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# Giving zombie firms a second chance: An assessment of the reform of the Portuguese insolvency framework

Ernesto Nieto-Carrillo [a,*], Carlos Carreira [a,b], Paulino Teixeira [a,b]

[a] University of Coimbra, Faculty of Economics, Av. Dias da Silva 165, 3004-512 Coimbra, Portugal
[b] CeBER, Av. Dias da Silva 165, 3004-512 Coimbra, Portugal

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ABSTRACT

In most advanced economies productivity growth has been hampered by barriers that allow zombie firms to survive. We examine the effectiveness of institutional reforms in Portugal that were aimed to improve efficiency in insolvency framework. Estimates show that reallocation barriers declined. The reforms appear to have larger and more effective results in zombie recovery than in exit. Firm size plays a major role in tackling zombie-entrenchment. The decline in barriers has also implied a lower distortion in the economy-wide selection process. The new setting seems to be more desirable than forcing zombie exit at all costs.



## 1. Introduction

The so-called productivity paradox has attracted the attention of academics and policy makers during the new century. In most developed countries the rate of aggregate productivity growth has been anemic despite continuous technological advances and an increasing qualified labor force (Summers, 2015). Although researchers have documented several factors that contribute to this poor economic performance, firm-based research has highlighted the widening productivity dispersion across firms, rising resource misallocation, and declining business dynamism (Decker et al., 2016, 2017, 2020). In this context, a matter of concern is the survival of poorly performing firms, namely zombie firms that would typically exit in a well-functioning market economy, with the potential to cause harm to aggregate productivity by crowding-out growth opportunities for more productive firms and new projects (Caballero et al., 2008; Kwon et al., 2015; McGowan et al., 2018).

Exit barriers play an important role in the case of zombie prevalence. In addition to evergreen loans that arise when banks make additional credits to problematic borrowers to avoid reporting losses on their own balance sheets, inefficient

* Corresponding author.
*E-mail addresses:* enietoc@fe.uc.pt (E. Nieto-Carrillo), ccarreir@fe.uc.pt (C. Carreira), pteixeira@fe.uc.pt (P. Teixeira).

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insolvency regimes have also been identified as a barrier to reallocation (Peek and Rosengren, 2005; McGowan et al., 2017a,b; Andrews and Petroulakis, 2017; Storz et al., 2017).

In this study, we empirically assess whether the 2012 reforms in the Portuguese insolvency framework, especially those policies aimed at improving the efficiency of prudential banking supervision and insolvency legislation, were effective. The analysis is focused on the case of financially distressed companies (zombie firms), over the period of 2004–2017, a zombie being defined as a company that is debt-ridden, with no potential to repay its debts due to lack of profitability over an extended period. Portugal is indeed one of the European countries most affected by the zombie prevalence (McGowan and Andrews, 2018; Carreira et al., 2022). At the same time, the country has been particularly active in the adoption of the best international practices related to bankruptcy legislation (Carcea et al., 2015; McGowan and Andrews, 2018). To this extent, the results found in this study are certainly relevant for a number of countries that face a similar need for policies aimed to avoid high reallocation barriers.

Unviable firms in a well-functioning market are expected either to recover or exit, and therefore zombie entrenchment is expected to reflect the extent of barriers to reallocation. (Entrenchment can be defined as the number of years during which a firm has remained in zombie status.) In this study we estimate a treatment effects model using the nearest-neighbor matching estimator to examine whether the implemented reforms have contributed to reducing the level of entrenchment. By estimating a multinomial logistic model and computing the differences in marginal effects across pre- and post-reforms, we then investigate how the institutional change has influenced the zombie transition, as well as whether the reforms were effective by permitting the recovery of viable firms with temporary financial distress, on the one hand, and the exit of unviable units, on the other. Finally, we analyze whether the institutional changes were associated with a higher productivity-enhancing reallocation. To this end, we estimated the effect of zombies on responsiveness of firm growth to productivity before and after the reforms, based on Decker et al. (2020).

Previous cross-country studies have shown that ill-designed insolvency regimes increase reallocation barriers (e.g. Andrews and Petroulakis, 2017; McGowan et al., 2017a,b). However, with the single exception of the study by Gouveia and Osterhold (2018), to the best of our knowledge it has not been addressed in the literature the within-country impact of legislative reforms that seek to make the legal setting more friendly to corporate restructuring in a context of strong zombie prevalence. The empirical strategies followed in Gouveia and Osterhold (2018) and in our study are nevertheless different: the former uses sectorial heterogeneity in exposure to insolvency regime changes as an analytical device, while we estimate the treatment effect of the reforms on the probability of exiting the zombie status. We also deploy a multinomial logistic model to investigate how the institutional change has distinctly influenced the recovery and exit transitions. As a distinct feature from most cross-countries studies, our study provides evidence for the manufacturing and service sectors, as well as a comparison between small and large firms. Our sample is, therefore, not restricted to publicly listed companies.

Our main findings indicate that reallocation barriers as a whole were effectively reduced after the reforms. The new institutional framework seems to have a larger effect on the recovery than on the exit transition. Our results also confirm that the firm size plays a key role in insolvency. The reforms make the restructuring transition more likely in companies characterized by complex ownership and debt structures, as well as in those typically prone to liquidation due to a high share of concentrated and secured debt. Finally, our estimates point out that the decline in entrenchment barriers is also associated with lower economy-wide distortion in selection and reallocation.

The remainder of the paper is organized as follows. In Section 2 the literature regarding the zombie phenomenon and frictions in market selection, in connection with insolvency regimes and productivity growth, is reviewed. Section 3 describes the institutional environment and the characteristics of the reforms implemented by the ECB and Portuguese authorities in 2012. Section 4 presents the dataset, defines zombie firms and discusses the empirical strategy. Regression results are discussed in Section 5, while Section 6 presents the conclusions and final remarks.

## 2. Literature review

### 2.1. Zombies and frictions in the responsiveness of selection

Productivity heterogeneity across firms is one of the main drivers of firm dynamics and, as a result, of aggregate efficiency of the economy. Decker et al. (2020), for example, developed a theoretical model to disentangle whether the secularly weakened business dynamism in the US economy is due to a change in the dispersion of shocks that firms face, or rather to a change in the response of firms to shocks (called the lower responsiveness hypothesis). A key aspect in the analysis is the productivity dispersion within sectors: weakened responsiveness of business growth to productivity accompanied by low technological dispersion indicates a greater degree of maturity of industries (i.e., lower intensity and dispersion of shocks), while lower degree of responsiveness accompanied by greater technological dispersion reflects the presence of reallocation frictions. After comparing the theoretical predictions with the statistical evidence, the authors concluded that the lower responsiveness thesis explains the behavior of business dynamism in the US economy.[1]

[1] In empirical terms, measuring the degree of responsiveness between productivity and reallocation is straightforward, since it is directly given by the marginal effect of lagged relative productivity on firm growth or exit, conditional on its initial size (Decker et al., 2020).

Although Decker et al. (2020) argue that reallocation frictions are possibly nested in the form of adjustment costs, they do not rule out that there may be other types of frictions, such as exit barriers. In the case of zombie firms, bank forbearance and inefficient insolvency regimes are certainly barriers to reallocation that weaken the responsiveness, as they hamper the normal functioning of selection by allowing poorly performing firms to survive and increasing the adjustment costs for the other firms. In effect, Andrews and Petroulakis (2017), McGowan and Andrews (2018) and Gouveia and Osterhold (2018) report that a higher zombie firms prevalence negatively impacts the marginal effect of productivity on capital growth. Gouveia and Osterhold (2018) also find a similar effect on the relationship between productivity and employment growth.

Caballero et al. (2008) showed that if the exit margin is hindered by allowing the survival of firms that otherwise would exit, the adjustment to negative shocks will be made through more productive units. It is hypothesized that the resulting congestion reduces the profitability margin and, then, the minimum productivity threshold for healthy projects increases, which in turn discourages the investment of both new and incumbent firms, while increases the destruction of relatively healthier firms. Aggregate productivity is therefore harmed not only by the preservation of zombie firms, but also by the negative externalities they generate on entry, growth, and exit of non-zombie projects (the "sclerosis" and "scrambling" effects, respectively). Given that zombies face a lower productivity threshold than non-zombies, the productivity gap between zombies and non-zombies widens with the share of zombie firms, which implies an increase in technological dispersion within industries. This prediction of the model of Caballero et al. (2008), in line with the lower responsiveness hypothesis of Decker et al. (2020), was empirically confirmed by Caballero et al. (2008) and McGowan and Andrews (2018).

### 2.2. Insolvency framework and zombie firms

Efficient insolvency and restructuring framework can play a fundamental role in reducing distortions in market selection and resource reallocation caused by zombie survival, especially if it promotes the recovery of weak (but viable) firms with temporary financial distress and the exit of non-viable ones (McGowan et al., 2017a,b). The ability to differentiate viable from non-viable companies in insolvency events is, however, affected by asymmetric information in the capital market, as well as by the different incentives that managers, shareholders, and creditors have in the ex-ante and ex-post stages of those events (Aghion, 1992; McGowan and Andrews, 2018; Morrison, 2007). Thus, ownership and debt structures play a crucial role in the way these financial conflicts are resolved. For instance, a typical SME is characterized by few owners with almost no division between managers and shareholders. The debt is generally concentrated in banks that collateralize their financing against assets. Banks have therefore an important influence on SMEs' normal activities and the resolution of insolvency events (Franks and Sussman, 2005; Bergthaler et al., 2015). Large companies are in turn characterized by complex ownership structures along with greater debt dispersion (and lower bank dependence). As a result, the agent-principal relationship exists both between managers and shareholders and between managers and creditors. Similarly, the complexity of ownership and debt structures is likely to complicate the resolution of insolvency conflicts, thus depressing the firm-value (Franken, 2004). For these reasons, the debate on the design of insolvency legislation has been centered around which orientation generates more efficient results. In other words, is a creditor-oriented regime better than a debtor-oriented regime or the other way around?

Creditor-oriented regimes promote agile liquidations and an immediate recovery of secured debt, accompanied by a quick dismissal of managers. These regimes also tend to preserve legal certainty, so the applicable redistributive regulation is the absolute-priority-rule, thus emphasizing the protection of the creditors' rights that were negotiated ex-ante (Aghion, 1992; Cirmizi et al., 2012; McGowan and Andrews, 2018). The maximization of ex-ante and ex-post efficiency is sought through a lower general interest rate that encourages business venture and the mitigation of over-investments that shareholders and managers could pursue after the insolvency event, respectively. Nevertheless, a creditor-oriented design can generate incentives for debtors to delay bankruptcy, while it may also result in excessive liquidation of viable firms (Adler et al., 2013).

Alternatively, a debtor-oriented regime allows a reorganization agreement that (i) leaves the manager in office during such process ("debtor-in-possession"), (ii) completely stops the execution of creditors' collaterals ("automatic-stay-on-assets"); and, (iii) permits deviations from the absolute-priority-rule ("loss-sharing"). Furthermore, reorganization plans must be approved by creditors, but in case of dissent, the plan can be imposed by majority ("cram-down") (Aghion, 1992; Cirmizi et al., 2012; McGowan and Andrews, 2018). In short, it is hunt for timely insolvency statements and greater recovery probability of viable firms, increasing the ex-ante and ex-post efficiency (Morrison, 2007). Yet, since creditors are less protected, this regime could lead to increased investment risk and, consequently, to a higher interest rate (Rodano et al., 2016). Moreover, as unsecured creditors and managers/shareholders can seek the business reorganization in any circumstance, the recovery likelihood of unviable firms may increase as well (Franken, 2004).

On balance, the losses obtained from insolvency regimes that overprotect creditors seem to exceed their gains. In this regard, the threat of premature liquidation would also be causing credit demand to be reduced and companies would tend to preserve higher levels of liquidity (Vig, 2013). This reduction in the optimal level of financial leverage would also have adverse effects on business investment and innovation, especially in industries that are more intensive in innovation and technology (Acharya and Subramanian, 2009).

Finally, the evidence suggests that if there is the possibility of negotiating a reorganization agreement, its success will be inversely proportional to the number of creditors classes involved (Kalay et al., 2007; Brunassi and Saito, 2018). On

the other hand, the larger and older a company is, the greater the likelihood that it will remain as a going-concern after the insolvency statement (García-Posada and Sánchez, 2018). Furthermore, the higher the proportion of secured debt, the lower the probability that reorganization agreements will be approved, even if the liquidation is inefficient, and conversely for unsecured debt (Ivashina et al., 2016; Brunassi and Saito, 2018).[2]

International best practices suggest that a balance between creditors' and debtors' rights will maximize the ex-ante and ex-post efficiency of insolvencies (Djankov et al., 2008; Cirmizi et al., 2012; McGowan and Andrews, 2018). Actually, the OECD recommends that insolvency regimes should enable restructuring agreements, but with the following caveats: (i) managers should remain in their duties during the reorganization period; (ii) creditors should not execute their collaterals immediately after insolvency is declared, albeit this period should be limited so as not to discourage future investment; (iii) deviations from the absolute-priority-rule to stimulate new financing should be allowed, but with the priority given to those who inject new funding only above unsecured creditors; and (iv) cram-down in the approval of the restructuring plans, although dissenting creditors should receive at least what they would receive in the liquidation event (McGowan and Andrews, 2018).

The design of insolvency regimes is especially relevant considering that, according to extant evidence, there would be barriers delaying the transition of zombies to where competitive pressure should naturally lead them, thus encouraging their entrenchment. For example, Carreira et al. (2022) found that, on average, a zombie requires three years and six months to exit and three years and two months to recover. Zombies are therefore not inherently unviable firms as recovery is a possible route. The results of both Fukuda and Nakamura (2011) and Carreira et al. (2022) indeed suggest that strategies such as downsizing, technological restructuring and debt restructuring increase the recovery likelihood of zombies.

Efficient insolvency regimes can therefore strengthen market selection not only through greater responsiveness at the exit margin, but also through increased competition driven by recovering zombies, which in turn can reduce aggregate losses linked to job destruction (McGowan and Andrews, 2018). In the same vein, estimates by McGowan et al. (2017b) and Gouveia and Osterhold (2018) indicate that insolvency regimes that hinder corporate restructuring, more than reducing the recovery likelihood of relatively more productive zombies, increase the chances of a healthy company becoming zombie. Hostile regimes to corporate restructuring can also affect the efficiency with which capital is reallocated, increasing the percentage of capital sunk in zombies (McGowan et al., 2017b), while hindering the technological catching-up of laggard firms (McGowan et al., 2017a). The impact on capital reallocation and technological diffusion is expected to be greater in dynamic industries and more dependent on external financing (McGowan et al., 2017a,b).

To assess the effectiveness of different legislative orientations, previous studies are based on cross-country comparisons. The emphasis of this paper is different. We focus rather on the within-country impact of legislative reforms that seek to make the Portuguese insolvency framework more friendly to corporate restructuring.

## 3. The institutional reforms as response to the crisis

The financial nature of the Great Recession has raised concerns about the macroeconomic impact of the low quality of balance sheets—mirrored in a growing stock of non-productive loans (NPLs). In this regard, Miller and Stiglitz (2010) suggested that, due to excessive leverage in the aftermath of the crisis, many small businesses were likely to be inefficiently liquidated, with assets transferred to less productive but "deep-pockets" agents. As a result, the negative shock is likely to be a lot amplified (Krishnamurthy, 2009; Carreira and Silva, 2010; Miller and Stiglitz, 2010).

