 for three consecutive years, (ii) same criteria with an age threshold of ten years, and (iii) interest coverage ratio ≤1 for five consecutive years with an age threshold of ten years. They confirmed that zombie prevalence increases with age and size. Non-zombie firms showed faster investment and employment growth, while zombies negatively impacted industry-wide growth and productivity. Younger non-zombie firms were particularly affected by zombies, with significant effects observed in employment growth.

Banerjee and Hofmann (2018) used data from 14 developed economies spanning 1980–2016. They classified zombies using two definitions: a broader one based on interest coverage ratio and age thresholds, and a narrower one adding low growth potential. They found that lower interest rates correlated with increased zombie shares, as low rates reduced incentives for restructuring. A 1% increase in zombies reduced non-zombies' investment by 1% and employment growth by 0.26 percentage points. Zombies also reduced TFP growth by 0.3 percentage points, though these effects were significant only under the narrower definition.

Andrews and Petroulakis (2019) explored the link between zombie firms, bank health, and productivity in 11 European countries (2001–2014). Weak banks were found to facilitate zombie survival, and this relationship persisted pre- and post-financial crisis, indicating non-cyclicality. Productive firms grew faster in industries with healthier banks, while zombie prevalence reduced capital allocation efficiency and limited healthy firms' access to loans.

Da Silva and Gonçalves (2022) studied zombie firms in Portugal (2011–2018). Zombies were identified by interest coverage ratios below one for three consecutive years, an age over ten years, and consecutive negative net income. A 1% increase in assets tied to zombies reduced sectoral investment by 23.1 percentage points and healthy firms' productivity by €43,000. However, no significant impact was found on employment growth. They also identified specific industries, such as food services and accommodation, where zombies had the most negative effects.

To summarize, studies often examine groups of countries (e.g., Balgova et al. 2017; Adalet McGowan et al. 2018; Hallak et al. 2018; Banerjee and Hofmann 2018; Andrews and Petroulakis 2019) or single-country cases (e.g., Ahearne and Shinada 2005 for Japan; Schivardi et al. 2017 for Italy; da Silva and Gonçalves 2022 for Portugal). Firm-level data is widely used, whether for listed firms (e.g., Ahearne and Shinada 2005; Caballero et al. 2008) or unlisted ones (e.g., Hallak et al. 2018; Andrews and Petroulakis 2019), or comparing between the two (e.g. Albuquerque and Iyer, 2024). The data spans from the 1970s to 2018 and covers manufacturing and services sectors, with little on the primary or financial sectors.

Most studies confirm zombies' negative effects on employment, investment, productivity, and GDP. Zombies create industry congestion, entry barriers, and productivity gaps (e.g., Caballero

et al. 2008; Adalet McGowan et al. 2018). Additionally, weak banks exacerbate zombie financing, limiting healthy firms' growth (e.g., Schivardi et al. 2017; Andrews and Petroulakis 2019). Lastly, bank loans to zombies are not used for productive purposes but rather to stabilize finances, perpetuating inefficiencies (Acharya et al. 2019).

## Data

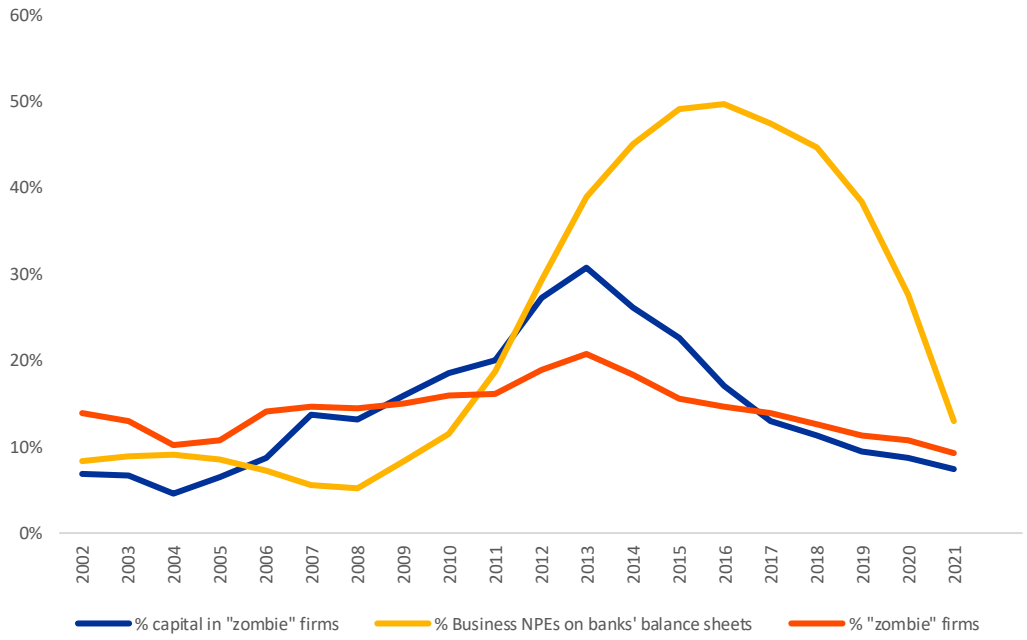
We use firm-level data for Greek businesses available from the ICAP Data.Prisma database, which provides annual balance sheet information, for the period 2000-2021. ICAP's database is the largest electronic repository of business activity information in Greece, encompassing financial and commercial data for businesses since 2000, as well as sectoral financial analyses. The dataset includes a wide range of financial metrics (e.g. fixed assets, deposits, trade receivables, equity capital, reserves, short- and long-term liabilities to banks, turnover, operating profits, financial income and expenses, net profits) and demographic variables (e.g. year of establishment, prefecture of headquarters, legal form, employment, export activity) for a significant portion of domestic businesses. For the descriptive analysis, we also use sector-specific data from the Bank of Greece regarding non-performing exposures of domestic banks and credit servicing firms ("servicers").

The definitions of variables and some descriptive analysis are presented in the following sections. Vettas et al. (2022) evaluated the representativeness of ICAP's sample of firms for the period 2005-2019 in terms of firm size (turnover) and structural characteristics in comparison with the dataset of the Hellenic Statistical Authority's (ELSTAT) Business Register. In terms of the turnover of the Greek economy, based on comparable data from ELSTAT's Business Register, the average coverage rate for the period 2005-2019 was close to 60%. In terms of the number of businesses by turnover class, representativeness was the highest for very large (annual turnover above €50 million) and large enterprises (annual turnover between €5.0 and €50 million), at 89.3% and 81.1%, respectively. Additionally, more than half of the businesses with an annual turnover between €1.5 and €5.0 million and at least 25% of those with an annual turnover between €0.5 and €1.5 million are also included in our sample. Conversely, micro businesses (annual turnover between €0 and €500 thousand) are underrepresented (only 2.1%) in ICAP's database, mainly due to the lack of data on sole proprietors, as most of them are not required to prepare and publish financial statements.

