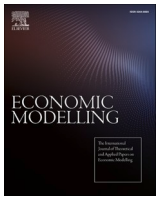
Economic Modelling 154 (2026) 107366

Contents lists available at ScienceDirect

Economic Modelling

journal homepage: www.journals.elsevier.com/economic-modelling



Lazarus, come forth! Public loan guarantees and the recovery of zombie firms

Enrique Acebo [a,*], Cristina Gutiérrez-López [a], Julio Abad-González [b], José-Ángel Miguel-Dávila [a]

[a] Department of Business Administration, University of León, Spain
[b] Department of Economics and Statistics, University of León, Spain

ARTICLE INFO

Dataset link: ICO COVID-19: Public Loan Guarantees in Spain (2020–2021) (Reference data)

JEL classification:
G32
H81
E58

Keywords:
Public loan guarantees
COVID-19
Zombie firms
Recovery
MSMEs

ABSTRACT

Can government support really contribute to the recovery of failing businesses? We studied whether financially struggling "zombie" firms benefited more from emergency loans during *covid-19* than healthy companies. Analysing 181,526 Spanish micro, small and medium enterprises that received government-backed loans versus 220,179 that did not, we tracked their performance over five years employing a difference-in-differences methodology. Contrary to fears about public resources misallocation, we find that emergency support (through Public Loan Guarantees) effectively revived distressed companies, especially small ones, which recovered notably better than healthy counterparts, achieving 80 % higher revenue growth and 30 % greater employment increases. Most remarkably, 53 % of small zombie firms fully recovered within two years. These findings suggest that targeted government intervention during crises can successfully rehabilitate struggling businesses, providing a roadmap for designing more effective economic rescue policies in future emergencies.

1. Introduction

Perpetuating non-viable, highly leveraged firms with low growth potential, known as 'zombies', through funding at low interest rates or public loan guarantees has always raised significant concerns about potential moral hazards. Indiscriminate financial support might prop up unproductive firms and exacerbate the problem of economic zombification (Guerini et al., 2024), diverting funds from solvent firms and potentially deepening the economic inefficiencies they aim to resolve (Cros et al., 2021; Ono and Yasuda, 2017; Nakamura, 2017). Recently, the pandemic and the public policies taken to avoid an economic freeze due to lockdowns have reignited worries about the risk of more companies becoming zombies as a result of the measures adopted to assist them (Altomonte et al., 2021; Hoshi et al., 2023; Zoller-Rydzek and Keller, 2020). The pandemic prompted governments worldwide to implement massive support programs in an unprecedented scale of intervention that reached $1.7 trillion in credit guarantee programs across seven advanced economies alone, averaging 6 % of GDP in developed countries, with Spain and Italy exceeding 10 % (Hong and Lucas, 2023). In this context, small and medium enterprises accounted for two-thirds of pandemic job losses, making them the primary target of most stimulus packages (Demmou et al., 2021; Dörr et al., 2022; Pedauga et al., 2022).

Careful calibration of these interventions is essential to avoid exacerbating economic inefficiency and to ensure that support is directed towards firms with genuine prospects for recovery and growth (Hoshi et al., 2023; Laeven et al., 2020). However, relatively few studies have analysed the impact of public guarantee programs, with most focusing on their effectiveness in restoring turnover (Belghitar et al., 2022) and employment levels (Endresz et al., 2015; Erhardt, 2017; Hancké et al., 2020; Horvath and Lang, 2021), reaching mixed and inconclusive results (Acharya et al., 2022). Moreover, such research examines aggregate firm performance without distinguishing between healthy and financially distressed companies (see Acharya et al., 2022; Sasso et al., 2025; Chetty et al., 2023; Doniger and Kay, 2021; Granja et al., 2020; Hancké et al., 2020; Horvath and Lang, 2021), thus leaving unanswered whether

* Corresponding author.
E-mail address: e.acebo@unileon.es (E. Acebo).

https://doi.org/10.1016/j.econmod.2025.107366
Received 25 March 2025; Received in revised form 29 September 2025; Accepted 20 October 2025
Available online 27 October 2025

supporting zombies creates economic value or perpetuates inefficiency.