These concerns have been particularly relevant in European countries. In reaction, the European Banking Authority (EBA) and the European Central Bank (ECB) deployed a series of actions to strengthen prudential supervision of credit institutions in the Eurozone, namely the creation of a Single Supervisory Mechanism of banks in 2013 and the adoption of EBA definition of NPLs (as well as forbearance) for the assessment of bank health in 2015 (Jassaud and Vidon, 2017).

In addition to the implementation of the prudential supervision policies of the ECB, several European countries reformed their insolvency regimes to adopt business reorganization procedures similar to Chapter 11 of the US Bankruptcy Act, following the recommendations of the European Commission and the International Monetary Fund to improve the efficiency of national insolvency regimes, encouraging in particular the reorganization of viable companies (Bergthaler et al., 2015; Carcea et al., 2015; McGowan and Andrews, 2018). In the case of Portugal, the reforms were firstly implemented in 2012.

The 2004 Insolvency and Company Recovery Code (or CIRE, the Portuguese acronym) was designed to give priority to protection of creditors' rights, with liquidation being favored over corporate restructuring. In 2012 and subsequent years, the Portuguese authorities carried out reforms in CIRE in order to generate a turn in its orientation, stimulating rather the business reorganization through solidification of the pre-insolvency regime.

Specifically, the 2012 reforms included: (i) a hybrid pre-insolvency mechanism (with judicial supervision) called "Special Revitalization Process" (PER), to promote a fast restructuring agreement between debtors and creditors in firms that are in an imminent insolvency situation, whose procedure can be initiated by both debtors and creditors; (ii) that those creditors who inject new capital for restructuring have priority if the company is subsequently liquidated, that is, if reorganization fails; and (iii) an out-of-court recovery mechanism (SIREVE) focused mainly on SMEs, which had

[2] The liquidation of a financial distressed firm becomes an inefficient result if its liquidation value is lower than its value as a going concern.

the technical support of the Portuguese Agency for Competition and Innovation (IAPMEI). Furthermore, early warning mechanisms have also been created in subsequent years. Specifically, the Bank of Portugal developed a mechanism for credit institutions to detect companies at "risk of default" in 2014, while the IAPMEI created a tool for the financial self-assessment of firms in 2015. Observe that the legislation contains in addition: (i) a "cram-down" for the approval of reorganization agreements where dissident creditors receive at least what they would receive in liquidation; (ii) an "automatic-stay-on-assets" only for a limited interval; and (iii) managers are not dismissed during the reorganization process.

Overall, this set of measures sought timely insolvency statements and resolved conflicts in an agile and efficient manner, while protecting the rights of both creditors and debtors in a balanced manner. As a matter of fact, according to the OECD study conducted by McGowan and Andrews (2018), comparing the legislation in force in 2010 and 2016, Portugal is one of the countries that carried out greater efficiency reforms in its insolvency regulation, placing the country among the four OECD economies with the most efficient regimes. Furthermore, as stated by the European Commission study conducted by Carcea et al. (2015), Portugal is one of the most efficient countries, in regulatory terms, in the pre-insolvency regime (second only to the UK). The main improvement was in the "facility/availability of preventive measures" component.

Nonetheless, McGowan and Andrews (2018) note that the reform that allowed new financing during the restructuring process was not entirely adequate, as the priority given to new creditors was placed above all previous creditors and not just over the unsecured. This is contrary to OECD recommendations, generating adverse effects on credit availability and legal certainty. The authors also argue that although the Portuguese regime distinguishes between honest and fraudulent bankruptcies, has a high time to discharge for failed entrepreneurs. This makes bankruptcy a very expensive event, which causes hostile effects on timely insolvencies and future entrepreneurship (Armour and Cumming, 2008; McGowan and Andrews, 2018).

While between 2007 and 2012 the number of "bankruptcy, insolvency and recovery" processes were 14,010, this number increased to 25,661 in the 2013–2018 period, of which 3,310 cases were related to PER procedures. Moreover, from the entry into force of SIREVE until 2018, 632 companies (98% of this total are SMEs) benefited from this out-of-court recovery mechanism, with 43% reaching an agreement in 7 months, on average.[3] Although these official figures do not allow us to differentiate zombie and non-zombie firms, they offer a preliminary description of the evolution of the main procedures, as well as an immediate measure of the impact of the implemented policy changes.

## 4. Data and methods

### 4.1. The dataset

Our raw information is extracted from SCIE-*Sistema de Contas Integradas das Empresas*, a longitudinal dataset containing the structure, activity, inputs and other elements related to the economic/financial nature and competitiveness of firms. The SCIE is a mandatory annual business survey administered by the Portuguese Statistical Office (INE) that covers the universe of Portuguese non-financial firms. The sample used in the study covers manufacturing and services sectors, except utilities, the financial sector and the social services (i.e., education, health care and cultural services), over the period 2004–2017.[4]

Firm exit is flagged when a unit ceases production (Carreira and Teixeira, 2011). The dataset allows identification of firms that are economically inactive (i.e., with gross output equal to zero) while still legally active. This feature enables us to identify firm exit with precision.[5] In the data cleaning process, we excluded all observations with non-strictly positive values for gross output and total net assets. We also excluded firms that never exceeded the threshold of three employees (profit generation is not likely to be the main motivation these "family" firms). Finally, since the identification of zombie firms depends on low profitability and high leverage criteria for three consecutive years (see Section 4.2), we linearly interpolate one-year gaps in missing values. Our final sample comprises an unbalanced panel of 269,584 firms, making up 2,014,233 firm-year observations over the selected interval.

### 4.2. Identification of zombie firms

We define zombie firms as mature firms that are debt-ridden and have no potential to repay their debt due to lack of profitability over an extended period. Several strategies have been proposed in the literature to identify which firms can be classified as zombies (see Carreira et al., 2022, for a survey). A common approach is the use of "profitability" and "evergreen lending" criteria proposed by Fukuda and Nakamura (2011). For example, Shen and Chen (2017) and Dai et al. (2019) define zombie firms as those that: (i) are capable of obtaining more debt, although they (ii) are already debt-ridden

[3] Sources: General Directorate of Justice Policy (Quarterly Statistical Highlight, Bulletin No. 60) and IAPMEI (Informative Summary, December 2018).

[4] These sectors generally show marked differences in the characteristics of the firms, especially with regard to financing and production.

[5] The SCIE data do not distinguish whether exit corresponds to bankruptcy, voluntary closure or M&A. Nevertheless, previous evidence suggests that M&A are rare events in the Portuguese economy, whose rate does not exceed 1% of the total number of closures (Mata and Portugal, 2004).

(leverage above 50%) and (iii) have no potential to repay that debt (negative operating profits for three consecutive years). Schivardi et al. (2022) propose the use of the following "profitability" and "risk of default" criteria: (i) return-on-assets (measured as the three-year moving average of Earnings Before Interests, Taxes, Depreciations and Amortizations (EBITDA) over total assets) below the low-risk interest rate; and (ii) leverage above the median in the low return-on-assets exiting group.

In this paper, as in Carreira et al. (2022), a firm is considered as zombie, whenever: (i) its return-on-assets is lower than the low-risk interest rate for at least 3 consecutive years; (ii) its leverage is higher than the industry-median (at two-digit NACE level) of the low return-on-assets exiting group; and (iii) it is older than 5 years. The rationale is that firms that are already debt-ridden and have no potential to repay their debt are likely to be on the border of exit, unless their creditors tolerate their continuation. The three-consecutive year criterion ensures that we are looking at persistently unprofitable firms. The age criterion is placed to distinguish 'true' zombie firms from young, innovative start-ups (McGowan and Andrews, 2018). The 5-years age threshold is chosen because it is the age limit used by several studies to define young, high-growth firms (Decker et al., 2016).

The return-on-assets is defined as EBITDA over total assets. EBITDA is what is left to remunerate capital after paying labor and intermediates inputs. We compare return-on-assets to the average Euribor-12-months interest rate, the indexing interest rate used by Portuguese banking system. The leverage is defined as the ratio of the sum of debt in current liabilities and long-term debt to total assets. That is, we assume that the financial protection of zombie firms does not come only from banks forbearance, but also from all types of creditors, a key issue in the context of the Portuguese economy. To avoid potential misidentifications of zombie firms, we exclude one-shot zombie firms (i.e., one-off zombies) and include one-shot restructuring firms (i.e., zombies that become non-zombies in $t$+1 and zombies again in $t$+2).

Once zombies are flagged in the data, we proceed to create the variable *zombie spell*, which corresponds to their lifetime in the zombie status. Since the identification strategy requires three consecutive observations, our estimation sample covers the 2005–2016 interval. To illustrate, a mature firm that is classified as zombie in 2005 is required to show low profitability and high risk of default in 2004 *and* 2006. From the first year a zombie is identified, we count the time up to recovery or exit.

Finally, we also use the Schivardi et al. (2022) definition for robustness checks, although we include the additional 5-year age criterion.

### 4.3. Productivity and key variables

Total factor productivity (TFP) is our selected efficiency measure. For that purpose, we proceed to estimate a logarithmic Cobb–Douglas production function, for each industry (2-digit level), as follows:

$$\ln TFP_{i,t} = \ln Q_{i,t} - \alpha_K \ln K_{i,t} - \alpha_L \ln L_{i,t} - \alpha_M \ln M_{i,t}, \quad (1)$$

where $Q_{i,t}$ is real output of the firm $i$ in year $t$, and $K_{i,t}$, $L_{j,t}$ and $M_{i,t}$ denote capital, labor and materials, respectively; $\alpha_e$ is the associated elasticity for input $e$ ($e \in \{K, L, M\}$). For tests of reliability and robustness of our results, we also use labor productivity (LP) as an alternative measure of efficiency, defined as gross value added (GVA) per worker, where GVA is computed as the difference between gross output and materials.

Gross output corresponds to gross sales less the value of purchases of goods for resale, adjusted for changes in the inventory of final goods, self-consumption of own production and other operating revenues. Gross output and gross value added were deflated by industry deflators, at 2-digit level, obtained from the INE. Labor corresponds to the 12-month employment average. Materials were deflated by the GDP deflator index. Real capital is measured using a perpetual inventory method to the change in total real assets. In detail, for the first year of a firm, we deflate the book-value of total net assets by the GDP deflator index of that year, to derive the capital stock $K_t$. For successive years, if the assets rise, then the increase is deflated by GDP deflator index of the current year and added to $K_{t-1}$ to yield the corresponding $K_t$. If it declines, $K_t$ is reduced proportionately. Output and input variables are measured in constant 2011 Euro.

To control for endogeneity and sample selection bias in the TFP estimation, we apply the semi-parametric method proposed by Levinsohn and Petrin (2003), controlling for endogenous exit (Rovigatti et al., 2018).[6] It is important to highlight that since our measure of productivity is a revenue measure firm-level prices are embedded. Thus, the selected productivity measure reflects idiosyncratic both technical efficiency and demand shocks. Finally, in order to abstract from shocks at aggregate and industrial level, our measures of efficiency are relative to the average industry productivity in that period (2-digit level). Yet, for convenience we denote them as TFP or LP in the remainder of the study.

The firms' growth in terms of employment and capital are measured as the log difference in annual-employment and real-capital between two consecutive years. Other specific variables of interest are explained next. All variables are winsorized at the 1st and 99th percentiles in the regression analysis below.

[6] There are different methodologies in the literature to estimate TFP, although they all tend to generate similar results (Decker et al., 2020; Syverson, 2011).

### 4.4. Empirical strategy

*Treatment effect of reforms on zombie entrenchment*— Our empirical approach aims to investigate whether a given set of institutional changes is effective in reducing reallocation barriers, that is, whether the reforms have the ability to strengthen business dynamism and market selection through (i) a reduction in the zombie entrenchment, manifested in (ii) a greater recovery likelihood of financially distressed but viable firms and (iii) a higher exit probability of 'true' zombies. We also aim to examine (iv) the responsiveness of reallocation to productivity.

We begin by describing the characteristics of the zombie population. Next, we deploy a failure-time analysis and estimate the extended means of survival spells using the methodology proposed by Klein and Moeschberger (2003).[7] Subsequently, our econometric strategy seeks to assess whether institutional reforms are effective in reducing the probability that a zombie in "$t$" remains in the same status in "$t$+1" (i.e., the entrenchment likelihood). Considering that in well-functioning markets the Schumpeterian "creative destruction" compels zombies to recover or exit, we assume that the greater the zombie entrenchment, the higher the reallocation barriers. In our data, we can observe the zombies that operated under the insolvency framework before the 2012 reforms (typically a more creditor-oriented regime) and the zombies that operated under the new institutional environment (a more balanced regime between debtors and creditors). However, a pure difference between the odds of entrenchment between pre- and post-reforms zombies is likely to give us a biased assessment of the effect of institutional changes. For example, some characteristics of zombies, which influence the probability of entrenchment, might be expected to induce 'self-selection' in their 'participation' in the post-reforms period.

The investigation of the causal effects of reforms requires therefore some speculation on what would have been the entrenchment likelihood of a zombie in the absence of reforms. We use the standard model of potential/counterfactual outcomes to tackle this issue (Cameron and Trivedi, 2005; Rubin, 1994). Let us denote the insolvency framework faced by the zombies by the binary variable IR, with IR = 1 being the treatment level (the new insolvency environment) and IR = 0 the control level (the old regime). Additionally, let us denote our binary outcome variable as $Y_{i,t+1}$, which takes the value of one if the company leaves the zombie status in $t$+1 (i.e., recovers or exits the market) and zero otherwise (the situation of zombie entrenchment). In this setting we have then $Y_{1,i,t+1}$ if IR = 1 and $Y_{0,i,t+1}$ if IR = 0, that is:

$$Y_{i,t+1} = (1 - IR)\, Y_{0,i,t+1} + IR\left(Y_{1,i,t+1}\right). \tag{2}$$

In addition, let us suppose that the probability that our outcome variable $Y_{i,t+1}$ takes the value of one is a function of observed zombie characteristics, and time-specific observed factors, so that:

$$E\left[Y_{i,t+1}\right] = P\left[Y_{i,t+1} = 1|\mathbf{D_{i,t}}\right] = F\left(\mathbf{D'_{i,t}B}\right), \tag{3}$$

where $\mathbf{D_{i,t}}$ is the matrix of predictors containing TFP (measured as deviation from the industry mean), capital, labor (employment), leverage, EBITDA (taken as a cash-flow proxy), and firm age (all variables in logs), as well as a business cycle measure (the annual growth rate of GDP in each region—NUTS II) and industry and location dummies. The inclusion of a cyclical variable in the matrix $\mathbf{D_{i,t}}$ plays a key role in our setting. Given that the treatment variable depends on the treatment period (after 2012), we expect that after controlling for the business cycle the IR variable will capture the effect of the institutional changes implemented by the ECB and the Portuguese authorities.