## Descriptive analysis

The estimated share of zombie firms is positively correlated with the share of business NPEs in bank balance sheets over the period 2002-2021 (Figure 1). However, the rise in the share of zombie firms preceded the rise in the share of NPEs in bank balance sheets, while the decline in the share of zombie firms preceded the decline in the share of NPEs. This suggests leading indicator properties of the zombie rate for the NPE ratio. In the recent period, the faster decline in the number of zombies relative to that in NPEs may be partly due to the accumulation and delayed resolution of non-performing loans owed by firms that have ceased operations and are in liquidation, therefore not included in the ICAP database. Moreover, the share of zombie firms is larger than the share of capital concentration in zombie firms up to 2008 and after 2017, implying that the average zombie firm was smaller in size before and after the Greek crisis.

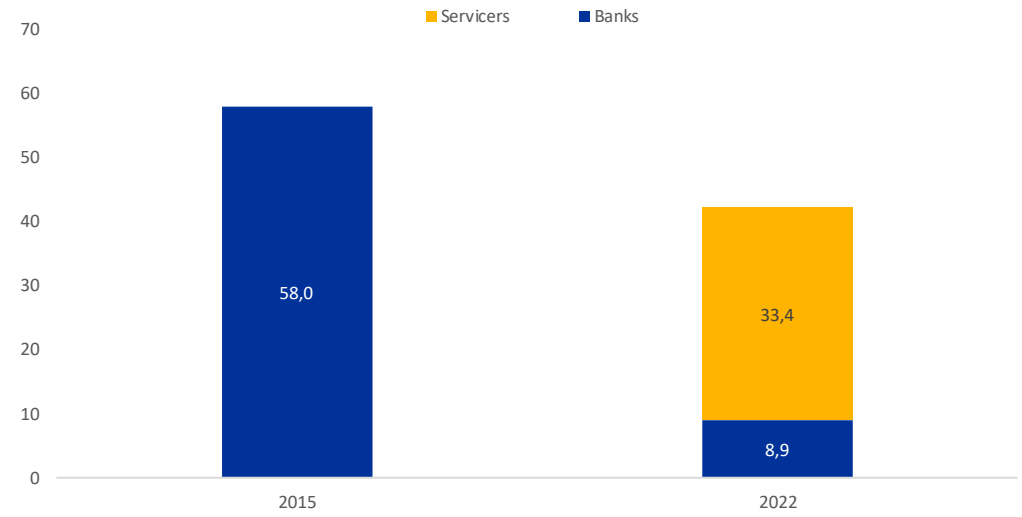
**Figure 1. Evolution of estimated share of "zombie" firms in Greece, share of business NPEs and capital share in "zombie" firms", 2002-2021**




**Source:** Bank of Greece, ICAP data.prisma, Data processing: Authors' calculations

Moreover, as shown in Figure 2, the significant reduction in NPEs on bank balance sheets does not automatically mean a removal of debt from Greek companies, as the largest part of NFCs' overdue liabilities, amounting to €33.4 billion, has been transferred to non-bank credit acquiring companies and is currently managed by servicers. The net reduction in NPEs towards NFCs in the economy as a whole is therefore estimated at around €15.7 billion during 2015-2022.

**Figure 2. Non-performing exposures to NFCs by banks and servicers for years 2015 and 2022**

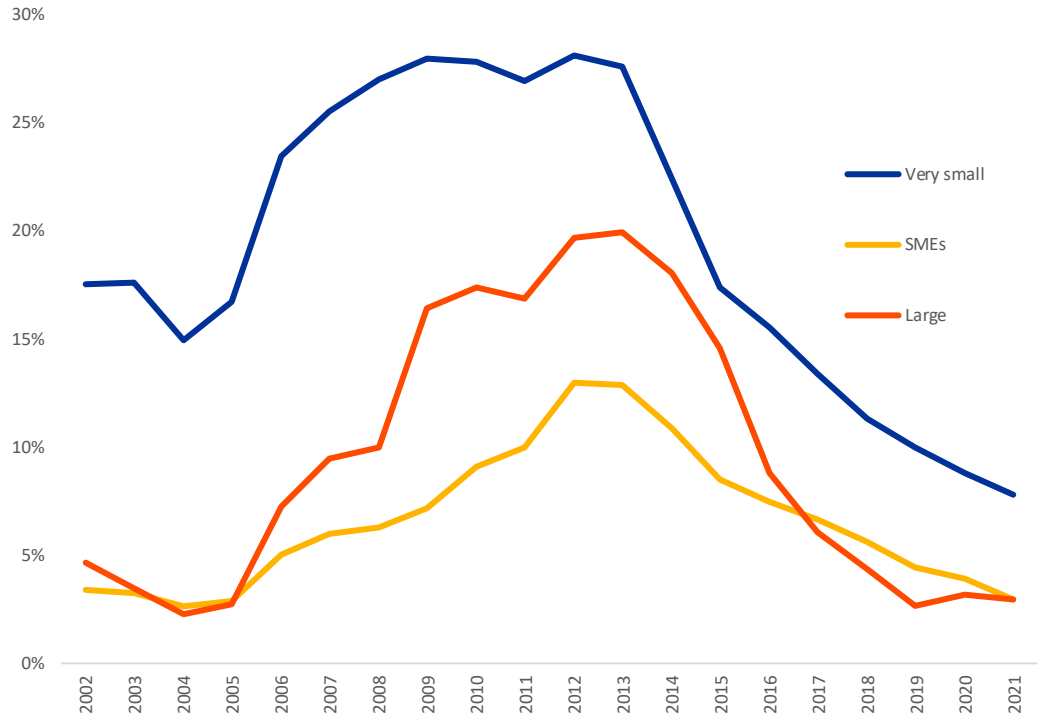



Source: Bank of Greece, Data processing: Authors' calculations

It is generally accepted in the literature that the existence of non-performing loans in banks has a negative effect on credit expansion rates, while a reduction in non-performing loans frees up resources that stimulate credit expansion. For example, Tölö and Virén (2021), using data on Euro area banks, estimate that a one-percentage-point increase in the NPL ratio contributes to a 0.08 percent decline in quarterly lending growth to the private non-financial sector. This finding highlights the critical importance of reducing the NPL ratio to support credit expansion. The analysis that follows aims to shed light on the effects of non-performing debt from the perspective of distressed firms, as well as the secondary consequences on the performance of healthy firms.

In this regard, Figure 3 shows the evolution of the percentage of zombie firms in the ICAP sample of firms by size class based on turnover. Specifically, businesses with an annual turnover of less than €2.0 million are classified as "micro", those with an annual turnover between €2 million and €50 million are classified as "small and medium-sized" (SMEs), and those with an annual turnover of more than €50.0 million are classified as "large". A downward trend in the proportion of zombie firms is evident across all size classes after 2013, with micro businesses featuring the highest zombie rate, 7.8%, compared with 3.0% for each of the other two size classes in 2021. The trend observed in the period 2005-2016, in which the share of zombie firms was higher among large firms than among small and medium-sized firms, is consistent with the findings in the literature (Adalet McGowan et al. 2018; Hallak et al. 2018). In the case of Greece, however, the above relationship is non-monotonic, as it reverses after 2016, while micro firms have the highest share over time (19.4% on average over the period 2002-2021).