The aim of this study is to analyze the impact of public loan guarantees on the performance of micro, small and medium enterprises (MSMEs), with a particular focus on zombies and their potential recovery or 'de-zombification'. This research question challenges conventional wisdom against assisting zombie firms. Using a difference-in-differences methodology, we examine data from 181,526 supported MSMEs between the years 2017 and 2022. Specifically, we measure the effects of the Spanish public loan guarantees issued during the *covid-19* crisis, with particular emphasis on the impact on zombie MSMEs in comparison with their non-zombie counterparts.

Our results reveal a significant impact of public loan guarantees on both zombie and non-zombie firms, particularly highlighting the substantial benefits for the former with increases in turnover and employment by 20 % and 5 %, respectively, in the following years, in comparison with non-treated ones. Small zombie firms experienced the most pronounced improvements, with an 80 % increase in turnover and a 30 % increase in employment two years post-implementation compared to their non-treated counterparts. Remarkably, about 53 % of supported small zombie firms successfully recovered, emphasizing the effectiveness of targeted financial aid. This evidence strongly supports the critical role of 'bridging' liquidity financing for MSMEs, as it is essential for maintaining viability and revitalizing zombie companies.

The study contributes to fill the void of understanding the consequences of crisis intervention by analysing whether public loan guarantees genuinely rehabilitate struggling firms or merely postpone market exits. Our findings indicate that target support can successfully revive zombie firms, particularly small ones, demonstrating that effective policy responses offer real opportunities for recovery and growth.

The remainder of this study is organised as follows. Section 2 reviews the previous literature about zombie firms and the risk of economic zombification. Section 3 presents the research setting and methodology. Section 4 describes the econometric results. Section 5 discusses the main results. Finally, Section 6 encompasses the main conclusions, limitations, and future lines of research.

2. Literature review

2.1. The risk of economy zombification

Over the past quarter-century, economists have grown increasingly concerned about economic "zombification"—a phenomenon where failing firms survive on borrowed time and capital, creating productivity drag through credit misallocation (Caballero et al., 2008; Kwon et al., 2015; Peek and Rosengren, 2005). When financial resources flow to companies that should naturally exit the market, they become unavailable to healthy, innovative businesses, creating significant crowding-out effects that undermine economic dynamism (Acharya et al., 2024; Andrews et al., 2017; Banerjee and Hofmann, 2018; 2022; Blattner et al., 2023). This misallocation distorts market competition and discourages long-term productive investments essential for sustained economic growth (Acharya et al., 2019; Andrews and Petroulakis, 2019; Schivardi et al., 2020; Tracey, 2019).

The pandemic reignited concerns about economic zombification due to the unprecedented stress on the global economy, prompting extraordinary governmental interventions after a challenging choice: allow massive business failures or risk artificially preserving unviable firms (Álvarez et al., 2023; Andrews et al., 2017; Banerjee and Hofmann, 2022). Economic disruptions often play a beneficial selection function, forcing out inefficient companies and creating space for innovative replacements (Guerini et al., 2024). However, the pandemic's sudden and universal impact meant that even sound businesses faced liquidity crises, making it nearly impossible to distinguish between temporary distress and fundamental unviability (Carreira et al., 2022; Carreira and Teixeira, 2016; Nurmi et al., 2022). This exceptional situation created a complex policy puzzle: how to prevent unnecessary businesses deaths without inadvertently sustaining economic zombies, particularly when traditional market signals became unreliable indicators of underlying firm viability during lockdowns.