Finally, assuming conditional mean independence (i.e., $E\left[Y_{1,i,t+1}|\mathbf{D_{i,t}},\ IR\right] = E\left[Y_{1,i,t+1}|\mathbf{D_{i,t}}\right]$ and $E\left[Y_{0,i,t+1}|\mathbf{D_{i,t}},\ IR\right] = E\left[Y_{0,i,t+1}|\mathbf{D_{i,t}}\right]$) and common support (i.e., $0 < P\left[IR = 1|\mathbf{D_{i,t}}\right] < 1$), the average treatment effect (ATE) and the average treatment effect on the treated (ATET) are given by:

$$ATE = E\left[Y_{1,i,t+1}|\mathbf{D_{i,t}}\right] - E\left[Y_{0,i,t+1}|\mathbf{D_{i,t}}\right], \tag{4}$$

$$\text{ATET} = E\left[Y_{1,i,t+1}|\mathbf{D_{i,t}}, IR = 1\right] - E\left[Y_{0,i,t+1}|\mathbf{D_{i,t}}, IR = 1\right]. \tag{5}$$

To obtain the average treatment effect and the average treatment effect on the treated, we apply the 'regression adjustment' and 'nearest-neighbor matching' methods. This procedure enables us to obtain the treatment effects without assuming any specific functional form for the treatment assignment process.

The 'regression adjustment' estimator executes separate regressions for each treatment level and uses averages of expected outcomes for the whole sample to estimate potential outcome means (Cameron and Trivedi, 2005). Specifically, we use a linear probability model and a logistic regression to predict our outcome variable. In the case of 'nearest-neighbor matching' estimator, a key aspect is to find for each unit $i$, and for each treatment level, the nearest counterfactual unit $i$. The *similarity* is computed by the Mahalanobis distance metric, which weights the differences by the inverse sample covariate covariance (Rubin, 1980). Moreover, since our matrix of predictors for the outcome variable contains several continuous covariates, we employ Abadie and Imbens (2011) approach to correct the resulting large-sample bias. Finally,

[7] The failure event corresponds to recovering or exiting the market, and the survival time to the *entrenchment time* (i.e., the life duration as zombie). Since the largest observed analysis time is censored, we estimate the extended means of survival spells, which are computed by extending the Kaplan–Meier product-limit survival function to zero (Klein and Moeschberger, 2003). Firms that are flagged as zombies more than once are considered different subjects (only 6.6% of the total zombies during 2005–2016).

we impose exact matching on industry affiliation and location. We apply this procedure with one and two matches for each observed zombie.

To ensure that the treatment assignment is not correlated with the covariates that influence the outcome variable (the likelihood of exiting the zombie status, in our case), we have to make sure that the predictors' distributions do not vary across treatment levels. Table A.1 of the Appendix section shows the predictors' standardized differences and variance ratios before and after matching (with one and two matches). The results reveal that after the matching process the observations of the treated and counterfactual groups are much more balanced, as the matched standardized differences of all covariates are close to zero and the variance ratios close to one.

*Transitions and within-zombie selection*—We investigate the determinants of zombie transition with a twofold objective. First, analyze whether the reforms efficiently strengthen the within-zombie selection (boosting both the recovery of the most productive and the exit of the least productive). Second, to examine whether zombie entrenchment changes occur due to changes in the likelihood of recovery, exit, or both. For this purpose, we apply a multinomial logistic model in which the base category is defined as remaining as a zombie, coded as 1. In contrast, recovery is coded as 2, and exit is coded as 3. Then, assuming independent and identically distributed error terms, the model is specified as follows ($j = 1$, 2, 3):

$$\Pr\left(Y_{i,t+1} = j\right) = \frac{\exp\left\{c_j + \psi_{0j} * IR_t + \mathbf{K}_{\mathbf{i,t}}^{'}\mathbf{\Phi_j} + \left[\mathbf{K}_{\mathbf{i,t}}^{'}\mathbf{\Psi_j}\right] * IR_t + \mathbf{W}_{\mathbf{i,t}}^{'}\mathbf{Z_j}\right\}}{\sum_{l=1}^{3}\exp\left\{c_l + \psi_{0l} * IR_t + \mathbf{K}_{\mathbf{i,t}}^{'}\mathbf{\Phi_l} + \left[\mathbf{K}_{\mathbf{i,t}}^{'}\mathbf{\Psi_l}\right] * IR_t + \mathbf{W}_{\mathbf{i,t}}^{'}\mathbf{Z_l}\right\}}, \tag{6}$$

where $\mathbf{K_{i,t}}$ contains our key explanatory variables TFP (or LP), capital, labor, and leverage (all in logs), while $\mathbf{W_{i,t}}$ includes the control variables EBITDA and firm age (also in logs), business cycle, and industry- and location-dummies. The Zombie spell variable is also considered as an additional regressor. The explanatory variables are lagged one period to avoid endogeneity generated by simultaneity bias (Fukuda and Nakamura, 2011; Carreira et al., 2022). We include the variable *IR* as an additional regressor in this setting. So, $IR = 1$ for the zombies under the new insolvency framework (during 2013–2016) and $IR = 0$ for the zombies under the previous regime (during 2005–2012). We are, in particular, interested in analyzing the changes in the probabilities of transition, or non-transition, in the post-reforms period, as well as the effect of the reforms on the relationship between a given set of covariates (e.g. productivity, capital, labor, and leverage) and those probabilities, using the corresponding interaction terms.

We interpret the effects of the key explanatory variables on each transition likelihood, and the interaction effects in this nonlinear model context, based on the computation of average marginal effects (AME) (Karaca-Mandic et al., 2012). Since we have three transition categories, we also have three marginal effects for each regressor. As is well-known, the marginal effects of each regressor add up to zero because probabilities add up to one (Cameron and Trivedi, 2010). This property conveniently allows us to examine which effect prevails. The AME of a one-unit change in $\kappa_k$ on the probability that the destination j is the outcome in t+1 is given by:

$$AME_{j\kappa_k\tau} = \frac{\partial \Pr(Y = j)}{\partial \kappa_k} = \frac{\partial p_j}{\partial \kappa_k}, \tag{7}$$

where the subscript $\tau$ denotes the period, with $\tau = 0$, 1, 2 indicating the ex-ante and ex-post reforms periods and the entire sample period, respectively. $\kappa$ represents the key explanatory variables included in $\mathbf{K}$ by order, with $k = 1, \ldots, 4$.

While the marginal effects for the entire interval allow analyzing the relationship between $\kappa_k$ and the probability $p_j$, the pairwise comparison of marginal effects 'before' and 'after' permits studying the effects of the reforms on these relationships—i.e., the interaction effects (Karaca-Mandic et al., 2012). For instance, if $AME_{j\kappa_k 1}$ and $AME_{j\kappa_k 0}$ have the same sign, but the former is larger than the latter, the corresponding relationship is strengthened in the post-reforms period.

It is expected that the more productive zombies have a greater probability of recovery, while the less productive ones have a greater exit probability. Moreover, one would expect the reforms implemented to strengthen this selection. Therefore, we expect $AME_{2\kappa_1 1} > AME_{2\kappa_1 0} > 0$ and $AME_{3\kappa_1 1} < AME_{3\kappa_1 0} < 0$. If $AME_{2\kappa_1 1} - AME_{2\kappa_1 0}$ is negative, it would imply that the reforms make the recovery event less likely despite an increase in productivity, which in turn would mean that the reforms impose greater barriers to the restructuring of viable companies. On the other hand, if $AME_{3\kappa_1 1} - AME_{3\kappa_1 0}$ is positive, we have that in the post-reforms period an increase in productivity is associated with a higher probability of exit, which implies that relatively more productive firms would have been inefficiently liquidated.

As discussed in the literature review, the effect of firm size is ambiguous. Due to a typical complex ownership and debt structures of large firms, a negative relationship between size and the probability of both recovery and exit may be expected, vis-à-vis continuing as a zombie. Moreover, regarding the exit probability, since smaller companies are more likely to be liquidated due to a greater share of concentrated and secured debt, the negative relationship between size and exit probability is reinforced. However, since larger firms often command more resources and have a greater managerial ability, one could expect that these firms have a higher likelihood of recovery and a lower risk of exit. On the other hand, considering that the reforms were designed to facilitate reorganization agreements, they are expected somehow to reverse the effect of size on both events. Thus, we expect $AME_{2\kappa_{2,3}1} > AME_{2\kappa_{2,3}0}$ and $AME_{3\kappa_{2,3}1} > AME_{3\kappa_{2,3}0}$.

Financially distressed firms are less likely to recover and have a greater exit risk. We thus expect that leverage has a negative (positive) effect on the recovery (exit) probability. Nonetheless, if the incentive for the injection of new financing for the reorganization of viable businesses is effective, this should result in healthier leverage ratios that increase the

chances of recovery. Therefore, we expect $AME_{2\kappa_4 1} - AME_{2\kappa_4 0}$ to be positive, thus diminishing the negative effect of leverage on recovery. So, we have that debt has to be reduced faster than assets or, scilicet, assets have to grow faster than debt. Otherwise, the new financing (or debt restructuring) would worsen the firm financial conditions rather than improve them. Concerning the exit probability, the lower banking forbearance should further reduce the survival chances of zombies with high levels of leverage. Hence, we expect a positive sign in $AME_{3\kappa_4 1} - AME_{3\kappa_4 0}$. Finally, since the reforms aim to facilitate the recovery of financially distressed but viable firms and the exit of unviable ones, we expect the difference in expected probabilities 'before' and 'after' to be positive in both cases.

*Effect on responsiveness*—The ultimate goal of reducing zombie prevalence is to strengthen business dynamism and market selection in the entire economy. Therefore, we proceed to evaluate whether there is a statistically significant change in the negative effect that zombie incidence has on productivity-enhancing reallocation and, by this channel, aggregate efficiency growth.

We use a standard model of firm dynamics in which, conditional on the initial state faced by the firm, more productive firms grow faster (Cooper et al., 2015; Decker et al., 2020). Nevertheless, as Decker et al. (2020) emphasized, if frictions affect the firm's cost function – such as market congestion created by zombies – the responsiveness in that relationship is weaker. Thus, we evaluate the distortion caused by zombies, so as the reforms' effect on the level of distortion, as follows:

$$Y_{i,s,t+1} = c + \beta TFP^{r}_{i,s,t} + \alpha_1 ZE_{s,t} + \alpha_2 \left(TFP^{r}_{i,s,t} * ZE_{s,t}\right) + \left[\lambda_1 ZE_{s,t} + \lambda_2 \left(TFP^{r}_{i,s,t} * ZE_{s,t}\right)\right] * IR_t + \mathbf{X}'_{i,s,t}\boldsymbol{\Theta}_{\mathbf{D}} + \mu_i + \varepsilon_{i,s,t+1}, \quad (8)$$

where the subscripts $i$ and $s$ denote firm and sector (2-digit level), respectively; $\mu_i$ represents the time-invariant idiosyncratic characteristics of the firm, and it is assumed to be correlated with the matrix of covariates. Our dependent variables are employment growth and capital growth, in separate runs. The TFP is the log deviation from the industry mean. **X** is the matrix of control variables and includes initial size (log of employment), business cycle, and industry- and location-dummies. When the dependent variable is capital growth, initial capital is added as a control. Since the sample comprises all the firms in this case (and not only zombies), we do not include the IR variable as a direct regressor. Year dummies are therefore included in ***X***. To avoid that our responsiveness estimates are contaminated by the cycle effects on selection (such as the cleansing-effect of recessions), we also include in **X** an interaction between TFP and the business cycle variable. Our key variable, ZE, denotes (industrial) zombie entrenchment. Unlike other studies in which zombie prevalence is measured as the percentage of industry resources in zombie firms (e.g., Caballero et al., 2008; McGowan and Andrews, 2018), our approach measures not only the sunk resources but also the average time that these resources are trapped in these firms as follows:

$$ZE_{s,t} = \sum_{z=1}^{n} \left( \frac{resource_{z,s,t}}{total\ industry\ resource_{s,t}} \right) \times Zombie\ spell_{z,s,t}, \quad (9)$$

where the subscript $z$ denotes zombies. Although it is expected that a higher share of sunk resources is directly related to a higher level of entrenchment, this approach is likely to capture the pervasiveness of barriers to exit or restructuring in each period and their effect on market selection. Yet, we also use the variable ZE measured as the share of industry resources sunk in zombies as a robustness check.

The effect of zombie entrenchment on the responsiveness of firm growth to productivity is given by the cross derivative $\frac{\partial^2 Y}{\partial TFP \partial ZE} = \alpha_2 + \lambda_2 * IR$. We, therefore, expect a negative sign in $\alpha_2$, which implies that the greater the zombie-entrenchment, the lower the responsiveness. On the other hand, if the reforms effectively reduce the reallocation barriers, we expect $\lambda_2$ to be positive; that is, the distortion created by zombies is expected to be lower during the post-reforms period.

Finally, in the spirit of Decker et al. (2020), we graphically illustrate the implications of the reforms by calculating the effect of zombie entrenchment on the growth differential between a productive firm – a firm with TFP one standard deviation above its industry mean – and the average firm, before and after the reforms. The results of these estimates are then compared with the within-industry productivity dispersion so that it is possible to interpret whether the changes in responsiveness have to do with a change in the dispersion of shocks faced by firms or a change in firm responses to shocks.

## 5. Results

### 5.1. Preliminary analysis

Table 1 shows the main economic and financial indicators of zombies, versus non-zombies, for the entire period and before, during, and after the Portuguese crisis. Notice that the average zombie is less productive, smaller (w.r.t. production and inputs), with less liquidity, and relatively more indebted than its non-zombie counterpart. Indeed, in terms of financial health, approximately 80% of zombies have negative equity (i.e., the liabilities are greater than the assets), indicating that most of them were on the verge of insolvency.

In Fig. 1, the largest share of zombies in the total number of firms is observed in 2012, possibly due to greater forbearance during the financial crisis. Note, however, that the share of labor and capital sunk in zombies was maximum in 2006 and 2007, respectively, and that by 2016 the zombie share (either weighted or unweighted) was substantially reduced.