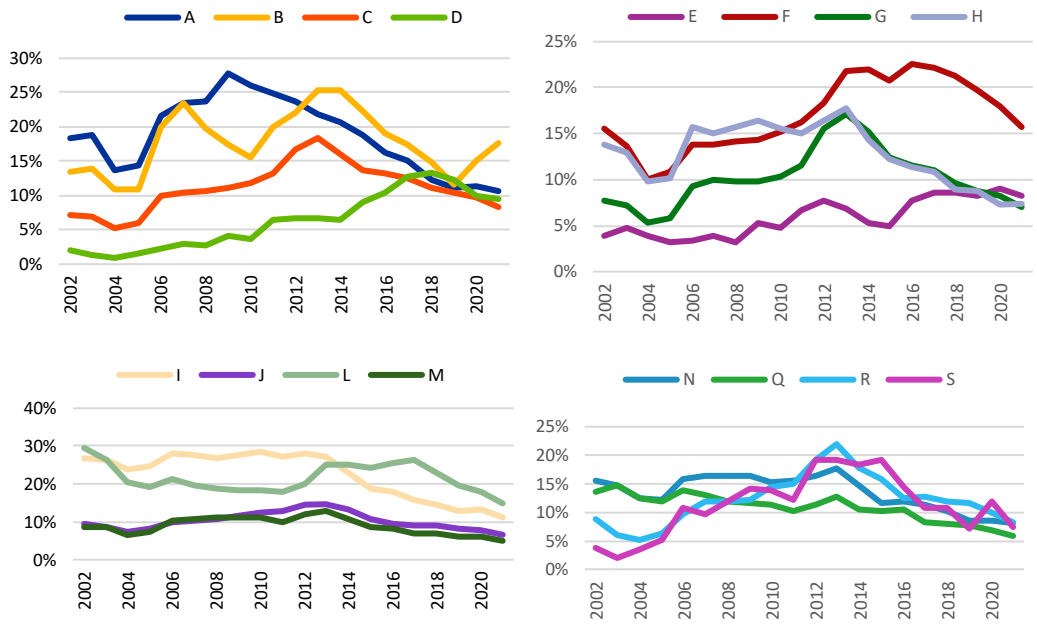
**Figure 3. Share of "zombie" firms by turnover size class, in ICAP data sample (2002-2021)**




Source: ICAP, Data processing: Authors' calculations

As is evident from Figure 4, the highest share of zombie enterprises over time within each sector of economic activity is found in NACE sector (I) Accommodation and food service activities (22.5% on average over the period 2002-2021), followed by (L) Real estate activities (21.6% on average), (A) Agriculture (18.7% on average), (B) Mining and quarrying (17.8% on average) and (F) Construction (17.0% on average). The turning point of the trend from rising to declining varies across sectors. Indicatively, in sector (F) Construction, the share of zombie firms followed an upward trend since 2005, peaking at 26.6% in 2016 and easing only partially to 12.7% in 2021. In sector (L) Real estate activities, after contracting between 2002-2009 from 29.5% to 18.3%, the percentage of zombie enterprises increased from 2010 onwards, peaking at 26.3% in 2017 and gradually decreasing thereafter, still remaining at a high level of 14.9% in 2021. On the other hand, single-digit percentages of zombie enterprises are found in sectors (E) Water supply; sewerage, waste management and remediation activities (5.9%), (D) Electricity, gas, steam and air conditioning supply (6.2%) and (M) Professional, scientific and technical activities (9.0%).

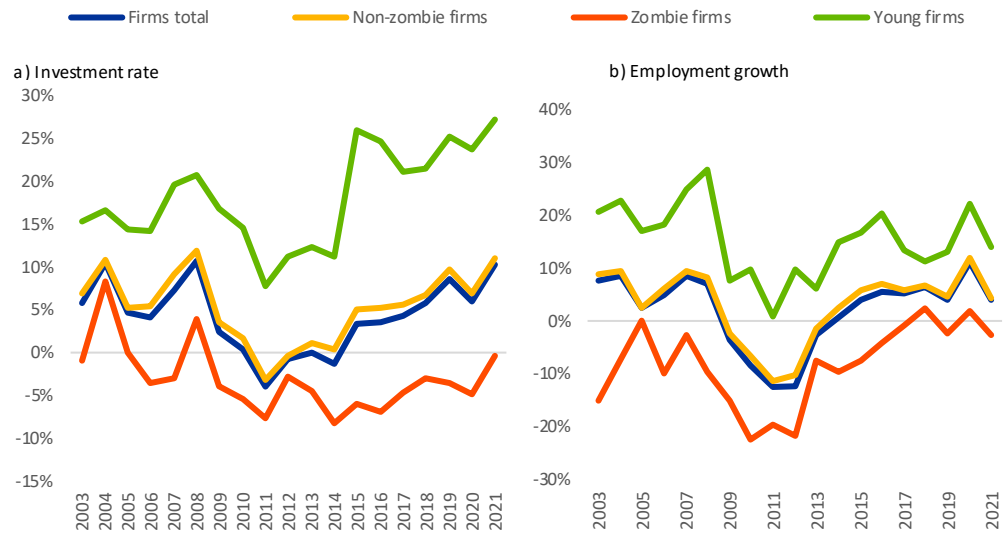
**Figure 4. Share of "zombie" firms by economic activity in ICAP database (2002-2021)**




Source: ICAP, Data processing: Authors' calculations

Figure 5 shows the investment rate and employment growth for all Greek firms in the business economy that are recorded in the ICAP database, as well as for the subsets of non-zombies, zombies and young firms. It is noteworthy that non-zombie firms perform systematically better than zombie firms over time, while young firms perform significantly better. Also, although the performance for the all-firms total appears to be close to that of non-zombie firms, which is due to the fact that the share of zombie firms is not particularly high, the question persists as to how the performance of non-zombie firms is affected by the existence of zombie firms.

**Figure 5. Investment rate and employment growth for total, non-zombie, zombie and young firms**




Source: ICAP, Data processing: Authors' calculations

# Model

This section presents the econometric model used in the estimations, which takes the following form:

$$Y_{ist} = \beta_1 Non\ zombie\ dummy_{ist} + \beta_2 Non\ zombie\ dummy_{ist} * Industry\ zombie\ share_{st} + \beta_3 \text{firm controls}_{\text{ist}} + \delta_{st} + \varepsilon_{ist}\ (1)$$

The variable $Y_{ist}$, is the dependent variable of the model and has three alternative definitions. The first refers to employment growth ($dlogEmp_{ist}$), i.e. the annual percentage change in employment approximated by the log differences of employment between two consecutive years ($logEmp_{ist} - logEmp_{ist-1}$). It is noted that in this variable, as well as in those that follow, the subscript $i$ denotes the $ith$ firm, the subscript $s$ denotes the 1-digit sector, and the $t$ denotes the time (year). Under the second alternative definition, the dependent variable of the model is the investment ratio $log\left(\frac{I}{K}\right)$, i.e. the log difference of the real capital stock. Under the third alternative definition, the dependent variable of the model is the level of total factor productivity (multi-factor productivity or MFP). The estimation of the specific index was based on the Solow residual theory and is defined as:

$$logY - (1 - s_L)logK - s_L logL,$$

where $logY$ is the logarithm of the firm's value added, $logK$ is the logarithm of fixed capital and $logL$ is the logarithm of employment. $s_L$ is the labour share of output and is defined as the ratio of compensation of employees to output. For estimating the labour share we used data on the cost of labour and on output at the 2-digit level of economic activity, retrieved from the National Accounts database of the Hellenic Statistical Authority (ELSTAT).