Recognizing these extraordinary circumstances, governments worldwide implemented unprecedented support programs, being public loan guarantees the preferred policy tool, representing enormous public resource commitments —averaging 6 % of GDP in developed countries, with Spain and Italy exceeding 10 % (Hong and Lucas, 2023). However, these measures inevitably raised concerns about moral hazard and resource misallocation (Anderson et al., 2021; International Monetary Fund, 2021), since research suggests these funds flowed disproportionately to riskier and more fragile firms—precisely the types most likely to become zombies (Core and De Marco, 2023; Martin et al., 2023). Additionally, support measures were concentrated in sectors that were already home for significant numbers of zombies, potentially amplifying existing economic distortions (Pelosi et al., 2021). During *covid-19*, MSMEs faced disproportionately severe challenges due to their structural vulnerabilities, defined by low margins, limited cash buffers, and heavy dependence on traditional banking relationships (World Bank COVID-19 Response, 2020). Moreover, the crisis hit hardest in sectors requiring face-to-face interaction —retail, hospitality, tourism— where small businesses dominate and maintaining working capital during lockdowns became a matter of survival rather than growth (Khan, 2022; Muñoz-Izquierdo et al., 2024). Thus, it was particularly difficult to distinguish between temporary pandemic-related distress and underlying business problems, as even previously successful enterprises suddenly appeared financially insolvent. This blurred the traditional boundaries between healthy firms experiencing temporary difficulties and genuine zombies.

The fundamental challenge was designing policies that could rapidly deploy support without creating perverse incentives or artificially sustaining businesses that should naturally exit the market (Cros et al., 2021; Hoshi et al., 2023; Laeven et al., 2020; Ono and Yasuda, 2017).

Empirical evidence on the effectiveness of such level of governmental intervention remains inconclusive (Acharya et al., 2022). US research yielded contradictory findings: while some studies found minimal employment effects from payroll protection loans (Chetty et al., 2023; Granja et al., 2020), others credited these programs with preserving millions of jobs, particularly in smaller firms (Doniger and Kay, 2021). European experiences varied even more dramatically, with UK programs showing limited success in preventing layoffs while German interventions proved more effective at job preservation (Hancké et al., 2020). Meanwhile, Eastern European studies suggested more consistently positive outcomes, with research from Bulgaria and Hungary indicating that earlier interventions could enhance employment, investment, and productivity (Endresz et al., 2015; Erhardt, 2017; Horvath and Lang, 2021). This geographic variation suggests that institutional factors, program design, and implementation quality may matter more than simply providing support or not.

This evidence suggests that further research needs to be undertaken around the impact of public guarantees on the recovery of distressed companies and their potential different reaction in comparison to healthy companies, since previous studies have not generally distinguished between them. Although zombies arguably represent a small portion of supported firms, they are a policy-relevant group with concerns about possible resource misallocation. Given this critical knowledge gap, this study first addresses the following research question.

RQ1. Do zombie and non-zombie firms exhibit different responses to public loan guarantees?

2.2. The 'de-zombification' opportunity

The increasing interest in zombie firms stems from their permanence in markets where economic theory predicts restructuring or bankruptcy. The concept of "de-zombification" —transitioning from economic

stagnation to financial soundness— challenges conventional knowledge about business failure (Carreira et al., 2022). Recent studies confirm this phenomenon (Barnejee and Hoffman, 2022; Nurmi et al., 2022), since two-thirds of zombie companies achieve meaningful financial recovery, though timelines and sustainability vary significantly. However, most zombies continue to struggle or exit the market within two years, and dezombified firms consistently underperform in comparison to never-zombie firms (Hallak et al., 2018). This contradictory evidence highlights the critical need for deeper understanding of what distinguishes real recovery cases from persistent failures.

Successful de-zombification typically requires comprehensive strategic interventions encompassing operational restructuring, technological innovation, and debt restructuring (Carreira et al., 2022; Fukuda and Nakamura, 2011). However, recovery paths are highly heterogeneous across firm types and institutional contexts (Banerjee and Hofmann, 2022). Even de-zombified firms face long-term challenges, with post-recovery profitability frequently remaining below industry averages for extended periods (Bowman, 2022).