**Table 1**
Descriptive statistics of Zombie and Non-Zombie firms.

| Variable | Full period (2005–2016) | | Pre-crisis | Crisis | Post-crisis |
|---|---|---|---|---|---|
| | Mean | Std. Dev. | Mean | Mean | Mean |
| A. Non-zombies | | | | | |
| TFP | 0.04 | 0.46 | 0.07 | 0.01 | 0.06 |
| Labor productivity | 0.99 | 0.85 | 1.05 | 0.96 | 0.99 |
| Output | 634.44 | 1726.30 | 671.88 | 621.32 | 622.26 |
| Capital | 1196.43 | 3352.85 | 1161.82 | 1223.22 | 1177.60 |
| Number of employees | 10.99 | 19.42 | 11.53 | 10.88 | 10.64 |
| Age | 12.81 | 10.49 | 10.54 | 12.90 | 14.98 |
| EBITDA | 70.64 | 219.45 | 76.90 | 66.48 | 72.65 |
| Leverage ratio | 0.81 | 0.85 | 0.77 | 0.81 | 0.85 |
| Percentage of firms with negative equity | 13.42% | | 10.83% | 13.59% | 15.75% |
| B. Zombies | | | | | |
| TFP | −0.36 | 0.67 | −0.29 | −0.39 | −0.38 |
| Labor productivity | 0.32 | 0.60 | 0.44 | 0.30 | 0.22 |
| Output | 254.40 | 1013.75 | 373.77 | 240.50 | 158.77 |
| Capital | 846.72 | 2869.86 | 1083.24 | 846.47 | 593.83 |
| Number of employees | 6.86 | 13.32 | 8.15 | 6.83 | 5.53 |
| Age | 13.91 | 8.78 | 9.89 | 14.05 | 17.88 |
| EBITDA | −26.54 | 77.84 | −15.94 | −29.79 | −30.38 |
| Leverage ratio | 2.30 | 2.18 | 1.82 | 2.19 | 3.05 |
| Percentage of firms with negative equity | 79.48% | | 70.85% | 79.60% | 88.44% |

*Notes:* Total factor productivity (TFP) and labor productivity are the deviations from the industry-year mean. The real output is the sales of good and services, adjusted for changes in inventory of final goods, self-consumption of own production and other operating revenues, deflated by industry-deflators (2-digit CAE). Real capital is measured using a perpetual inventory method to the change in total real assets. EBITDA denotes the earnings before interests, taxes, depreciation and amortization. The leverage is defined as the ratio of the sum of debt in current liabilities and long-term debt to total assets. A firm is flagged with negative equity when total debt is greater than total assets. Monetary values are in $10^3$ Euros. All variables were winsorized at the 1st and 99th percentiles. Pre-crisis, Crisis, Post-crisis correspond to 2005–2007, 2008–2013, and 2014–2016, respectively.

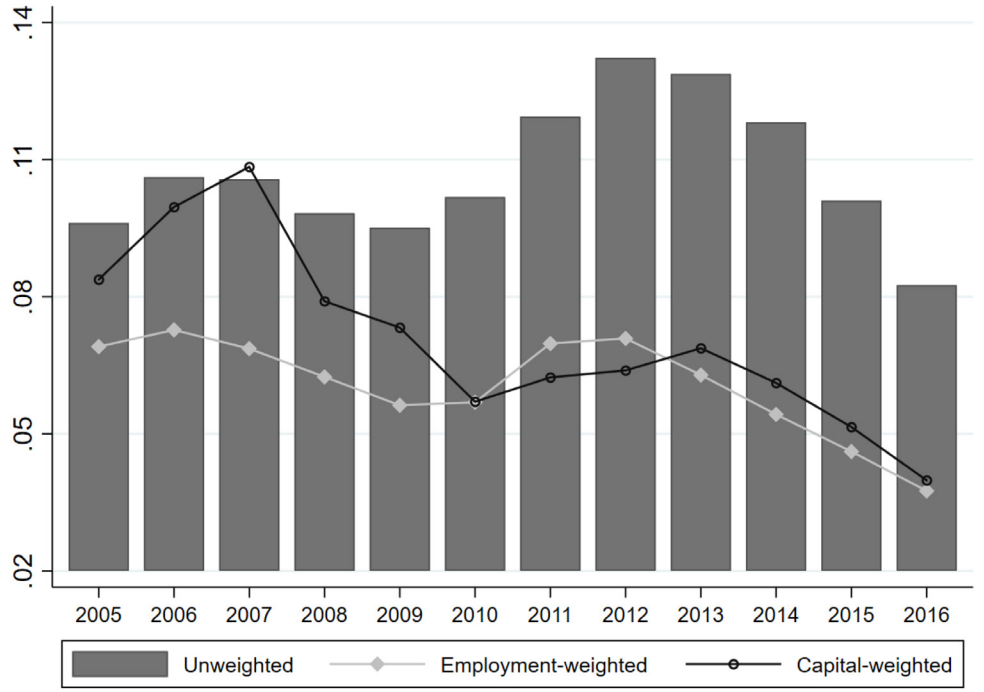


**Fig. 1.** The share of zombie firms, 2005–2016.
Notes: Zombies are defined as firms older than 5 years with a return-on-assets below the low-risk interest rate over three consecutive years and a leverage ratio is higher than the industry median of the low return-on-the-assets exiting group (the default). Capital and employment refer to the share pertaining to zombie firms.

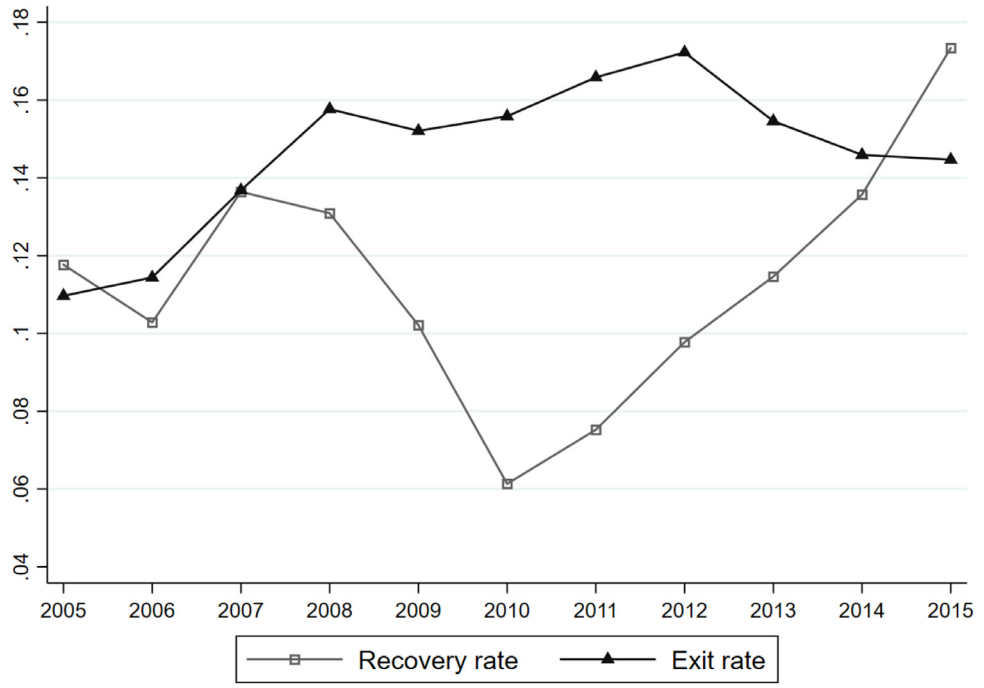


**Fig. 2.** Recovery and exit rates of zombie firms, 2005–2015.
Notes: The unweighted-recovery (exit) rate of zombies is defined as the ratio of zombies that recover (exit) in $t$+1 to the total number of zombie firms in $t$.

**Table 2**
Recovery and exit rate of Zombie Firms by sector and period (In percentage).

| Sector | Recovery rate | | | Exit rate | | |
|---|---|---|---|---|---|---|
| | Pre-crisis | Crisis | Post-crisis | Pre-crisis | Crisis | Post-crisis |
| Manufacturing | 10.0 | 9.7 | 16.0 | 14.8 | 17.5 | 15.4 |
| Construction | 14.6 | 10.9 | 18.2 | 12.2 | 20.5 | 18.7 |
| Trade | 10.5 | 9.3 | 14.3 | 11.9 | 16.0 | 15.1 |
| Accommodation | 11.9 | 6.3 | 14.3 | 10.1 | 10.9 | 10.9 |
| Real estate | 14.7 | 13.2 | 19.3 | 7.9 | 14.2 | 13.0 |
| Business services | 14.7 | 13.9 | 15.8 | 10.9 | 15.3 | 16.5 |

*Notes:* The reported values denote the unweighted-recovery (exit) rate of zombies which is defined as the ratio of zombies that recover (exit) in $t$+1 to the total number of zombie firms in $t$. Pre-crisis, Crisis, Post-crisis correspond to 2005–2007, 2008–2013, and 2014–2016, respectively.

The evolution of the recovery and exit rates of zombie firms is shown in Fig. 2. The recovery (exit) rate corresponds to the ratio of the total number of firms that were zombies in "t" and recovered (exited) in "t+1" to the total number of zombies in "t". First, the recovery and exit rates are relatively low throughout the selected interval, which means the "remain as a zombie" rate is quite high. Second, the exit rate increased to maximum values, around 16% during the crisis, with a peak of 17% in 2012, while the recovery rate dropped dramatically. These two aspects, plus the possible fall of new zombies, explain the observed rise in the share of zombie firms during the crisis. Third, there is a growing and sustained trend in the recovery rate after 2010, with a slight decrease in the exit rate after 2012.

Table 2 presents the recovery and exit rates of zombie firms at the sector level. The previous values are broadly confirmed: on average, in all sectors, the recovery rate decreased, and the exit rate increased during the crisis. Furthermore, the recovery rate in the post-crisis period is higher than that of the crisis and the pre-crisis. Regarding the exit rate, although this rate is higher in the post-crisis than in the pre-crisis, it is still lower than that of the crisis period (except in the *Business Services* sector). In any case, the survival rate (i.e., remain as a zombie) in the post-crisis period is lower than that in the two previous sub-periods.

Table 3 shows the distribution of employment-zombie and capital-zombie by size category. First, although large firms represent, on average, only 0.2% of the total of zombies, the share of employment and capital sunk in this size group is on average 14% and 10%, respectively, over the entire period. Second, by comparing the pre-crisis and post-crisis periods, the

**Table 3**
Resources sunk in the Zombie population by size and period (In percentage).

| Size-category | All years (1) | Pre-crisis (2) | Crisis (3) | Post-crisis (4) | Relative change (%): Pre- to Post-crisis (5) = [(4)/(2)] |
|---|---|---|---|---|---|
| A. Share of employment sunk | | | | | |
| Micro | 40.38 | 34.35 | 40.02 | 47.14 | 37.22 |
| Small | 27.99 | 30.76 | 28.44 | 24.30 | −21.00 |
| Medium | 18.12 | 17.44 | 19.20 | 16.64 | −4.56 |
| Large | 13.51 | 17.45 | 12.34 | 11.92 | −31.70 |
| B. Share of capital sunk | | | | | |
| Micro | 46.49 | 47.07 | 47.27 | 44.38 | −5.72 |
| Small | 26.56 | 31.92 | 24.97 | 24.39 | −23.57 |
| Medium | 16.60 | 15.16 | 16.84 | 17.56 | 15.80 |
| Large | 10.34 | 5.85 | 10.93 | 13.67 | 133.63 |

*Notes:* The table shows the distribution of labor and capital sunk in zombie firms by size category in different economic periods. The size categories are defined according to the European Union classification. Pre-crisis, Crisis, Post-crisis correspond to 2005–2007, 2008–2013, and 2014–2016, respectively.

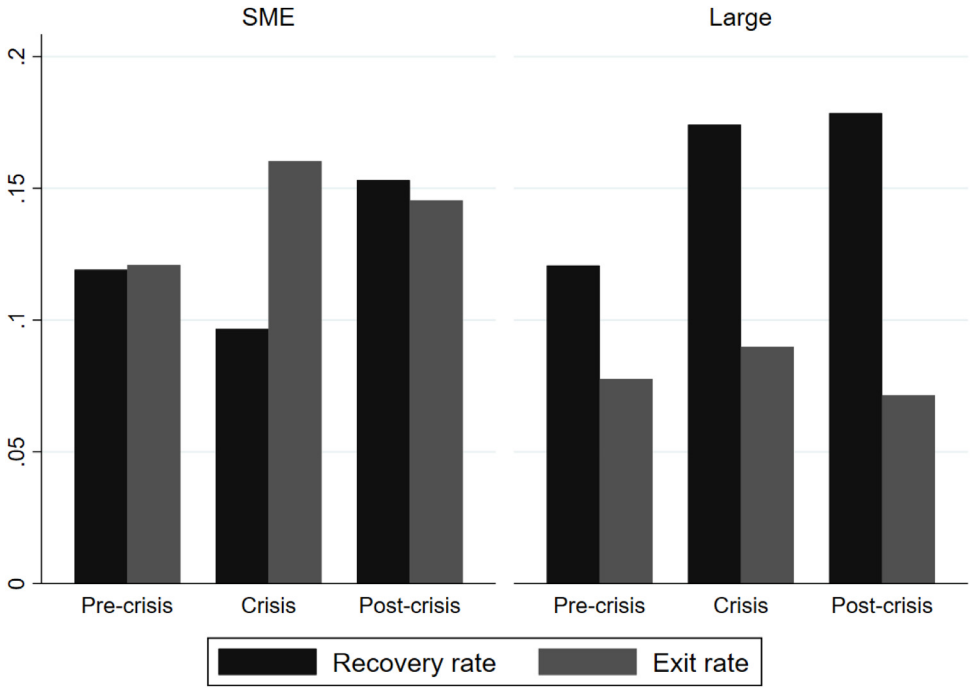


**Fig. 3.** Recovery and exit rates by size and period.
Notes: The size categories are defined according to the European Union classification. Pre-crisis, Crisis, and Post-crisis correspond to 2005–2007, 2008–2013 and 2014–2016, respectively.

nature of the evolution of the zombie incidence was not homogeneous in terms of the resources sunk by size. Specifically, while the rate of reduction of zombie employment is lower in the case of micro-businesses, the rate of reduction of zombie capital is lower in medium and large firms. Therefore, in the post-crisis period, we have an increase of the relative share of micro firms and medium and large firms in the case of zombie-employment and zombie-capital, respectively.

The recovery and exit rates by size are presented in Fig. 3. Three main results are in order: (i) SMEs have higher (lower) exit (recovery) likelihood than their large counterparts; (ii) in the crisis period, while the recovery rate of SMEs is reduced, it increases for large firms; and (iii) both small and large firms have increased their chances of recovery after the crisis. Therefore, it is clear that firm size plays a key role in restructuring versus liquidation in financially distressed businesses and, consequently, in the zombie incidence.