Before presenting the independent variables of the model, it should be noted that due to a lack of data regarding value added per firm, turnover was used instead, and both turnover and fixed capital were deflated in order to express these figures in constant values. To deflate the turnover series, we used the GDP and to deflate the fixed capital series we used the deflators of gross fixed capital formation, at the 2-digit level of economic activity.

The independent variable $Non - zombie\ dummy_{ist}$ is a dummy variable that takes the value of 1 if the firm is non-zombie and 0 otherwise. A firm is characterised as zombie if, for three consecutive years:

- the value of the interest coverage ratio is less than 1, where the interest coverage ratio is the ratio of operating profits to financial expenses $\left(\frac{Operating\ Profit_{ist}}{Financial\ Expenses_{ist}} < 1\right)$,
- the age of the firm is equal to or greater than 10 years. In line with the relevant literature, ten years is introduced as a threshold, because firms less than ten years old are at an early stage of their operation and are expected to show unsatisfactory financial performance (e.g. negative net profitability, operating losses, negative equity), as they try to increase their market share and secure their presence in an industry. Age is defined as the difference between the year for which data is available for a firm and the year when it was founded, plus one year. We added a year to the above difference so that firms founded at the beginning of the period under review (i.e. 2002), do not have a zero value of age in that particular year.

Some criticism exists in the literature regarding the use of the above criteria to classify a firm as zombie (e.g. Artavanis et.al., 2024). However, in the absence of precise data on the interest rate banks charge firms – as in our case – the above approach remains the only viable alternative for investigating the presence of zombie firms within an industry. Besides, the approach we adopt is widely used in the literature and minimizes the errors of (i) characterizing a firm as zombie although it might be not zombie, and (ii) failing to classify a firm as zombie when it is. This is achieved through the combined application of age, interest coverage ratio, and time-based criteria.

The independent variable $Industry\ zombie\ share_{st}$ represents the share of zombie firms in an industry. The independent variable $firm\ controls_{ist}$ includes a number of dummy variables at the firm level, related to the age and size of each firm. The dummy variable concerning the age of the firm – following the relevant literature – is defined as follows:

- dummy variable for age $(\text{Young})$ takes the value of 1 if the firm is less than 6 years old, and 0 otherwise, i.e. $\text{young} = \begin{cases} 1, \text{if age} < 6 \text{ years} \\ 0 \text{ otherwise} \end{cases}$,

Regarding the size dummy variables, firms were classified into micro, small/medium-sized and large, using the European Commission's definition. The definition of the corresponding dummies is as follows:

- micro dummy $(\text{Micro dummy})$, takes the value of 1 if the firm has an annual turnover of less than €2.0 million, and 0 otherwise, thus:

  $\text{Micro dummy} = \begin{cases} 1, \text{if turnover} < €2 \text{ million} \\ 0 \text{ otherwise} \end{cases}$,

- small and medium-sized dummy $(\text{Small/Medium dummy})$ takes the value of 1 if the firm has an annual turnover greater than or equal to €2.0 million and less than €50.0 million, and 0 otherwise, thus:

  $\text{Small/Medium dummy} = \begin{cases} 1, \text{if } €2 \text{ million} \leq \text{turnover} < €50 \text{ million.} \\ 0 \text{ otherwise} \end{cases}$.

- large dummy $(\text{Large dummy})$ takes the value of 1 if the firm has an annual turnover greater than or equal to €50.0 million, and 0 otherwise, thus:

  $\text{Large dummy} = \begin{cases} 1, \text{if turnover} \geq €50 \text{ million} \\ 0 \text{ otherwise} \end{cases}$,

The independent variable $\delta_{st}$ captures year- and industry-fixed effects. A fixed-effects approach is used to analyse the effect of time-varying variables on the rate of change in labour and investment and the level of total factor productivity. Each firm has its own special characteristics (e.g. business practices, business culture) that do not change with time (time invariant characteristics) and may affect the estimates of the independent variables. By using the fixed-effects approach, the effect of the above characteristics is controlled so that they do not lead to biased estimates of the independent variables. Consequently, it is assumed that the error term $\varepsilon_{ist}$ and regressors $x_{ist}$ are not correlated.

Our specification builds on the approach of Adalet McGowan et al. (2018), with a modification that uses the zombie share instead of the share of capital sunk in zombie firms, though we tested both specifications. We opted for the zombie share metric because our data pertains to a single country, so parameter identification relies primarily on within-sector variation

rather than cross-country sectoral differences. The results from using the share of capital sunk in zombies are similar in terms of coefficient signs but generally show weaker statistical significance. This weaker significance is likely due to substantial fluctuations in the share of capital sunk in zombie firms at various points, especially as large firms transition from zombie to non-zombie status over time. Such shifts reduce the variable's explanatory power, as large changes in the regressor do not correspond to comparable changes in the dependent variable within the same timeframe.

Regarding the expected results of the estimations, coefficient $\beta_1$ according to Adalet McGowan et al. (2018) may exhibit different results. A positive sign indicates that non-zombie firms are expected to have higher rates of change in employment, investment and in the level of total factor productivity than zombie firms, if the latter are unable to spend as much as non-zombie firms, due to their lack of access to bank credit. On the other hand, a negative sign indicates that non-zombie firms are expected to have lower rates of change in employment, investment, and in the level of total factor productivity, compared to zombie firms, if the latter still have access to bank lending.

As far as the coefficient $\beta_2$ is concerned, a positive sign is expected when the dependent variable of the model is total factor productivity. A positive sign indicates that the gap between zombie and non-zombie firms in terms of total factor productivity widens in favour of the latter due to the higher productivity level they have to achieve in order to overcome entry barriers created by zombie firms. If the dependent variable of the model is the rate of change in employment and investment, a negative sign is expected for the coefficient $\beta_2$, which shows that the presence of zombies in an industry creates "congestion" and reduces the ability and/or incentives of non-zombie firms to grow in terms of employment and investment.

In addition, possible distortions caused by zombie firms in the allocation of resources between them and non-zombie firms are also explored. In this respect we examine the effect of a firm's productivity level on attracting capital for investment. In this context, we employ the approach proposed by Adalet McGowan et al. (2018) which is reflected in the following econometric model:

$$Kgrowth_{ist} = \alpha + \beta_1 MFP_{ist-1} + \beta_2 MFP_{ist-1} * Industry\ zombie\ capital\ sunk_{st} + \beta_3 firm\ controls_{ist} + \delta_{st} + \varepsilon_{ist} \quad (2)$$

The dependent variable of the model, $Kgrowth_{ist}$, denotes the rate of change in capital of firm $i$, in sector $s$, in year $t$. The independent variable $MFP_{ist-1}$ is the total factor productivity – as estimated above – of firm $i$, in sector $s$, in year $t-1$. We use total factor productivity with one year lag because a firm first acquires knowledge about its productivity levels (and hence its profitability) and then makes a decision on whether to invest or not. The independent variable, $Industry\ zombie\ share_{st}$, defined above, indicates the share of zombie firms in industry $s$ at time $t$. The independent variable $firm\ controls_{ist}$ includes a number of control variables for the age and size of each firm, as defined above.