The institutional environment crucially determines success rates, with efficient insolvency frameworks stimulating market dynamics by encouraging competition among recovering firms, while rigid structures increase zombification risks and prolong recovery timelines (Nieto-Carrillo et al., 2022). Cross-country evidence reveals notable variation in zombie recovery rates, ranging from 40 % to over 70 % across jurisdictions, largely explained by differences in institutional quality and policy design (Banerjee and Hofmann, 2022). Corporate governance improvements, especially increased board independence and professional management practices, strongly correlate with successful turnarounds and sustained post-recovery performance (Rodríguez-Sanz et al., 2024). Recent IMF analysis of $1.7 trillion in guarantee programs reveals that partial guarantees (70–90 %) combined with sector-specific targeting produce superior recovery outcomes compared to full guarantees or blanket approaches (Hong and Lucas, 2023). This suggests that institutional design and policy architecture matter more than simply providing support versus withholding it.

Public policy's role in facilitating de-zombification presents complex challenges, and impose different effects based on implementation design and firm characteristics. Contrary to conventional concerns about moral hazard, emerging evidence suggests that well-designed government support can successfully rehabilitate struggling firms when combined with appropriate performance requirements and institutional frameworks (Carreira et al., 2022), and targeted subsidies effectively sustain survival and encourage genuine recovery (Nurmi et al., 2022; Szücs, 2021). However, unconditional government support may impede essential structural changes necessary for improved efficiency, creating dependency relationships that inhibit rather than facilitate recovery (Dai et al., 2019; Deng and Wang, 2022).

Covid-19 support programs provide a unique natural experiment to assess whether public loan guarantees can catalyse genuine recovery among zombie firms, which is critical for policymakers. In doing so, we can observe whether such interventions facilitate operational restructuring, innovation, and deleveraging, thus leading to de-zombification or simply postpone insolvency and reveal inefficient resource allocation. Accordingly, our second research question is.

RQ2. Can public loan guarantees enable recovery of zombie firms?

In this context, firm size emerges as a critical moderating factor with important implications for both policy effectiveness and recovery outcomes. Larger firms are initially less likely to evolve into zombie status due to greater access to capital markets and economies of scale; however, once "zombified," they often exhibit pronounced organizational inertia and resistance to restructuring (Banerjee and Hofmann, 2022; Hoshi, 2006), because they require complex, time-consuming and multistage reforms and their recovery involves modest improvements. On the contrary, smaller firms may be more susceptible to insolvency without support but are more responsive when they receive it. Studies prove the effectiveness of interventions targeted at SMEs (Szücs, 2021), which adapted quickly when enrolled in support programs (Chetty et al., 2023) and recover at rates 2–3 times greater than large counterparts when receiving restructuring packages (Carreira et al., 2022; Nieto-Carrillo et al., 2022). Small firms were 3–4 times more likely than large ones to implement digital transformation projects and adopt new business models during *covid-19*, despite facing tighter liquidity constraints (Klein and Todesco, 2021; Zheng et al., 2024). Micro-firms utilize social capital and established community networks to maintain customer relationships and access informal financing, which can substitute formal institutional support when needed (Montserin et al., 2021). In the US and EU, supported startups and SMEs demonstrated a 43.3 % higher incidence of new product introductions, expanded online sales channels, and diversified delivery services compared to unsupported peers (Zheng et al., 2024).

Drawing on this evolving literature, it becomes clear that public intervention can ameliorate the adverse effects associated with zombie firms, but the magnitude and durability of these effects may vary substantially by firm size. Large and small firms differ not only in their initial propensity to become zombies but also in their capacity to leverage external support for meaningful recovery. While SMEs and micro-enterprises appear uniquely suited to translate targeted guarantees or concessional loans into operational restructuring and innovation, larger firms often require more complex, multimodal interventions that may yield smaller marginal returns. Understanding these size-based dynamics is therefore essential for designing effective guarantee schemes. Consequently, our third research question is posed as follows.

RQ3. Do the effects of public loan guarantees vary among companies depending on their size?

3. Research setting and methodology

3.1. Public loan guarantees: The Spanish ICO program

In response to the *covid-19* shock, the Spanish government, via the Instituto de Crédito Official (ICO), launched a public guaranteed scheme in 2020, committing €140 billion to bolster liquidity for firms and self-employed workers. These guarantees covered up to 80 percent of losses on new SME loans (and 60–70 percent for larger firms). To qualify, borrowers had to be registered in Spain by March 17, 2020 and free of arrears or insolvency proceedings at end-2019. The guarantees were distributed based on each bank's market share before the crisis, preserving banks' discretion in credit decisions while ensuring a swift flow of private lending (Martin et al., 2023).