We report the extended means of survival spells in Table 4. Firstly, zombies require approximately three years and eight months to recover or exit the market (Column 1). Secondly, the results indicate that reallocation barriers were reduced, as the survival time of zombies in the post-crisis period is shorter than those of the two previous intervals, both

**Table 4**
Estimated survival time of Zombies.

| | Full period (1) | Pre-crisis (2) | Crisis (3) | Post-crisis (4) | Relative change (%): Post- to Pre-crisis (5) = [(4)/(2)] | Relative change (%): Post-crisis and Crisis (6) = [(4)/(3)] |
|---|---|---|---|---|---|---|
| Entire economy | 3.62 | 3.68 | 3.87 | 2.91 | −21% | −25% |
| A. By industry | | | | | | |
| Manufacturing | 3.63 | 3.56 | 3.72 | 3.33 | −7% | −11% |
| Construction | 3.20 | 3.22 | 3.24 | 2.95 | −8% | −9% |
| Trade | 3.92 | 3.97 | 3.94 | 3.52 | −11% | −11% |
| Accommodation | 4.87 | 4.17 | 5.53 | 4.19 | 1% | −24% |
| Real estate | 3.65 | 3.81 | 3.66 | 3.32 | −13% | −9% |
| Business services | 3.39 | 3.43 | 3.40 | 3.20 | −7% | −6% |
| B. By size | | | | | | |
| SMEs | 3.79 | 3.68 | 3.87 | 3.51 | −4% | −9% |
| Micro | 3.80 | 3.71 | 3.87 | 3.54 | −5% | −8% |
| Small | 3.61 | 3.53 | 3.80 | 3.17 | −10% | −17% |
| Medium | 3.92 | 3.36 | 4.13 | 3.82 | 14% | −7% |
| Large | 3.57 | 4.13 | 3.38 | 3.79 | −8% | 12% |

*Notes:* The reported values denote extended means of zombie spell (in years), using the method of Klein and Moeschberger (2003), which is computed by extending the Kaplan–Meier product-limit survival curve to zero. The size categories are defined according to the European Union classification.

at the aggregate level and in all sectors.[8] Thirdly, the results unexpectedly show that the average zombie spell over the entire period is roughly three months longer for SMEs than for large firms. Yet, this difference seems to be explained by a substantial reduction in the zombie spell for large firms and an increase in the spell for SMEs during the crisis period. In the other two sub-periods, we observe that large firms have, on average, a longer survival time. Fourthly, the zombie spell is also shorter in the post-crisis than in the pre-crisis for both SMEs and large firms. Finally, as shown in Fig. 4, preliminary evidence suggests that zombies under the new institutional setting experienced a lower probability of entrenchment than their counterparts from the previous regime. Conditional on the business cycle, the survival function of the former is below that of the latter.[9] For instance, while a company that has been three years in zombie status under the old regime has an entrenchment likelihood of approximately 56%, its post-reform counterpart has an entrenchment chance of 49%.

### 5.2. Treatment effect estimators and multinomial regression

Table 5 presents the estimations of the average treatment effect (ATE) and the average treatment effect on the treated (ATET) of the reforms on the probability of exiting the zombie status (via recovery/exit). We observe that the treatment effects are highly significant, showing that zombies *treated* by the new institutional framework (insolvency regime and prudential banking supervision) exhibited a greater likelihood of leaving the zombie status than their counterfactual zombies (under the old framework). In other words, the *treatment* reduced the chances of entrenchment. For instance, in the case of the 'nearest-neighbor matching' (NNM) estimator of one match, the results suggest that the reforms increased the likelihood of exiting the zombie status, on the treated zombies, by 10.2 percentage points. Therefore, these results indicate that the new institutional setting promoted by the European and Portuguese authorities had a *causal* effect in reducing the zombie entrenchment, thus decreasing the reallocation barriers that facilitate the survival of these otherwise insolvent firms.

While institutional reforms have proven effective in reducing zombie survival, it remains to be seen whether the lower entrenchment was due to a higher probability of recovery, exit, or both. Since the main aim of the institutional changes was to foster reorganization over liquidation (as opposed to the previous regime), recovery is expected to have been the favored route. However, a key element is the regime's efficiency. The designed mechanisms must ensure a screening process that reduces information asymmetries and perverse incentives so that the most productive zombies recover with the greatest ease. Furthermore, in the case of the exit transition, the implemented reforms are expected to prevent viable companies from being inefficiently liquidated and facilitate the liquidation of the 'true' zombies. The multinomial analysis allows examining these aspects.

Table 6 shows the main post-estimation results obtained from the multinomial regression model. In particular, the expected probabilities for each transition, the average marginal effects (AMEs), and the interaction effects—i.e., the

[8] Except for *Accommodation and Food Services*, where there was a slight increase of 1% in the survival time in the post-crisis period in comparison with the pre-crisis period.

[9] We apply the semi-parametric Cox Proportional Hazard model to estimate the conditional survival function. We have two regressors: a categorical variable containing each zombie group and the business cycle measure. We thus control for the cycle and baseline hazard function "$h_0(t)$". To deal with 'tied failures,' derived from annual information, we use the method proposed by Breslow (Cleves et al., 2010).

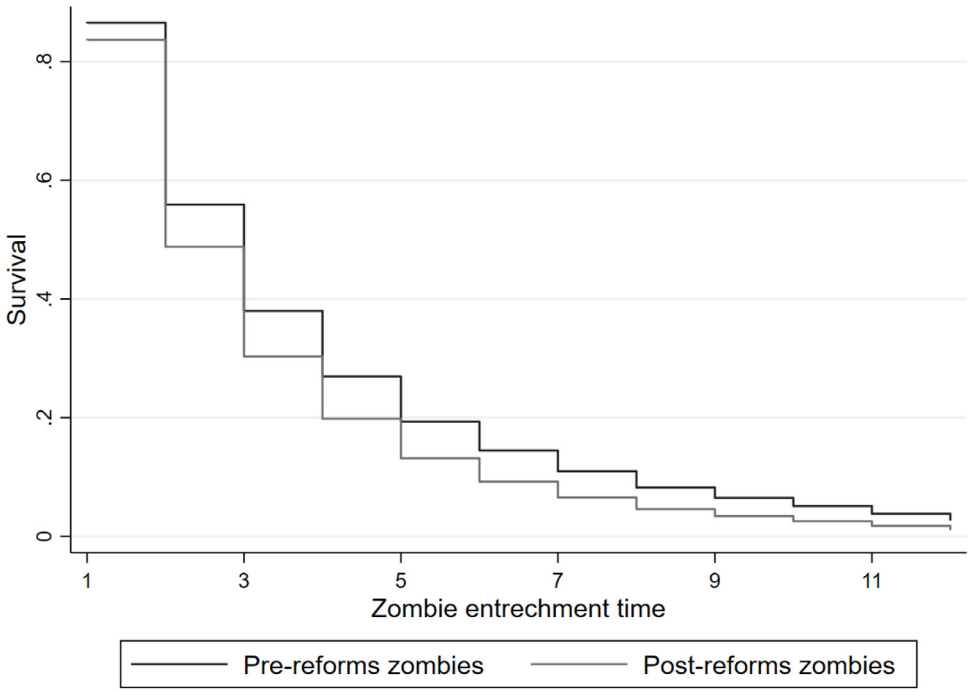


**Fig. 4.** Conditional survival function of zombies before and after the reforms.
Notes: The graph shows the estimated survival function of zombies, before and after the reforms, conditional on the business cycle. The survival function reports the probability of surviving (as zombie, in this case) beyond *t*.

**Table 5**
Average treatment effect (ATE) and average treatment effect on the treated (ATET) of the reforms on the probability of exit from the Zombie status.

| Effect | Regression adjustment (RA) | | Nearest neighbor matching (NNM) | |
|---|---|---|---|---|
| | LPM | Logit | 1 match | 2 matches |
| ATE | 0.0680*** | 0.0730*** | 0.0668*** | 0.0656*** |
| | (0.0026) | (0.0025) | (0.0036) | (0.0033) |
| ATET | 0.0636*** | 0.0667*** | 0.1021*** | 0.1009*** |
| | (0.0026) | (0.0027) | (0.0036) | (0.0032) |
| Observations | 198,104 | 198,104 | 198,104 | 198,104 |

*Notes:* The binary outcome variable takes the value of 1 if the company leaves the zombie status in $t + 1$ (i.e., recovers or exits the market) and 0 otherwise (i.e. zombie entrenchment). The covariates for the outcome variable contain TFP (as deviation from the industry mean), capital, labor (employment), leverage, EBITDA (as a cash-flow proxy), and firm age (all in logs), as well as a business cycle measure (the annual growth rate of GDP in each region—NUTS II) and industry and location dummies. In the NNM case, the similarity is computed by the Mahalanobis distance metric. The Abadie and Imbens' (2011) approach is used to correct the large sample bias. It was imposed exact matching on industry affiliation and location. The covariates were winsorized at the 1st and 99th percentiles. Robust standard errors are given in parenthesis.
*** Significant at the 1 percent level.
** Significant at the 5 percent level.
* Significant at the 10 percent level.

(average) differences between pre- and post-reforms. First, the model's predictions for the entire sample period show that the probability of remaining as a zombie is approximately 73%, which is about 5 to 6 times larger than in the other two alternative transitions (i.e., recovery and exit). Yet, in line with the treatment effect model, estimations show that the entrenchment of a typical zombie decreases after the reforms. The "remain as a zombie" probability is 75.02% for zombies under the old regime ($IR = 0$), whereas it is 66.94% for zombies under the new framework ($IR = 1$). That is, a decrease of 8.08 percentage points. It is worth noting that the reduction in the entrenchment likelihood is mainly explained by an increase of 6.12 percentage points in the recovery probability. In comparison, the increase in the exit likelihood is 1.96 percentage points.

**Table 6**
Expected probabilities, average marginal effects and differences between pre- and post-reforms periods, multinomial logistic regression.

| Covariate | Transition | 2005–2016 (1) | IR = 0 (2) | IR = 1 (3) | Pairwise comparison (Post minus Pre-reforms) (4) |
|---|---|---|---|---|---|
| A. Expected probabilities: $Pr(Y_{i,t+1} = j)$ | | | | | |
| | Remain as zombie | 0.7276*** | 0.7502*** | 0.6694*** | −0.0808*** |
| | Recovery | 0.1268*** | 0.1064*** | 0.1676*** | 0.0612*** |
| | Exit | 0.1456*** | 0.1434*** | 0.1630*** | 0.0196*** |
| B. Average marginal effects (AMEs): $\partial p_j/\partial \kappa_k$ | | | | | |
| | Remain as zombie | 0.0187*** | 0.0323*** | −0.0051* | −0.0374*** |
| TFP | Recovery | 0.0506*** | 0.0420*** | 0.0691*** | 0.0271*** |
| | Exit | −0.0693*** | −0.0743*** | −0.0641*** | 0.0103*** |
| | Remain as zombie | 0.0135*** | 0.0131*** | 0.0108*** | −0.0022 |
| Capital | Recovery | 0.0024*** | 0.0054*** | −0.0023* | −0.0077*** |
| | Exit | −0.0159*** | −0.0185*** | −0.0086*** | 0.0099*** |
| | Remain as zombie | 0.0096*** | 0.0080*** | 0.0055** | −0.0025 |
| Labor | Recovery | 0.0067*** | 0.0043*** | 0.0189*** | 0.0146*** |
| | Exit | −0.0163*** | −0.0123*** | −0.0244*** | −0.0121*** |
| | Remain as zombie | −0.0148*** | −0.0303*** | 0.0133*** | 0.0436*** |
| Leverage | Recovery | −0.0402*** | −0.0296*** | −0.0671*** | −0.0375*** |
| | Exit | 0.0550*** | 0.0599*** | 0.0538*** | −0.0061** |

*Notes:* TFP, Capital, Labor and Leverage are in logs. IR is a dummy for the post-reforms zombies. The pairwise comparison between marginal effects express the interaction effect, that is, the difference in effects between the "zombies after the reforms" and the "zombies before the reforms". Unreported are estimates of control variables including log of EBITDA, log of age, log of zombie duration, business cycle, industry- and location-dummies.
*** Significant at the 1 percent level.
** Significant at the 5 percent level.
* Significant at the 10 percent level.

Second, as expected, the more (less) productive the zombies are, the more likely is the recovery (exit), vis-à-vis remaining as a zombie. Moreover, as shown in Column (4) of Table 6 (pairwise comparisons), the difference in marginal effects of TFP upon conditional recovery likelihood – before and after – is positive (at 2.71 percentage points) and highly statistically significant, which means that the more productive zombies are even more likely to recover after the reforms. In the case of exit, contrary to the hypothesized, the difference in AMEs is significantly positive. Indeed, although a one-unit change in TFP is still associated with a decrease in exit probability of 6.41% in the post-reforms period, this decrease is less than the corresponding of the pre-reforms period, at 7.43%. Since the base category is non-transition, the pairwise comparison results show that the less productive zombies become 1.03 percentage points less (more) likely to exit (remain as a zombie). Thus, the estimates indicate that the within-zombie selection at the exit margin has weakened—or that potentially viable firms were inefficiently liquidated after the reforms.[10]

Third, the greater the zombies' financial distress, the lower (higher) is the likelihood of transition into recovery (exit). The pairwise comparison of AMEs between periods is statistically negative in both cases (−3.75 and −0.61 percentage points, respectively). Apparently, from this perspective, the reforms were not efficient. These results suggest that instead of having reduced the forbearance of creditors, it has increased; and that the attempts to refinance the debt are unsuccessful, rather encouraging a greater probability of zombie survival, as shown by the positive sign and the statistical significance of the interaction effect on the "remain as zombie" likelihood.

Finally, we address the effects of firm size on the zombie's transitions. The larger the firm (proxied by capital and labor), the greater (lower) the probability of recovery (exit). However, since the size effect on the exit likelihood is larger than on the recovery likelihood, there is a positive relationship between size and non-transition probability, which is consistent with the hypothesis that the larger the company, the more likely it is to remain in the zombie status. Nonetheless, the reforms' effects on the recovery and exit likelihoods go in opposite directions, depending on whether the size is in terms of capital or employment. The positive (negative) relationship between capital and recovery (exit) is reduced by 0.77 (0.99) percentage points in the post-reforms period. On the other hand, the positive (negative) relationship between employment and recovery (exit) is increased by 1.46 (1.21) percentage points after the reforms.

To deepen this issue, we follow Williams (2012) and compute the adjusted conditional probabilities at representative values of the (log) capital and (log) labor in the pre- and post-reforms periods. Table 7 reports the adjusted predictions, for each transition, of two zombies that just differ in the value of the corresponding firm size variable (to make it close in spirit to the marginal effect concept). The representative values are given by the average sample value of each covariate by size category (SMEs and large zombies).

[10] As a robustness test, Table A.3 in Appendix we present the results using labor productivity. The finding is confirmed.

**Table 7**
Expected probabilities at average size (Capital and Labor), multinomial logistic regression.

| Variable | Transition | Size | 2005–2016 (1) | IR = 0 (2) | IR = 1 (3) | Difference in expected probabilities (4) = [(3)–(2)] | Pairwise comparison (Large vs SME) (5) |
|---|---|---|---|---|---|---|---|
| Capital | Remain as zombie | SME | 0.7297*** | 0.7538*** | 0.6697*** | −0.0841*** | 0.0029 |
| | | Large | 0.7702*** | 0.7922*** | 0.7110*** | −0.0811*** | |
| | Recovery | SME | 0.1255*** | 0.1058*** | 0.1680*** | 0.0622*** | −0.0311*** |
| | | Large | 0.1364*** | 0.1274*** | 0.1585*** | 0.0311*** | |
| | Exit | SME | 0.1449*** | 0.1404*** | 0.1623*** | 0.0219*** | 0.0282*** |
| | | Large | 0.0934*** | 0.0804*** | 0.1305*** | 0.0501*** | |
| Labor | Remain as zombie | SME | 0.7296*** | 0.7519*** | 0.6722*** | −0.0797*** | −0.0192** |
| | | Large | 0.7412*** | 0.7716*** | 0.6727*** | −0.0989*** | |
| | Recovery | SME | 0.1275*** | 0.1064*** | 0.1671*** | 0.0607*** | 0.0472*** |
| | | Large | 0.1556*** | 0.1192*** | 0.2271*** | 0.1079*** | |
| | Exit | SME | 0.1430*** | 0.1417*** | 0.1607*** | 0.0190*** | −0.0280*** |
| | | Large | 0.1032*** | 0.1092*** | 0.1002*** | −0.0090 | |

*Notes:* IR is a dummy for the post-reforms zombies. Columns (1), (2) and (3) reports the estimated probabilities for the "average" firm in each representative value (sample average of ln(capital) and ln(labor)), where "average" means that the estimate is conditional on the observed values for the other explanatory variables—including the other size value. The difference in expected probabilities expresses the interaction effect in each representative size-value. Unreported are estimates of TFP, leverage and the control variables including log of EBITDA, log of age, log of zombie duration, business cycle, industry and location dummies. Standard errors (not reported) for statistical significance tests are obtained using the delta-method.
*** Significant at the 1 percent level.
** Significant at the 5 percent level.
* Significant at the 10 percent level.