Regarding the expected results from the estimations of model (2) for coefficient $\beta_1$, Adalet McGowan et al. (2018) argue that it will have a positive sign, since firms with higher productivity are expected to attract resources in order to invest and grow. The coefficient $\beta_2$ is expected to have a negative sign if the presence of zombies causes distortions in the efficient allocation of resources, with negative consequences on investment and growth for firms exhibiting high productivity.

We conducted separate estimation for the Greek business economy using the 1-digit (NACE Rev. 2) classification of economic activity. However, most of these 1-digit sectors include more than one 2-digit sectors as in the case of the Manufacturing 1-digit sector which includes 24 2-digit sectors (sectors 10-33). In such cases, with the inclusion of sector-year fixed effects we control for differences across those sectors over time. In the case where the 1-digit sector includes only one 2-digit sector, for example in the case of Real Estate sector (sector 68) the sector-year effects are just year effects and in this case, we only control for differences over time.

# Results

This section discusses the results of the quantitative estimations, which can be found in the Appendix, of the two econometric models presented in the previous section. The estimations use annual firm-level panel data covering the period 2002-2021, broken down by firm size and sector of economic activity, focusing on the business economy. We also note that the analysis is carried out at the level of 2-digit economic sectors when data are available, otherwise 1-digit economic sectors are used.

Table A1 in the Appendix reports the results when the investment rate is the dependent variable. In the economy as a whole (column "Total"), the estimate of the coefficient of the dummy variable for non-zombie firms (**Non-zombie dummy**) is positive and statistically significant, and suggests that non-zombie firms have, on average, an investment rate 7.03 pps (percentage points) higher compared to firms classified as zombies, probably because the latter are not able to spend as much as healthy firms due to their difficulty in raising funds from the banking system. The interaction of this dummy variable with the percentage of zombie firms by sector (**Non-zombie dummy x Industry zombie share**) was estimated to be positive, but statistically insignificant. That is, in the economy as a whole it appears that the concentration of capital in zombie firms does not reduce the ability and/or incentives of non-zombie firms to grow in terms of investment.

Compared to the other sectors, where the impact of zombie firms on investment rates is positive, it is indicative that in sector (C) Manufacturing, non-zombie firms exhibit an investment rate which is 5.18 pps higher compared to zombie firms, while in sector (G) Wholesale and retail trade, they show a 6.70 pps higher investment rate compared to zombie firms.

Based on the above, the impact of reducing the zombie ratio to zero on the investment rate of the average non-zombie firm in the ICAP database for 2021 can be estimated as follows. In the most recent year of our sample (2021), the average investment rate for non-zombie firms is 12.2%, while the zombie ratio stands at 9.2%. According to the results in Table A.1, eliminating zombie firms would increase the average investment rate for the average firm in the business sector by 30%, raising it from 12.2% to 15.9%.

Table A2 presents the estimates of the regressions, with the rate of change in employment as the dependent variable. It should be noted that the number of observations compared to Table A1 is considerably lower, due to numerous missing observations in the employment data through ICAP. The results in this case are broadly similar in terms of the sign of the coefficient, but the level of statistical significance of the results is lower, most likely due to the limited number of observations. In summary, the results of the estimations that are statistically significant show that the non-zombie dummy firms (**Non-zombie dummy**) exhibit a higher rate of change in employment compared to zombie firms in sectors (C) Manufacturing, (G) Wholesale and retail trade, Information-Communications (J), Administrative-Support Activities (N) and the whole sample. In the case of the variable **Non-zombie dummy x Industry zombie share** a statistically significant positive result is obtained only in the Other Services sector.

Table A3 shows the results of the regression when total factor productivity is the dependent variable. It is first clear that the magnitude of the effects is strong and, in most cases, statistically significant. In the case of the **Non-zombie dummy** variable, statistically significant results are found in sectors (C) Manufacturing, (G) Wholesale and retail trade, (I)

Accommodation and food service activities, (J) Information and communication, (M) Professional, scientific and technical activities, (N) Administrative and support service activities, and (S) Other service activities, showing a positive coefficient, which indicates that non-zombie enterprises are expected to achieve higher levels of total factor productivity compared to enterprises classified as zombie. It should be noted that in the business economy as a whole (column "Total"), non-zombie firms also exhibit higher total factor productivity, as indicated by the positive and statistically significant coefficient of the non-zombie dummy variable.

Regarding the variable **Non-zombie dummy x Industry zombie share**, in those cases where a statistically significant result is obtained, i.e. in the total sample and in sectors (C) Manufacturing, (F) Construction, (G) Wholesale and retail trade, (H) Transportation and storage, (L) Real estate activities and (S) Other service activities, this result is positive and in line with the result of the estimations of Adalet McGowan et. al (2018). According to this finding, as the congestion of capital in zombie firms increases, the gap between zombies and non-zombies in terms of total factor productivity widens in favour of the latter due to the higher productivity threshold non-zombies have to achieve in order to overcome the entry and activity barriers created by zombie firms. On the contrary, a negative and statistically significant result is found for this variable only in sector (I) Accommodation and food service activities.

Table A4 presents the results of the estimations of model (2), which explores the existence of possible distortions caused by zombie firms in the allocation of resources between them and healthy firms within a sector of economic activity. Besides, it highlights the effect of the level of productivity of firms (with a lag of one year) on the attraction of capital for investment, both in the whole business economy (column "Total") and by sector of economic activity.

The results of the estimations are in line with the literature for the whole business economy (column "Total") and for all sectors except (D) Electricity, gas, steam and air conditioning supply and (S) Other service activities. The positive and statistically significant coefficient result for the variable $MFP_{t-1}$ indicates that firms with higher than average productivity also perform better in attracting capital in order to invest and grow. The strongest effects are found in sectors (J) Information and communication, (I) Accommodation and food services, (M) Professional, scientific and technical activities, (G) Wholesale and retail trade and (C) Manufacturing. On the other hand, weaker effects were estimated in sectors (F) Construction, (L) Real estate activities and (N) Administrative and support service activities.

Similarly, the estimated coefficients for the interaction of productivity with industry capital sunk in zombies are consistent with the results in the literature. They show a negative sign and are statistically significant both in the total economy case (column "Total") and in sectors (C) Manufacturing, (G) Wholesale retail trade, (I) Accommodation and food service activities, (L) Real estate activities and (M) Professional, scientific and technical activities, suggesting that the presence of zombie enterprises causes distortions in the efficient allocation of resources, with negative consequences on investment and growth of high-productivity enterprises. In other words, the greater the congestion of capital in zombie firms, the more limited the reallocation of capital to more productive investment across industries.