The Spanish economy is characterised by an overwhelming predominance of micro, small and medium-sized enterprises—over 99 percent of all firms and accounting for 72 percent of employment—and by a bank-centric financial system with limited access to capital markets or public grants (Martin et al., 2023). Italy and France exhibit similar structures, with MSMEs comprising around 95 percent and 92 percent of businesses respectively, and banks remaining the primary source of corporate finance (Hong and Lucas, 2023).

Whereas Spain's ICO scheme insured 80 percent of losses on MSME loans, France's *Prêt Garanti par l'État* backed up to 90 percent for microenterprises and MSMEs, and Italy's *Fondo Centrale di Garanzia* provided 100 percent cover for loans under € 30,000 (Core and De Marco, 2023; Hong and Lucas, 2023). Germany, despite a comparable MSME share, saw more moderate take-up due to milder restrictions, extensive tax deferrals, *Kurzarbeit* schemes and deeper capital markets, as well as less favourable terms on guaranteed loans (Martin et al., 2023). These variations demonstrate that the ICO programme's design —its coverage levels, eligibility rules and allocation method— serves as a clear, transferable benchmark for emergency credit interventions in other bank-based economies.

3.2. Dataset

Our analysis draws on data from the Spanish National Database of Subsidies,[1] a centralized platform overseen by the General Comptroller of the State Administration. This public repository compiles information on all subsidies and public aid distributed by national, regional, and local governments in Spain. As a transparency and accountability tool, it facilitates citizen oversight and enables academic research into public resource allocation and economic outcomes. For this study, we focus specifically on ICO-guaranteed loans awarded to micro, small, and medium-sized enterprises (MSMEs) during the critical period of the *covid-19* crisis (2020–2021). We restrict our sample to firms that, as of 2019, employed fewer than 250 people, generated under €50 million in revenue, and held total assets below €43 million.[2]

These thresholds match the European Commission's criteria for defining MSMEs and ensure our focus remains on businesses most vulnerable to pandemic-related financial strain and possible zombification. To develop a credible counterfactual, we adopt a province (NUTS 3 level) and four-digit NACE Rev. 2 sector matching strategy, as used by Bertoni et al. (2019, 2023). Non-treated firms were matched to ICO-supported counterparts based on geography, industry, and the same size thresholds. Additionally, all firms had to demonstrate at least three consecutive years of operational history prior to 2019. This procedure enhances comparability and ensures that both treated and control groups would plausibly have had access to the ICO program under similar conditions.

We supplement this matching process with detailed firm-level financial and operational data extracted from the SABI database (Bureau van Dijk) covering the period from 2017 to 2022. Our final dataset includes 181,526 ICO-supported MSMEs and 220,179 matched non-supported firms. This longitudinal data allows us to assess pre- and post-treatment performance, providing a robust framework for impact evaluation.[3] Tables 1 and 2 display summary statistics and distributions across sectors and regions, offering an overview of the sample's composition. These statistics validate the balance between treated and control groups, confirming the quality of our matching and laying the foundation for causal inference regarding the effects of ICO guarantees on firm survival, performance, and employment outcomes.

Table 1
Sample by industry and treatment.