According to Column (4) of Table 7 (differences in expected probabilities between pre- and post-reforms), the recovery likelihood of an average small-in-capital zombie raises 6.22 percentage points in the post-reforms interval. In comparison, the increase is only 3.11 percentage points in a typical large-in-capital zombie. It seems then that the positive relationship between capital and recovery is weakened not because large-in-capital zombies reduce their chances of reorganization but because the increase in recovery probability is higher in small-in-capital zombies. The estimates suggest that the impact of the reforms, by encouraging the negotiation of a reorganization agreement, is greater in small-in-capital businesses, probably because the number of creditors classes is lower in this type of firm, which simplifies coordination for the agreement. Additionally, since the larger the capital, the greater the debt (in absolute terms), the resolution of financial distress is relatively delayed. But note that the effect of the institutional changes is positive in large financially distressed firms.

In the case of exit, although the liquidation probability increases in both types of zombies, the rise is 2.82 percentage points superior in those large-in-capital (see the pairwise comparison in Column 5). The exit likelihood of a typical small zombie increases from 14.04% to 16.23%, while this probability rises from 8.04% to 13.05% in the average large zombie. Thus, even though the negative relationship between capital size and exit likelihood holds after the reforms, the exit-risk gap between large and small financially distressed firms is reduced. This finding suggests that SMEs were relatively less prone to liquidation. As the increase in exit probability is more than twice as high in large companies, it seems, however, that capital intensity also plays an important role in the changes in liquidation probability.

Regarding employment size, the upsurge in the recovery probability of an average large-in-employment zombie is 4.72 percentage points higher than that of its small counterpart (pairwise comparison in Column 5 of Table 7). Thus, due to commanding more resources and higher managerial capabilities, large companies seem to achieve a successful restructuring in a shorter time, taking advantage of the new institutional framework. Concerning the exit transition, only the change in expected probabilities in the representative SME is statistically significant, and its exit likelihood increases 1.90 percentage points in the post-reforms period. Therefore, the negative relationship between size-in-employment and liquidation probability increases after the institutional reforms, suggesting that the "too-big-to-fail" effect is likely to have played a crucial role in insolvency events.

To further confirm that no confounding variables affect the interpretation of institutional changes' effectiveness, in the Appendix section, we present the results of a multinomial specification implemented in two separate subsamples, namely high turbulence industries and low turbulence industries, respectively.[11] Following Gouveia and Osterhold (2018), we make the assumption that industries with a higher degree of turbulence are more exposed to reforms in the case of

[11] High-turbulence industries account for the most turbulent 20% of 3-digit industries, while low-turbulence industries account for the least turbulent 20% of 3-digit industries. Industrial turbulence is defined as the sum of the weighted average entry rate and average exit rate in each 3-digit industry for all companies (zombies and non-zombies) observed over the sample period 2005–2016. The weighting factor is the number of firms per year.

shocks. Thus, the impact of reforms on more turbulent industries is expected to be greater than that of their less turbulent counterparts. As shown in Table A.4, we found that the entrenchment probability was reduced by a greater probability of recovery and exit in both sectors. However, as hypothesized, the reduction in the zombie survival likelihood was almost 0.7 p.p. greater in high turbulence industries than in less turbulent industries. This greater reduction in zombie entrenchment in the former is mainly due to a greater recovery probability (1.1 percentage points higher in the high turbulent sector). Finally, the reforms' interaction effect on the relationship between productivity and the recovery and exit likelihoods, more than having been noticeably greater, was only statistically significant for high turbulence industries (at the 1% level). As found in the entire sample, the reforms efficiently encouraged the recovery of the most productive zombies, albeit were less efficient in the exit transition.

Overall, the results suggest that the reforms effectively reduce the barriers that hinder the transition of zombies to both recovery and exit. Since not all zombies are unviable firms, the implemented reform package (aimed at balancing the rights of debtors and creditors) reveals to be a more appropriate and efficient route, as it encourages reorganization to prevail over liquidation in financially distressed firms—note that zombie entrenchment is reduced mainly by a greater recovery probability of the more productive zombies, which is in line with results found by Gouveia and Osterhold (2018). Simultaneously, both large and small companies increase their reorganization likelihood, indicating that the reforms mitigate delays in resolving insolvency conflicts that are characteristic of large companies with many creditors and somehow complement the lower bargaining power of small businesses. Nevertheless, a misleading selection at the exit margin also reduces the zombie prevalence, as more productive firms are not risk-free from liquidation.

To examine whether our results are sensitive to the definition of zombie firms, Tables A.5 and A.6 in the Appendix, we performed a robustness check using the criteria of Schivardi et al. (2022). Despite the differences in magnitude, the results show that both the sign and statistical significance of the main results hold.

### 5.3. Reallocation analysis in the entire economy

In the previous section, we found that institutional reforms do discourage the entrenchment of zombie firms. Tables 8 and 9 now show the results of the linear fixed-effects panel regressions in which we analyze the effect of zombie prevalence on the economy-wide reallocation of employment and capital, respectively, using model (6).

Regarding employment growth, in Table 8, observe that a higher level of idiosyncratic productivity is linked to higher firm growth, given by the highly significant and positive TFP coefficient in all specifications. Since the TFP is relative to the annual industry mean, if we multiply all the regression coefficients by the within-industry standard deviation, we estimate the growth differential between a "productive" firm and the average firm in the sector (Decker et al., 2020). Thus, assuming specification (2) and a scenario of a zero-zombie share and neutral economic cycle (i.e., the cyclical indicator set to zero), we obtain that the growth differential is 8.66% $[= 0.1345 \times S.D.\,(TFP^r)]$.[12]

As expected, the zombie entrenchment undermines the responsiveness of employment growth to productivity, as the TFP-ZE interaction term (either weighted by employment- or capital-sunk) is negative and highly statistically significant. However, the adverse impact of the zombie entrenchment on responsiveness seems to have been attenuated after the reforms, as the coefficient associated with the TFP-ZE-IR interaction term is significantly positive—Columns (2) and (4) of Table 8. Therefore, the results suggest that the reduction in responsiveness caused by zombies is lower after the reforms. The decline in entrenchment barriers is also translated into a lower distortion in selection and reallocation in the entire economy. Specifically, as Fig. 5 shows, the zombie entrenchment (sample average) is associated with a reduction in the growth differential – between the productive and the average firm – of 2.77% in the pre-reforms interval $\{= S.D.\,(TFP^r) \times [-0.2644 \times \text{mean}(ZE)]\}$, whereas the reduction is only 1.37% in the post-reforms interval $\{= S.D.\,(TFP^r) \times [(-0.2644 \times \text{mean}(ZE)) + (0.1334 \times \text{mean}(ZE))]\}$.[13]

Capital reallocation estimates are in the same direction (Table 9). The capital growth differential between a productive and the average firm, without zombie and cyclical effects, is 4.21% $[= 0.0654 \times S.D.\,(TFP^r)]$. The regression results also show that the negative effect of zombie entrenchment on the responsiveness of capital growth to productivity decreases during the post-reforms interval: from 0.5% to 0.1%, *before* and *after* reforms, respectively (Fig. 6).

Finally, Fig. 7 shows the evolution of the technological dispersion within industries, measured by the productivity differential between the 90 and 10 percentiles and by the standard deviation of the TFP distribution (unweighted and weighted by output-industry-shares). Although there is a growing trend in productivity dispersion over the entire sample period, there has been a slight reduction since 2013. This reduced dispersion is then consistent with the prediction that, under fewer reallocation barriers, the productivity gap between zombies and non-zombies is smaller, reducing the within-industry productivity dispersion (Caballero et al., 2008). In addition, this result is consistent with the responsiveness hypothesis of Decker et al. (2020), who have pointed out that when adjustment costs (or frictions in a broader sense) are lower, the effect of idiosyncratic productivity on business growth is greater and the productivity dispersion lower.

In Tables A.7 and A.8 in Appendix, we present robustness tests using the zombie share in resources by industry instead of the ZE variable. Again, the findings are confirmed.

[12] The standard deviation of relative TFP during the selected interval is 0.6437. To abstract from changing TFP dispersion, we use the sample average value.

[13] The average sample value of the employment- and capital-weighted ZE are 0.1627 and 0.2042, respectively.

**Table 8**
Employment growth, fixed-effects panel regression.

| Variable | (1) | (2) | (3) | (4) |
|---|---|---|---|---|
| TFP | 0.1221*** | 0.1345*** | 0.1026*** | 0.1043*** |
| | (0.0023) | (0.0024) | (0.0015) | (0.0015) |
| Employment-weighted ZE | −0.0665*** | −0.0838*** | | |
| | (0.0068) | (0.0096) | | |
| TFP × Employment-weighted ZE | −0.1276*** | −0.2644*** | | |
| | (0.0103) | (0.0143) | | |
| Employment-weighted ZE × IR | | 0.0235** | | |
| | | (0.0094) | | |
| TFP × Employment-weighted ZE × IR | | 0.1334*** | | |
| | | (0.0091) | | |
| Capital-weighted ZE | | | −0.1278*** | −0.1010*** |
| | | | (0.0039) | (0.0045) |
| TFP × Capital-weighted ZE | | | −0.0204*** | −0.0370*** |
| | | | (0.0041) | (0.0053) |
| Capital-weighted ZE × IR | | | | −0.0362*** |
| | | | | (0.0034) |
| TFP × Capital-weighted ZE × IR | | | | 0.0176*** |
| | | | | (0.0050) |
| Observations | 1,742,104 | 1,742,104 | 1,742,104 | 1,742,104 |
| R-squared | 0.1971 | 0.1973 | 0.1979 | 0.1980 |
| Number of firms | 245,885 | 245,885 | 245,885 | 245,885 |

*Notes:* Employment-growth is measure as difference in logs. ZE denotes zombie entrenchment. Employment- and capital-weighted ZE are measured as employment- and capital-weighted averages of zombie spell by industry (2-digit CAE). IR is a dummy for the post-reforms zombies. Unreported are estimates of control variables (log of employment, business cycle, interaction between TFP and business cycle, year-, industry- and location-dummies). The variables were winsorized at the 1st and 99th percentiles. Firm-cluster standard errors are given in parenthesis.
*** Significant at the 1 percent level.
** Significant at the 5 percent level.
* Significant at the 10 percent level.

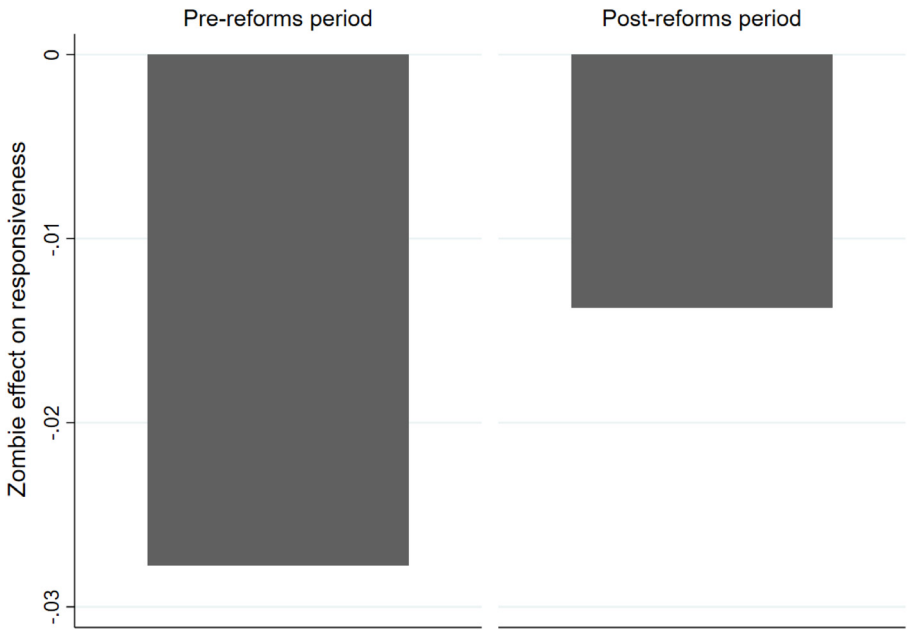


**Fig. 5.** Zombie effect on responsiveness of employment-growth to productivity.
Notes: Cross derivative between industry-ZE and productivity on employment-growth, evaluated at the standard deviation of TFP and the sample average employment-weighted ZE (2005–2016).

## 6. Conclusions and final remarks

The survival of less productive firms has hampered the aggregate productivity growth in most developed economies over the last two decades. Encouraged by the forbearance of creditors and inefficient insolvency regimes, the zombie

**Table 9**
Capital growth, fixed-effects panel regression.

| Variable | (1) | (2) | (3) | (4) |
|---|---|---|---|---|
| TFP | 0.0638*** | 0.0654*** | 0.0480*** | 0.0607*** |
| | (0.0016) | (0.0016) | (0.0023) | (0.0025) |
| Capital-weighted ZE | −0.0696*** | −0.0643*** | | |
| | (0.0038) | (0.0044) | | |
| TFP × Capital-weighted ZE | −0.0170*** | −0.0387*** | | |
| | (0.0039) | (0.0053) | | |
| Capital-weighted ZE × IR | | −0.0071** | | |
| | | (0.0033) | | |
| TFP × Capital-weighted ZE × IR | | 0.0306*** | | |
| | | (0.0050) | | |
| Employment-weighted ZE | | | −0.1992*** | −0.1795*** |
| | | | (0.0076) | (0.0100) |
| TFP × Employment-weighted ZE | | | 0.0569*** | −0.0822*** |
| | | | (0.0107) | (0.0144) |
| Employment-weighted ZE × IR | | | | −0.0248** |
| | | | | (0.0097) |
| TFP × Employment-weighted ZE × IR | | | | 0.1334*** |
| | | | | (0.0093) |
| Observations | 1,742,104 | 1,742,104 | 1,742,104 | 1,742,104 |
| R-squared | 0.1680 | 0.1681 | 0.1685 | 0.1687 |
| Number of firms | 245,885 | 245,885 | 245,885 | 245,885 |

*Notes:* Fixed effect panel data model. Capital-growth is measure as difference in logs. ZE denotes zombie entrenchment. Capital- and employment-weighted ZE are measured as capital- and employment-weighted averages of zombie spell by industry (2-digit CAE). IR is a dummy for the post-reforms zombies. Unreported are estimates of control variables (log of employment in t, log of capital in t, business cycle, interaction between TFP and business cycle, year-, industry- and location-dummies). The variables were winsorized at the 1st and 99th percentiles. Firm-cluster standard errors are given in parenthesis.
*** Significant at the 1 percent level.
** Significant at the 5 percent level.
* Significant at the 10 percent level.