A recurring trend evident across all the aforementioned findings is the consistently positive and statistically significant impact of the "Young" variable, indicating that newly-established firms tend to demonstrate higher levels of performance. This outcome likely suggests that

newborn enterprises, in order to survive and then stabilise and improve their market position, must exhibit higher productivity and adopt a more aggressive approach towards investment and employment expansion. Furthermore, the results of the estimations for the dummy variables related to small/medium-sized enterprises (Small/Medium dummy) and micro enterprises reveal the existence of a negative and statistically significant relationship between performance and firm size. It is plausible that some of the firms experiencing weak growth or stagnation have limited capacity to secure resources for investment or employment.

Finally, we conducted two additional robustness checks. First, we defined a firm as non-zombie only if it maintained this status throughout the entire sample period, thus eliminating the potential impact of status changes on estimated coefficients. Second, to control for heterogeneity not only across sectors, but also across individual firms, we introduced firm-fixed effects, thus allowing coefficients to be identified solely through the time dimension. While the tables with the detailed results are not presented here for economy of space, both checks yielded consistent findings in terms of coefficient signs and statistical significance.

## Discussion

The high share of non-performing business loans, either on or off bank balance sheets, and the density of zombie companies are major challenges for the Greek economy. Corporate NPEs and the number of zombie firms in Greece have recorded a significant decline since their peak in 2015 and 2013, respectively, but remain high, especially in individual sectors of activity. The analysis in the case of the Greek economy confirms literature findings that the prolonged presence of non-performing business loans and zombie firms constitutes an obstacle to investment and employment prospects, while negatively affecting productivity and the efficient allocation of resources. The effects are both direct at the firm level and broader at the total economy level, as they spill over to healthy firms in each sector of economic activity, thus damaging healthy competition in goods and services markets. Overall, a faster resolution of non-performing loans and zombie firms can release significant financial and physical resources, whose reallocation towards more productive uses may contribute to sustainable economic growth.

The estimated share of zombie firms is positively correlated with the share of business NPEs in bank balance sheets over the period 2002-2021. However, the increase in the share of zombie firms preceded the increase in the share of NPEs in bank balance sheets, while the decrease in the share of zombie firms preceded the decrease of NPE ratios. This suggests leading indicator properties of the zombie rate for the NPE ratio. In the recent period, the faster decline in the number of zombies relative to that in NPEs may be partly due to the accumulation and delayed resolution of non-performing loans owed by firms that have ceased operations and are, therefore, no longer included in the ICAP database.

At the same time, the evolution over time of the estimated percentage of zombie firms in the Greek economy shows a similar trend but leads [in time] the respective trend of NPEs. The percentage of zombie firms, based on a range of widely applied criteria, increased from 10% to 18.6% in the period 2005-2013 and declined thereafter, to reach 8.9% in 2022. In relation to the size class of enterprises by turnover, a higher share of zombie enterprises is observed among micro enterprises, with a downward trend after 2013 in all size classes. It is noteworthy that, during 2005-2016, the share of zombie firms was higher among large firms than among small and medium-sized firms, which is nevertheless consistent with findings in the literature.

A qualitative analysis of the evolution of zombie firms by sector of economic activity shows a relatively higher density of zombie firms in sectors (F) Construction, (I) Accommodation and food service activities and (L) Real estate activities. Looking at the level of NFCs' liabilities to banks, the Construction sector consistently shows the highest liabilities from zombie firms, especially since the global financial crisis in 2008.

Within the quantitative analysis, five key findings emerge. First, non-zombie firms outperform zombie firms in terms of investment growth, employment growth and productivity levels. Second, a high concentration of capital in zombie firms negatively affects the rate of investment and productivity growth of healthy firms in certain sectors of economic activity. Third, a high concentration of capital in zombie firms forces healthy firms in many sectors of activity to increase their overall productivity and investment in order to survive. Fourth, a high concentration of capital in zombie firms prevents the reallocation of capital to more productive investments across firms and sectors of activity. Fifth, younger and larger firms generally perform better in terms of investment growth, employment growth and productivity levels.

More specifically, econometric models were used to investigate the effect of the congestion of zombie firms on non-zombie firms in Greece, both in the aggregate and in individual sectors of the business economy. Both the direct and indirect effects on healthy firms from capital bottlenecks in zombie firms vary across economic sectors. Indicatively, the effects of zombie concentration on investment rates among healthy firms and on the speed of capital reallocation towards productive investments are relatively high in sectors with a significant share in the gross value added of the Greek economy, such as (I) Accommodation and food service activities and (C) Manufacturing.

The findings highlight the potential benefits for the Greek economy from resolving NPEs and reducing the number of zombie companies. This would have direct positive effects, such as through higher rates of investment, employment and productivity growth for the overall economy. Besides, this would yield significant, indirect positive effects, such as enhancing the operating and growth prospects for existing healthy firms. This is expected through the process of freeing up of financial and physical resources and their efficient and more productive re-allocation within the economy and across sectors of economic activity.

Policy priorities and measures aiming at a rapid and effective reduction in the amount of NPEs and the number of zombie companies are expected to accelerate the narrowing of the investment gap in the Greek economy, as well as to reduce the unemployment rate. Moreover, they may enhance the prospect of strengthening the overall productivity of the economy, as well as the reallocation of capital to productive investments, which are necessary conditions for achieving strong and sustainable growth rates of the Greek economy in the medium to long term. The results highlight the importance for economic policy makers to strengthen institutions and develop effective instruments aiming towards the resolution of non-performing debt. This priority appears even more intense for economies which exhibit high levels of overdue debt or barriers in the re-allocation of resources.

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# Appendix

**Table A1: Results of model (1) estimations for the whole economy and by sector of economic activity with the investment rate [log(I/K)] as the dependent variable for 2002-2021**

| Variables | Total | C | D | E | F | G | H | I | J | L | M | N | S |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Non-zombie dummy** | 0.0703*** | 0.0518*** | 0.1923** | 0.0982* | -0.0539 | 0.0670*** | 0.0235 | 0.0851*** | 0.1070*** | -0.1025** | 0.0780 | 0.0200 | 0.3994 |
| | (0.0068) | (0.0123) | (0.0760) | (0.0594) | (0.0453) | (0.0146) | (0.0360) | (0.0170) | (0.0335) | (0.0483) | (0.0670) | (0.0472) | (0.2952) |
| **Non-zombie dummy × Industry zombie share** | -0.2956*** | -0.1730** | -3.7843*** | -0.8203** | 0.4628* | -0.1568 | 0.1125 | -0.3779*** | -0.4017** | 0.4881** | 0.0243 | -0.1082 | -1.5868 |
| | (0.0332) | (0.0727) | (0.8528) | (0.3983) | (0.2434) | (0.1054) | (0.2257) | (0.0694) | (0.1948) | (0.2272) | (0.6162) | (0.2610) | (3.9920) |
| **Young** | 0.1803*** | 0.2159*** | 0.3511*** | 0.2200*** | 0.1832*** | 0.1557*** | 0.1990*** | 0.2005*** | 0.1830*** | 0.1251*** | 0.1565*** | 0.1613*** | 0.1185 |
| | (0.0034) | (0.0089) | (0.0210) | (0.0449) | (0.0113) | (0.0061) | (0.0154) | (0.0095) | (0.0163) | (0.0117) | (0.0129) | (0.0153) | (0.1271) |
| **Small/Medium dummy** | -0.0239*** | -0.0189* | 0.0058 | 0.1161 | -0.0138 | -0.0303*** | -0.0235 | -0.0424 | -0.0165 | -0.1947* | -0.0410 | -0.0005 | |
| | (0.0070) | (0.0109) | (0.0478) | (0.1351) | (0.0385) | (0.0107) | (0.0295) | (0.0445) | (0.0354) | (0.1028) | (0.0741) | (0.0312) | |
| **Micro dummy** | -0.1076*** | -0.0779*** | -0.0047 | 0.0716 | -0.1164*** | -0.1249*** | -0.1241*** | -0.0929** | -0.1256*** | -0.2431** | -0.1473** | -0.1235*** | -0.1163 |
| | (0.0071) | (0.0112) | (0.0420) | (0.1375) | (0.0382) | (0.0108) | (0.0293) | (0.0443) | (0.0351) | (0.1014) | (0.0743) | (0.0303) | (0.0952) |
| **Sector-year FE** | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| **Observations** | 492,966 | 90,334 | 15,012 | 2,327 | 39,444 | 148,391 | 18,574 | 70,683 | 21,475 | 33,408 | 31,995 | 21,005 | 318 |
| **Sectors** | 47 | 19 | 1 | 2 | 1 | 3 | 5 | 1 | 4 | 1 | 5 | 4 | 1 |
| **Adjusted $R^2$** | 0.0231 | 0.0314 | 0.0708 | 0.0274 | 0.0165 | 0.0177 | 0.0227 | 0.0292 | 0.0144 | 0.0113 | 0.0111 | 0.0153 | -0.0060 |

**Source:** Authors' estimations based on ICAP data. **Notes:** The dependent variable log (I/K) refers to the investment rate, that is the difference in logarithms of deflated net fixed capital. The variable "Industry zombie share" refers to the share of zombie firms (with age larger or equal to 10 years and an interest coverage ratio < 1 for more than 3 consecutive

years) in an industry in the relevant sector of economic activity. The classification NACE Rev. 2 is used for business economy sectors (sectors 10-82, except for sectors 64-66) and sectors 94-96. Standard errors are included in parentheses. ***, ** and * denote statistical significance at levels 1%, 5%, and 10%, respectively.

**Table A2: Results of model (1) estimations for the whole economy and by sector of economic activity with employment growth (dLogEmp) as the dependent variable for 2002-2021**

| Variables | Total | C | D | E | F | G | H | I | J | L | M | N | S |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Non-zombie dummy** | 0.0554*** | 0.0562*** | 0.3069 | 0.0937 | 0.1449 | 0.0537*** | 0.0317 | -0.0527 | 0.0371 | 0.1456 | -0.1007 | 0.0982 | -0.5263* |
| | (0.0119) | (0.0200) | (0.2134) | (0.1065) | (0.1793) | (0.0173) | (0.0499) | (0.0888) | (0.0357) | (0.1681) | (0.0903) | (0.0789) | (0.2982) |
| **Non-zombie dummy × Industry zombie share** | 0.0602 | 0.0533 | -2.0547 | -0.2767 | -0.5131 | 0.1720 | 0.3088 | 0.4136 | 0.4437 | -0.6551 | 1.3382 | 0.1734 | 8.1101* |
| | (0.0866) | (0.1312) | (2.1199) | (0.6351) | (0.8938) | (0.1337) | (0.3537) | (0.5565) | (0.3086) | (0.7590) | (1.0299) | (0.5593) | (4.2937) |
| **Young** | 0.1399*** | 0.1580*** | 0.0909 | 0.1396** | 0.1741*** | 0.1336*** | 0.1474*** | 0.1210*** | 0.1328*** | 0.1724** | 0.1208*** | 0.1299*** | -0.3363 |
| | (0.0061) | (0.0134) | (0.0856) | (0.0646) | (0.0309) | (0.0079) | (0.0240) | (0.0410) | (0.0259) | (0.0725) | (0.0228) | (0.0316) | (0.3057) |
| **Small/Medium dummy** | 0.0002 | 0.0110 | -0.1113** | 0.0580 | -0.0123 | -0.0017 | -0.0117 | -0.1008 | 0.0241 | -0.0428 | -0.0542 | -0.0285 | |
| | (0.0052) | (0.0071) | (0.0506) | (0.0601) | (0.0498) | (0.0072) | (0.0240) | (0.1249) | (0.0195) | (0.0631) | (0.0644) | (0.0411) | |
| **Micro dummy** | -0.0813*** | -0.0570*** | -0.1330*** | -0.0097 | -0.1486*** | -0.0805*** | -0.0640*** | -0.2148* | -0.0474** | -0.1822*** | -0.1471** | -0.1111*** | -0.0229 |
| | (0.0055) | (0.0080) | (0.0461) | (0.0658) | (0.0499) | (0.0077) | (0.0248) | (0.1244) | (0.0202) | (0.0595) | (0.0647) | (0.0417) | (0.0592) |
| **Sector-year FE** | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| **Observations** | 112,444 | 29,321 | 1,087 | 695 | 6,463 | 45,320 | 4,832 | 6,822 | 5,511 | 1,886 | 5,952 | 4,441 | 114 |
| **Sectors** | 47 | 19 | 1 | 2 | 1 | 3 | 5 | 1 | 4 | 1 | 5 | 4 | 1 |
| **Adjusted $R^2$** | 0.0434 | 0.0580 | 0.0336 | 0.0078 | 0.0409 | 0.0558 | 0.0390 | 0.0205 | 0.0335 | 0.0287 | 0.0246 | 0.0362 | 0.1603 |

**Source:** Authors' estimations based on ICAP data. **Notes:** The dependent variable dLogEmp refers to the employment growth rate. The variable "Industry zombie share" refers to the share of zombie firms (with age larger or equal to 10 years and an interest coverage ratio < 1 for more than 3 consecutive years) in an industry in the relevant sector of economic activity. The classification NACE Rev. 2 is used for business economy sectors (sectors 10-82, except for sectors 64-66) and sectors 94-96. Standard errors are included in parentheses. ***, ** and * denote statistical significance at levels 1%, 5%, and 10%, respectively.