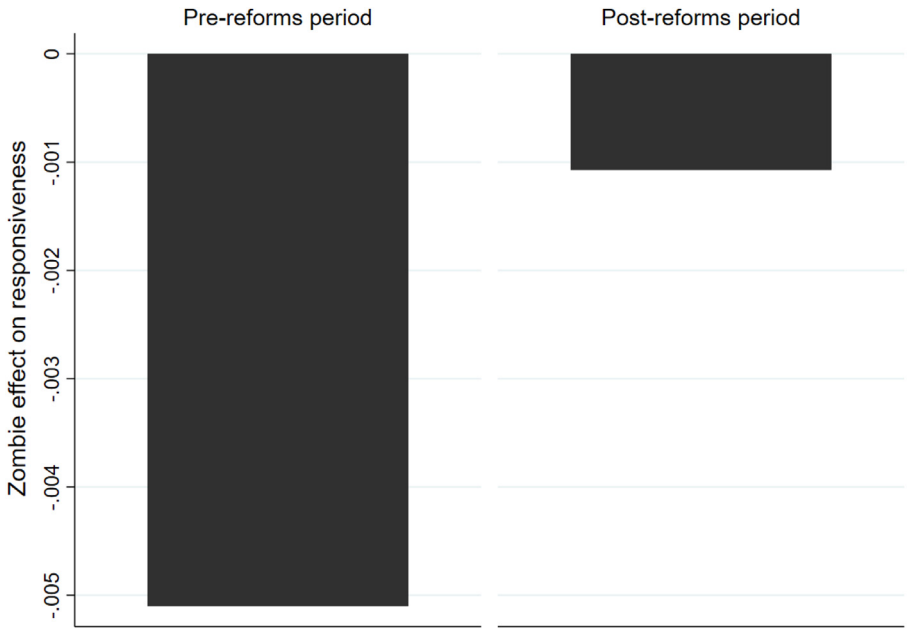


**Fig. 6.** Zombie effect on responsiveness of capital-growth to productivity.
Notes: Cross derivative between industry-ZE and productivity on capital-growth, evaluated at the standard deviation of TFP and the sample average capital-weighted ZE (2005–2016).

phenomenon has weakened business dynamism, making resource reallocation and industrial restructuring less dependent on the innovative efforts of economic agents.

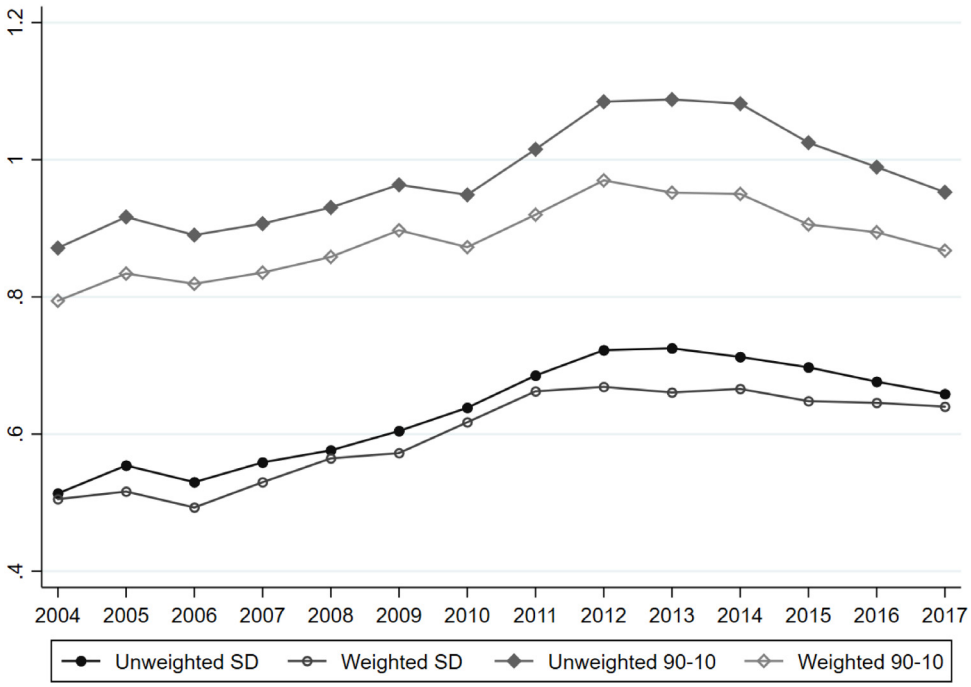


**Fig. 7.** Within-industry TFP dispersion.
Notes: Standard deviation and 90–10 differential of within-industry log TFP (as a deviation from the industry mean). Unweighted and weighted measures (output-industry shares as weights).

We studied how institutional reforms related to insolvency regimes and prudential supervision of credit institutions, promoted by the Portuguese and European Authorities, respectively, have affected the reallocation barriers that characterize the zombie phenomenon; and how they have impacted the growth of aggregate productivity. We focus on the Portuguese case, as it has been one of the OECD countries with a very large zombie prevalence. Portugal has also implemented a vigorous institutional package sought to facilitate the reorganization of viable companies that are temporarily financially distressed, on the one hand, and the exit of unviable ones, on the other.

The results suggest that the reforms were effective in reducing the reallocation barriers for zombie firms. The 'nearest-neighbor matching' estimates show that zombies operated under the new institutional setting (treated group) reduced their likelihood of entrenchment by about 10 percentage points vis-à-vis the corresponding counterfactual zombies (operating under the old regime). The multinomial regression analysis further indicates that the entrenchment time has been shortened by a greater likelihood of recovery and exit. At the root of this reduction is a larger increase in the probability of recovery than in the probability of exit.

As in previous studies, firm size – and the underlying ownership and debt structures – plays a major role in the way zombie incidence in the Portuguese economy has been reduced. Firstly, in larger companies solving financial distress is a complex matter and therefore the zombie status tends to remain for a longer period; and, secondly, smaller firms, having a higher share of secured debt (and less dispersed), are more easily liquidated in times of financial distress.

The reforms have been proved positive in stimulating business reorganization. Specifically, in the post-reforms period we found that (i) the most productive firms have an increased recovery probability, a result that is in line with Gouveia and Osterhold (2018); and (ii) this increase happens in both small and large companies. Nevertheless, it seems that the effect of the reforms is relatively less effective in relation to the exit transition. In fact, after the reforms the within-zombie selection at the exit margin is weaker. Finally, as the probability of exit increases relatively more in the large-in-capital and small-in-employment firms, the results suggest that both the liquidation value and the "too-big-to-fail" incentive play a crucial role in insolvencies.

The estimates from the fixed-effects panel regression finally show that the negative effect of zombie entrenchment on the responsiveness of firm growth (in terms of employment and capital) to productivity is reduced in the post-reforms period, which is accompanied by a slight decrease in the within-industry productivity dispersion. In other words, as the reallocation barriers decrease, their adverse impact on productivity-enhancing resource reallocation decreases too.

These results have non-trivial policy implications. Specifically, our findings suggest that a proper balance between debtors' and creditors' rights is an important vehicle to ensure that inefficient liquidation does not prevail in the case of financially distressed firms. The results show in particular that not all zombies are unviable firms, and that an adequate

institutional framework can increase the transition probability into reorganization and recovery. This setting seems to be more desirable than forcing zombie exit at all costs and, in the process, destroying promising projects.

One limitation of our study is the selected exit variable, which may misclassify a merger and acquisition (M&A) as an exit. Nevertheless, previous evidence suggests that M&A are rare events in the Portuguese economy as documented in Section 4. We performed robustness checks using different definitions of zombie firms, although data limitations have precluded us to replicate McGowan and Andrews (2018) and Caballero et al. (2008) classifications. There is also some weakness in our approach in the sense that despite our control for the business cycle, it is difficult to distinguish between the effect arising from the reforms and macroeconomic shocks that hit the Portuguese economy over our sample interval.

We believe that the reported results are not confined to the specific Portuguese case, as the implemented reforms share some important features with those followed in many other OECD countries. We have therefore proposed a methodology that can be used to assess in general the effectiveness of similar reforms.

## Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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## Appendix

See Tables A.1–A.8.

**Table A.1**
Post-matching test for covariate balance over treatment levels of treated Zombies.

| Predictor | One match | | | | Two matches | | | |
|---|---|---|---|---|---|---|---|---|
| | Standardized differences | | Variance ratio | | Standardized differences | | Variance ratio | |
| | Raw | Matched | Raw | Matched | Raw | Matched | Raw | Matched |
| TFP | −0,0791 | −0,0280 | 1,2446 | 1,1116 | −0,0791 | −0,0321 | 1,2446 | 1,1342 |
| Capital | −0,3738 | −0,0382 | 1,0036 | 1,0986 | −0,3738 | −0,0420 | 1,0036 | 1,1151 |
| Labor | −0,2860 | −0,0532 | 0,9093 | 1,1160 | −0,2860 | −0,0618 | 0,9093 | 1,1437 |
| Leverage | 0,4270 | 0,0731 | 1,5951 | 1,0881 | 0,4270 | 0,0800 | 1,5951 | 1,1013 |
| Age | 0,6855 | 0,1553 | 1,4747 | 1,0978 | 0,6855 | 0,1688 | 1,4747 | 1,1052 |
| EBITDA | −0,4442 | −0,0022 | 0,2991 | 0,9817 | −0,4442 | −0,0022 | 0,2991 | 0,9796 |
| Zombie duration | 0,5271 | 0,1495 | 1,3230 | 1,3085 | 0,5271 | 0,1575 | 1,3230 | 1,3143 |
| Business cycle | 0,5351 | 0,0642 | 0,4000 | 0,7531 | 0,5351 | 0,0679 | 0,4000 | 0,7439 |
| Industry dummy: | | | | | | | | |
| Construction | −0,1543 | 0,0000 | 0,7462 | 1,0000 | −0,1543 | 0,0000 | 0,7462 | 1,0000 |
| Trade | −0,0508 | 0,0000 | 0,9651 | 1,0000 | −0,0508 | 0,0000 | 0,9651 | 1,0000 |
| Accommodation | 0,3092 | 0,0000 | 1,5910 | 1,0000 | 0,3092 | 0,0000 | 1,5910 | 1,0000 |
| Real estate | −0,0476 | 0,0000 | 0,7778 | 1,0000 | −0,0476 | 0,0000 | 0,7778 | 1,0000 |
| Business services | 0,0001 | 0,0000 | 1,0002 | 1,0000 | 0,0001 | 0,0000 | 1,0002 | 1,0000 |
| Location dummy: | | | | | | | | |
| Algarve | −0,0114 | 0,0000 | 0,9565 | 1,0000 | −0,0114 | 0,0000 | 0,9565 | 1,0000 |
| Central Region | −0,0112 | 0,0000 | 0,9820 | 1,0000 | −0,0112 | 0,0000 | 0,9820 | 1,0000 |
| Lisbon | 0,0120 | 0,0000 | 1,0084 | 1,0000 | 0,0120 | 0,0000 | 1,0084 | 1,0000 |
| Alentejo | 0,0105 | 0,0000 | 1,0443 | 1,0000 | 0,0105 | 0,0000 | 1,0443 | 1,0000 |
| Açores | 0,0408 | 0,0000 | 1,4938 | 1,0000 | 0,0408 | 0,0000 | 1,4938 | 1,0000 |
| Madeira | 0,0119 | 0,0000 | 1,0678 | 1,0000 | 0,0119 | 0,0000 | 1,0678 | 1,0000 |

*Notes:* The table shows the standardized differences and variance ratios of the outcome variable' predictors, for the raw data and the matched sample (with one and two matches). The binary outcome variable takes the value of one if the company leaves the zombie status in $t + 1$ (i.e., recovers or exits the market) and zero otherwise (i.e., zombie entrenchment). The matrix of predictors contains TFP (as deviation from the industry mean), capital, labor (employment), leverage, EBITDA (as a cash-flow proxy), and firm age (all in logs), as well as business cycle measure (the annual growth rate of GDP in each region—NUTS II), and industry and location dummies. The similarity is computed by the Mahalanobis distance metric. The Abadie and Imbens (2011) approach is used to correct the large-sample bias. It is imposed exact matching on industry affiliation and location.

**Table A.2**
Effects on recovery and exit probability, multinomial logistic regression.

| Variables | Recovery | | | Exit | | |
|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) |
| IR | | 0.5774*** | 1.3884*** | | 0.1999*** | −0.5092*** |
| | | (0.0157) | (0.1302) | | (0.0174) | (0.1653) |
| TFP | 0.3953*** | 0.4072*** | 0.3681*** | −0.5719*** | −0.5695*** | −0.6503*** |
| | (0.0135) | (0.0135) | (0.0174) | (0.0094) | (0.0094) | (0.0119) |
| TFP × IR | | | 0.0741*** | | | 0.2177*** |
| | | | (0.0253) | | | (0.0181) |
| Capital | 0.0023 | 0.0090 | 0.0363*** | −0.1428*** | −0.1414*** | −0.1678*** |
| | (0.0063) | (0.0062) | (0.0074) | (0.0072) | (0.0072) | (0.0085) |
| Capital × IR | | | −0.0659*** | | | 0.0935*** |
| | | | (0.0112) | | | (0.0139) |
| Labor | 0.0431*** | 0.0651*** | 0.0319*** | −0.1409*** | −0.1321*** | −0.1108*** |
| | (0.0094) | (0.0094) | (0.0113) | (0.0106) | (0.0107) | (0.0127) |
| Labor × IR | | | 0.0789*** | | | −0.0646*** |
| | | | (0.0169) | | | (0.0221) |
| Leverage | −0.3138*** | −0.3429*** | −0.2506*** | 0.4533*** | 0.4447*** | 0.5292*** |
| | (0.0139) | (0.0140) | (0.0192) | (0.0133) | (0.0133) | (0.0163) |
| Leverage × IR | | | −0.1909*** | | | −0.1789*** |
| | | | (0.0240) | | | (0.0233) |
| Observations | 198,104 | 198,104 | 198,104 | 198,104 | 198,104 | 198,104 |

*Notes:* The base category for the dependent variable is the continuing zombie status. TFP, Capital, Labor and Leverage are in logs. IR is a dummy for the post-reforms zombies. Unreported are estimates of control variables including log of EBITDA (as proxy of cash-flow), log of age, log of zombie duration, business cycle measure (GDP-growth rate by region), and industry and location dummies. The variables were winsorized at the 1st and 99th percentiles. Firm-cluster robust standard errors are given in parenthesis.
*** Significant at the 1 percent level.
** Significant at the 5 percent level.
* Significant at the 10 percent level.