**Table A3: Results of model (1) estimations for the whole economy and by sector of economic activity with multifactor productivity (MFP) as the dependent variable for 2002-2021**

| Variables | Total | C | D | E | F | G | H | I | J | L | M | N | S |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Non-zombie dummy** | 0.5380*** | 0.3296*** | -0.1022 | 1.2673*** | 0.1750 | 0.4278*** | 0.2542 | 0.8346*** | 0.6268*** | 3.1616*** | 0.3256 | 1.0357*** | -0.2061 |
| | (0.0325) | (0.0551) | (0.3629) | (0.3278) | (0.3839) | (0.0575) | (0.1905) | (0.1532) | (0.1266) | (0.6707) | (0.2269) | (0.2175) | (1.6553) |
| **Non-zombie dummy × Industry zombie share** | 0.9686*** | 2.3195*** | 4.6884 | -9.4074*** | 5.6381*** | 2.0653*** | 1.7385 | -1.9409*** | 0.1210 | -9.9932*** | 2.2717 | -1.7258 | 32.9065 |
| | (0.2014) | (0.3414) | (5.3529) | (1.6911) | (2.0064) | (0.4065) | (1.2366) | (0.6352) | (0.7660) | (3.0354) | (2.4990) | (1.2648) | (22.4443) |
| **Young** | 0.3875*** | 0.2760*** | 0.4820*** | 0.0360 | 0.6502*** | 0.4885*** | 0.2924*** | 0.3629*** | 0.1640*** | 0.6724*** | 0.1553*** | 0.1556*** | -0.1290 |
| | (0.0088) | (0.0184) | (0.1126) | (0.0885) | (0.0360) | (0.0124) | (0.0407) | (0.0354) | (0.0354) | (0.1209) | (0.0362) | (0.0418) | (0.1981) |
| **Small/Medium dummy** | -0.3476*** | -0.1580*** | -1.2917*** | 0.1063 | 0.3875*** | -0.6751*** | 0.4022*** | 0.3382** | 0.4340*** | 0.5306* | -0.5626*** | -0.2315 | |
| | (0.0173) | (0.0196) | (0.1572) | (0.1914) | (0.0864) | (0.0270) | (0.0720) | (0.1505) | (0.0660) | (0.3153) | (0.1585) | (0.1494) | |
| **Micro dummy** | -0.9516*** | -0.6314*** | -1.9423*** | -0.6944*** | -0.4128*** | -1.2939*** | -0.3137*** | -0.0560 | -0.1374** | -1.1187*** | -1.2507*** | -0.8902*** | -0.0481 |
| | (0.0178) | (0.0210) | (0.1464) | (0.2011) | (0.0873) | (0.0276) | (0.0740) | (0.1505) | (0.0662) | (0.3111) | (0.1593) | (0.1496) | (0.1888) |
| **Sector-year FE** | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| **Observations** | 175,861 | 44,310 | 1,673 | 982 | 10,811 | 69,706 | 7,106 | 13,086 | 8,458 | 3,242 | 9,477 | 6,848 | 162 |
| **Sectors** | 47 | 19 | 1 | 2 | 1 | 3 | 5 | 1 | 4 | 1 | 5 | 4 | 1 |
| **Adjusted $R^2$** | 0.7075 | 0.5966 | 0.4829 | 0.5396 | 0.5551 | 0.2999 | 0.6855 | 0.3795 | 0.5888 | 0.1933 | 0.6614 | 0.7818 | 0.7289 |

**Source:** Authors' estimations based on ICAP data. **Notes:** The dependent variable MFP refers to the estimate of the level of total factor productivity, based on the Solow residual theory. The variable "Industry zombie share" refers to the share of zombie firms (with age larger or equal to 10 years and an interest coverage ratio < 1 for more than 3 consecutive years) in an industry in the relevant sector of economic activity. The classification NACE Rev. 2 is used for business economy sectors (sectors 10-82, except for sectors 64-66) and sectors 94-96. Standard errors are included in parentheses. ***, ** and * denote statistical significance at levels 1%, 5%, and 10%, respectively.

**Table A4: Zombie firms and capital reallocation: sensitivity of net fixed assets to lagged multifactor productivity for the whole economy and by sector of economic activity. Dependent variable: log (I/K)**

| Variables | Total | C | D | E | F | G | H | I | J | L | M | N | S |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| $MFP_{t-1}$ | 0.0799*** | 0.0766*** | 0.0962 | 0.0272 | 0.0299 | 0.0859*** | 0.0743*** | 0.1008*** | 0.1099*** | -0.0563 | 0.1043*** | 0.0166 | 0.0839 |
| | (0.0047) | (0.0095) | (0.0675) | (0.0302) | (0.0281) | (0.0104) | (0.0250) | (0.0239) | (0.0183) | (0.0584) | (0.0271) | (0.0192) | (0.1295) |
| $MFP_{t-1}$× Industry zombie share | -0.2261*** | -0.2111*** | -0.7414 | 0.2083 | 0.1124 | -0.2847*** | -0.1898 | -0.3478*** | -0.3048* | 0.3658 | -0.3748 | 0.2180 | -0.1083 |
| | (0.0307) | (0.0637) | (0.6155) | (0.3643) | (0.1520) | (0.0927) | (0.1742) | (0.0976) | (0.1722) | (0.2759) | (0.2684) | (0.1355) | (1.4642) |
| Young | 0.0882*** | 0.1058*** | 0.1595*** | 0.1193*** | 0.0942*** | 0.0795*** | 0.0602** | 0.0387** | 0.1401*** | 0.0309 | 0.0940*** | 0.1201*** | 0.1928 |
| | (0.0055) | (0.0119) | (0.0483) | (0.0385) | (0.0204) | (0.0089) | (0.0241) | (0.0160) | (0.0269) | (0.0432) | (0.0249) | (0.0249) | (0.1925) |
| Small/Medium dummy | 0.0094 | -0.0016 | 0.0160 | 0.0562 | 0.0294 | 0.0215** | -0.0216 | -0.0894* | -0.0289 | -0.1296 | 0.0065 | 0.0076 | |
| | (0.0060) | (0.0081) | (0.0664) | (0.0461) | (0.0293) | (0.0097) | (0.0294) | (0.0529) | (0.0238) | (0.1068) | (0.0965) | (0.0391) | |
| Micro dummy | -0.0419*** | -0.0424*** | -0.0652 | -0.0029 | -0.0323 | -0.0261** | -0.0827*** | -0.1409*** | -0.0893*** | -0.1650 | -0.0495 | -0.0949** | -0.2715** |
| | (0.0066) | (0.0091) | (0.0557) | (0.0507) | (0.0296) | (0.0111) | (0.0317) | (0.0528) | (0.0231) | (0.1029) | (0.0978) | (0.0396) | (0.1261) |
| Sector-year FE | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Observations | 151,668 | 38,827 | 1,402 | 838 | 9,390 | 59,633 | 6,038 | 11,303 | 7,299 | 2,857 | 8,098 | 5,812 | 128 |
| Sectors | 47 | 19 | 1 | 2 | 1 | 3 | 5 | 1 | 4 | 1 | 5 | 4 | 1 |
| Adjusted $R^2$ | 0.0326 | 0.0428 | 0.0635 | 0.0510 | 0.0300 | 0.0313 | 0.0245 | 0.0317 | 0.0333 | 0.0173 | 0.0296 | 0.0391 | 0.0398 |

**Source:** Authors' estimations based on ICAP data. **Notes:** The dependent variable MFP refers to the estimate of the level of total factor productivity, based on the Solow residual theory. The variable "Industry zombie share" refers to the share of zombie firms (with age larger or equal to 10 years and an interest coverage ratio < 1 for more than 3 consecutive years) in an industry in the relevant sector of economic activity. The classification NACE Rev. 2 is used for business economy sectors (sectors 10-82, except for sectors 64-66) and sectors 94-96. Standard errors are included in parentheses. ***, ** and * denote statistical significance at levels 1%, 5%, and 10%, respectively.