**Table A.3**
Effects on recovery and exit probability, multinomial logistic regression Robustness Check Using Labor Productivity.

| Variables | Recovery | | | Exit | | |
|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) |
| IR | | 0.5805*** | 1.6516*** | | 0.1972*** | −0.4529*** |
| | | (0.0157) | (0.1267) | | (0.0171) | (0.1550) |
| Labor productivity | 0.0791*** | 0.0822*** | 0.0719*** | −0.1314*** | −0.1307*** | −0.1513*** |
| | (0.0027) | (0.0027) | (0.0037) | (0.0021) | (0.0021) | (0.0026) |
| Labor productivity × IR | | | 0.0207*** | | | 0.0577*** |
| | | | (0.0051) | | | (0.0040) |
| Capital | −0.0255*** | −0.0202*** | 0.0158** | −0.0926*** | −0.0910*** | −0.1180*** |
| | (0.0061) | (0.0061) | (0.0073) | (0.0067) | (0.0067) | (0.0078) |
| Capital × IR | | | −0.0852*** | | | 0.0975*** |
| | | | (0.0108) | | | (0.0129) |
| Labor | 0.0107 | 0.0320*** | −0.0015 | −0.1129*** | −0.1048*** | −0.0722*** |
| | (0.0097) | (0.0097) | (0.0117) | (0.0105) | (0.0105) | (0.0124) |
| Labor × IR | | | 0.0792*** | | | −0.1001*** |
| | | | (0.0174) | | | (0.0217) |
| Leverage | −0.2511*** | −0.2791*** | −0.1899*** | 0.3470*** | 0.3395*** | 0.3977*** |
| | (0.0143) | (0.0144) | (0.0198) | (0.0128) | (0.0128) | (0.0157) |
| Leverage × IR | | | −0.1882*** | | | −0.1065*** |
| | | | (0.0247) | | | (0.0228) |
| Observations | 198,104 | 198,104 | 198,104 | 198,104 | 198,104 | 198,104 |

*Notes:* The base category for the dependent variable is the continuing zombie status. Labor productivity, Capital, Labor and Leverage are in logs. IR is a dummy for the post-reforms zombies. Unreported are estimates of control variables including log of EBITDA (as proxy of cash-flow), log of age, log of zombie duration, business cycle measure (GDP-growth rate by region), and industry and location dummies. The variables were winsorized at the 1st and 99th percentiles. Firm-cluster robust standard errors are given in parenthesis.
*** Significant at the 1 percent level.
** Significant at the 5 percent level.
* Significant at the 10 percent level.

**Table A.4**
Expected probabilities, average marginal effects and (average) differences-in-differences between pre- and post-reforms periods.

| Robustness Check comparing effects by industrial turbulence | | | | | |
|---|---|---|---|---|---|
| High turbulence industries | | | | | |
| Covariate | Transition | 2005–2016 (1) | IR = 0 (2) | IR = 1 (3) | Pairwise comparison (Post minus Pre-reforms) |
| A. Expected probabilities: $Pr(Y_{i,t+1} = j)$ | | | | | |
| | Remain as zombie | 0.7142*** | 0.7361*** | 0.6512*** | −0.0849*** |
| | Recovery | 0.1266 *** | 0.1058*** | 0.1702*** | 0.0644*** |
| | Exit | 0.1592*** | 0.1580*** | 0.1785*** | 0.0205*** |
| B. Average marginal effects (AMEs): $\partial p_j/\partial \kappa_k$ | | | | | |
| | Remain as zombie | 0.0215*** | 0.0398*** | −0.0154*** | −0.0552*** |
| TFP | Recovery | 0.0480*** | 0.0374*** | 0.0717*** | 0.0343*** |
| | Exit | −0.0696*** | −0.0772*** | −0.0563*** | 0.0208*** |
| | Remain as zombie | 0.0207*** | 0.0204*** | 0.0208*** | 0.0004 |
| Capital | Recovery | −0.0001 | 0.0041*** | −0.0085*** | −0.0127*** |
| | Exit | −0.0206*** | −0.0245*** | −0.0123*** | 0.0122*** |
| | Remain as zombie | 0.0044* | 0.0064** | 0.0016 | −0.0048 |
| Labor | Recovery | 0.0122*** | 0.0074*** | 0.0230*** | 0.0155*** |
| | Exit | −0.0167*** | −0.0139*** | −0.0247*** | −0.0107** |
| | Remain as zombie | −0.0186*** | −0.0344*** | 0.0123** | 0.0468*** |
| Leverage | Recovery | −0.0361*** | −0.0220*** | −0.0670*** | −0.0449*** |
| | Exit | 0.0547*** | 0.0565*** | 0.0546*** | −0.0018 |
| Low turbulence industries | | | | | |
| A. Expected probabilities: $Pr(Y_{i,t+1} = j)$ | | | | | |
| | Remain as zombie | 0.7270*** | 0.74961*** | 0.67110*** | −0.0785*** |
| | Recovery | 0.1747*** | 0.15663*** | 0.21004*** | 0.0534*** |
| | Exit | 0.0982*** | 0.09375*** | 0.11885*** | 0.0250*** |
| B. Average marginal effects (AMEs): $\partial p_j/\partial \kappa_k$ | | | | | |
| | Remain as zombie | −0.0133* | −0.0089 | −0.0206 | −0.0116 |
| TFP | Recovery | 0.0627*** | 0.0595*** | 0.0706*** | 0.0110 |
| | Exit | −0.0493*** | −0.0505*** | −0.0499*** | 0.0006 |
| | Remain as zombie | 0.0028 | 0.0031 | 0.0023 | −0.0008 |
| Capital | Recovery | 0.0018 | 0.0019 | 0.0016 | −0.0003 |
| | Exit | −0.0047 | −0.0051 | −0.0039 | 0.0011 |
| | Remain as zombie | 0.0105 | 0.0075 | 0.0176 | 0.0100 |
| Labor | Recovery | 0.0036 | 0.0047 | 0.0018 | −0.0029 |
| | Exit | −0.0141*** | −0.0123** | −0.0194** | −0.0071 |
| | Remain as zombie | 0.0047 | −0.0083 | 0.0301** | 0.03850* |
| Leverage | Recovery | −0.0493*** | −0.0403*** | −0.0681*** | −0.0277** |
| | Exit | 0.0446*** | 0.0487*** | 0.0379*** | −0.0107 |

*Notes:* Estimates from multinomial logistic model for high and low turbulence industries. High turbulence industries account for the most turbulent 20% of 3-digit industries, while low turbulence industries account for the least turbulent 20% of 3-digit industries. TFP, Capital, Labor and Leverage are in logs. IR is a dummy for the post-reforms zombies. The pairwise comparison between marginal effects express the interaction effect, that is, the difference in effects between the "zombies after the reforms" and the "zombies before the reforms". Unreported are estimates of control variables including log of EBITDA, log of age, log of zombie duration, business cycle measure, and industry and location dummies.

*** Significant at the 1 percent level.

** Significant at the 5 percent level.

* Significant at the 10 percent level.

**Table A.5**
Expected probabilities, average marginal effects and differences between pre- and post-reforms periods, multinomial logistic regression—Robustness check using Schivardi et al. (2017) definition of Zombies.

| Covariate | Transition | 2005–2016 (1) | IR = 0 (2) | IR = 1 (3) | Pairwise comparison (Post minus Pre-reforms) (4) |
|---|---|---|---|---|---|
| A. Expected probabilities: $Pr(Y_{i,t+1} = j)$ | | | | | |
| | Remain as zombie | 0.6714*** | 0.6851*** | 0.6237*** | −0.0614*** |
| | Recovery | 0.1879*** | 0.1730*** | 0.2359*** | 0.0629*** |
| | Exit | 0.1407*** | 0.1419*** | 0.1403*** | −0.0015 |
| B. Average marginal effects (AMEs): $\partial p_j/\partial \kappa_k$ | | | | | |
| | Remain as zombie | 0.0142*** | 0.0297*** | −0.0285*** | −0.0582*** |
| TFP | Recovery | 0.0524*** | 0.0388*** | 0.0921*** | 0.0533*** |
| | Exit | −0.0666*** | −0.0685*** | −0.0636*** | 0.0049** |
| | Remain as zombie | −0.0038 | −0.0129*** | 0.0200*** | 0.0330*** |
| Leverage | Recovery | −0.0809*** | −0.0745*** | −0.0991*** | −0.0245*** |
| | Exit | 0.0847*** | 0.0874*** | 0.0790*** | −0.0084*** |

*Notes:* TFP and Leverage are in logs. IR is a dummy for the post-reforms period. The pairwise comparison between marginal effects express the interaction effect, that is, the difference in effects between the "zombies after the reforms" and the "zombies before the reforms". Unreported are estimates of control variables including log of EBITDA, log of age, log of zombie duration, business cycle measure, industry- and location-dummies.
*** Significant at the 1 percent level.
** Significant at the 5 percent level.
* Significant at the 10 percent level.

**Table A.6**
Expected probabilities at average size (Capital and Labor), multinomial logistic regression—Robustness check using Schivardi et al. (2017) definition of Zombies.

| Variable | Transition | Size | 2005–2016 (1) | IR = 0 (2) | IR = 1 (3) | Difference in expected probabilities (4) = [(3)-(2)] | Pairwise comparison (Large vs SME) (5) |
|---|---|---|---|---|---|---|---|
| Capital | Remain as zombie | SME | 0.6692*** | 0.6839*** | 0.6228*** | −0.0612*** | −0.0373*** |
| | | Large | 0.6958*** | 0.7203*** | 0.6218*** | −0.0985*** | |
| | Recovery | SME | 0.1901*** | 0.1751*** | 0.2364*** | 0.0612*** | 0.0176*** |
| | | Large | 0.1677*** | 0.1484*** | 0.2273*** | 0.0788*** | |
| | Exit | SME | 0.1407*** | 0.1409*** | 0.1408*** | −0.0001 | 0.0197*** |
| | | Large | 0.1365*** | 0.1313*** | 0.1509*** | 0.0197*** | |
| Labor | Remain as zombie | SME | 0.6740*** | 0.6870*** | 0.6263*** | −0.0606*** | 0.0231*** |
| | | Large | 0.6870*** | 0.6940*** | 0.6565*** | −0.0375*** | |
| | Recovery | SME | 0.1874*** | 0.1726*** | 0.2356*** | 0.0630*** | −0.0046 |
| | | Large | 0.2210*** | 0.2075*** | 0.2660*** | 0.0585*** | |
| | Exit | SME | 0.1386*** | 0.1404*** | 0.1381*** | −0.0024 | −0.0186*** |
| | | Large | 0.0920*** | 0.0985*** | 0.0775*** | −0.0210*** | |

*Notes:* IR is a dummy for the post-reforms period. Columns (1), (2) and (3) reports the estimated probabilities for the "average" firm in each representative value (sample average of ln(capital) and ln(labor)), where "average" means that the estimate is conditional on the actual observed values for the other explanatory variables—including the other size value. The difference in expected probabilities express the interaction effect in each representative size-value. Unreported are estimates of TFP, leverage and the control variables including log of EBITDA, log of age, log of zombie duration, business cycle measure, and industry and location dummies. Standard errors (not reported) for statistical significance tests are obtained using the delta-method.
*** Significant at the 1 percent level.
** Significant at the 5 percent level.
* Significant at the 10 percent level.

**Table A.7**
Employment Growth, Fixed-Effects Panel Regression—Robustness Check Using Zombie-Share Variable.

| Variable | (1) | (2) | (3) | (4) |
|---|---|---|---|---|
| TFP | 0.1214*** | 0.1234*** | 0.0962*** | 0.0997*** |
| | (0.0026) | (0.0026) | (0.0017) | (0.0017) |
| Employment-weighted zombie share | −0.3002*** | −0.2275*** | | |
| | (0.0196) | (0.0253) | | |
| TFP × Employment-weighted zombie share | −0.3294*** | −0.4302*** | | |
| | (0.0328) | (0.0363) | | |
| Employment-weighted zombie share × IR | | −0.1232*** | | |
| | | (0.0287) | | |
| TFP × Employment-weighted zombie share × IR | | 0.1522*** | | |
| | | (0.0223) | | |
| Capital-weighted zombie share | | | −0.0881*** | −0.0178 |
| | | | (0.0138) | (0.0142) |
| TFP × Capital-weighted zombie share | | | 0.0249 | −0.0343** |
| | | | (0.0152) | (0.0162) |
| Capital-weighted zombie share × IR | | | | −0.3850*** |
| | | | | (0.0136) |
| TFP × Capital-weighted zombie share × IR | | | | 0.0065 |
| | | | | (0.0169) |
| Observations | 1,742,104 | 1,742,104 | 1,742,104 | 1,742,104 |
| R-squared | 0.1972 | 0.1972 | 0.1969 | 0.1977 |
| Number of firms | 245,885 | 245,885 | 245,885 | 245,885 |

*Notes:* Employment-growth is measure as difference in logs. ZE denotes zombie entrenchment. Employment- and capital-weighted ZE are measured as employment- and capital-weighted averages of zombie spell by industry (2-digit CAE). IR is a dummy for the post-reforms period. Unreported are estimates of control variables (log of employment, business cycle measure, interaction between TFP and business cycle measure, and year, industry and location dummies). The variables were winsorized at the 1st and 99th percentiles. Firm-cluster standard errors are given in parenthesis.
*** Significant at the 1 percent level.
** Significant at the 5 percent level.
* Significant at the 10 percent level.

**Table A.8**
Capital Growth, Fixed-Effects Panel Regression—Robustness Check Using Zombie-Share Variable.

| Variable | (1) | (2) | (3) | (4) |
|---|---|---|---|---|
| TFP | 0.0702*** | 0.0711*** | 0.0809*** | 0.0865*** |
| | (0.0017) | (0.0017) | (0.0026) | (0.0026) |
| Capital-weighted zombie share | −0.1456*** | −0.1068*** | | |
| | (0.0138) | (0.0141) | | |
| TFP × Capital-weighted zombie share | −0.1157*** | −0.1814*** | | |
| | (0.0143) | (0.0155) | | |
| Capital-weighted zombie share × IR | | −0.1958*** | | |
| | | (0.0133) | | |
| TFP × Capital-weighted zombie share × IR | | 0.1112*** | | |
| | | (0.0165) | | |
| Employment-weighted zombie share | | | −0.6379*** | −0.4242*** |
| | | | (0.0213) | (0.0253) |
| TFP × Employment-weighted zombie share | | | −0.3102*** | −0.5768*** |
| | | | (0.0327) | (0.0354) |
| Employment-weighted zombie share × IR | | | | −0.3674*** |
| | | | | (0.0293) |
| TFP × Employment-weighted zombie share × IR | | | | 0.3954*** |
| | | | | (0.0223) |
| Observations | 1,742,104 | 1,742,104 | 1,742,104 | 1,742,104 |
| R-squared | 0.1679 | 0.1682 | 0.1687 | 0.1691 |
| Number of firms | 245,885 | 245,885 | 245,885 | 245,885 |

*Notes:* Fixed effect panel data model. Capital-growth is measure as difference in logs. ZE denotes zombie entrenchment. Capital- and employment-weighted ZE are measured as capital- and employment-weighted averages of zombie spell by industry (2-digit CAE). IR is a dummy for the post-reforms period. Unreported are estimates of control variables (log of employment in t, log of capital in t, business cycle measure, interaction between TFP and business cycle measure, and year, industry and location dummies). The variables were winsorized at the 1st and 99th percentiles. Firm-cluster standard errors are given in parenthesis.
*** Significant at the 1 percent level.
** Significant at the 5 percent level.
* Significant at the 10 percent level.

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