NACE Rev. 2 – Industry Sections	Treated		Non-Treated	
	No. of companies	%	No. of companies	%
Agriculture, Livestock, and Fisheries	2	0.00	14	0.01
Automotive and Transport Material	601	0.33	575	0.26
Business, Professional, and Administration	23,141	12.75	38,784	17.61
Capital Goods and Industrial Products	2728	1.50	2425	1.10
Chemical Industry	3726	2.05	3569	1.62
Construction and Infrastructure	26,182	14.42	34,223	15.54
Consumer Goods and Retail	62,569	34.47	66,561	30.23
Energy	407	0.22	1011	0.46
Environment	715	0.39	791	0.36
Extractive Industries	425	0.23	544	0.25
Financial services	2	0.00	15	0.01
Food and Beverage Industry	4885	2.69	5034	2.29
Health Industry and Services	1	0.00	1	0.00
Information and Communication Technol.	5242	2.89	7808	3.55
Metallurgy and Other Materials	6439	3.55	6305	2.86
Paper, Wood Industry, and Services	4400	2.42	3637	1.65
Real Estate Services	6155	3.39	22,163	10.07
Textile Industry and Fashion Retail	2509	1.38	2047	0.93
Tourism, Leisure, and Culture	20,234	11.15	13,969	6.34
Transport and Logistic	11,163	6.15	10,703	4.86
Total	181,526	100.00	220,179	100.00

Note: This table follows the sections of the NACE Rev. 2 framework. A more detailed table showing the distribution of the NACE Rev. 2 categories at the four-digit level can be provided upon request. The treated firms are those that received public guarantees, while non-treated firms did not receive this financial support.

3.3. Variables

Following established literature (Alekseev et al., 2023; Banerjee and Hofmann, 2018; Bighelli and Lalinsky, 2021; Fernández-Cerezo et al., 2023; Hoshi et al., 2023; Pelosi et al., 2021; Zoller-Rydzek and Keller, 2020), we employ a comprehensive set of financial and operational variables to assess MSME health and performance. We utilize two primary operational indicators: turnover and employment. Turnover serves as a fundamental measure of market presence and economic activity, directly reflecting a firm's operational scale and market reach (Fernández-Cerezo et al., 2023; Hoshi et al., 2023; Banerjee and Hofmann, 2018). Employment captures workforce size and indirectly measures human resource capacity and growth potential (Alekseev et al., 2023; Banerjee and Hofmann, 2018; Bighelli and Lalinsky, 2021; Pelosi et al., 2021). Following standard practice, we apply log transformations to ensure accurate interpretation of these metrics (Fernández-Cerezo et al., 2023; Hoshi et al., 2023). For firm size classification, we categorize enterprises as "micro" (fewer than 10 employees), "small" (10–49 employees), and "medium" (50–250 employees), with reference year 2019.

The concept of "zombie" firms was originally introduced by Kane (1987) to describe "bloodsucker" companies characterized by high debt and low profitability that impede financial market efficiency. The definition by Caballero et al. (2008) refined this concept, identifying zombie firms as those receiving subsidized credit rather than necessarily exhibiting low productivity or profitability, though reduced performance in both indicators is typically expected. The absence of a formal definition has led to diverse approaches in the literature. Some studies focus on low profitability (Schivardi et al., 2020), high leverage with weak growth prospects (Favara et al., 2021), or persistent unprofitability over extended periods (Altomonte et al., 2021), all indicating comparatively low future growth potential (Banerjee and Hofmann, 2018, 2022). This variety in zombie firm proxies creates challenges, particularly the risk of misclassifying financially distressed firms as zombies, when zombie firms represent only a subset of distressed firms (Álvarez et al., 2023).

Zombie firms are best understood as companies in permanent distress that remain operational without serious restructuring, sustained by creditor and/or government assistance, while imposing opportunity costs through misallocation of productive resources (Hoshi et al., 2023); while these firms are typically in financial difficulties and may receive subsidized bank credit, the latter criterion is often hard to measure empirically (Acharya et al., 2022). Given these constraints, current

[1] The database used in this study was sourced from Jaime Gómez-Obregón's citizen science initiative, available at https://github.com/JaimeObregon/subvenciones.git.

[2] Following the Commission Recommendation of 6 May 2003 concerning the definition of micro, small and medium-sized enterprises (http://data.europa.eu/eli/reco/2003/361/oj).

[3] Banks had processed 500,035 ICO-guarantee operations, of which 98 % were approved for MSMEs (de Barrón, 2020). Under such near-universal approval among applicants, any selection bias is negligible.

Table 2
Sample by region and treatment.

NUTS-2 Regions	Treated		Non-Treated	
	No. of companies	%	No. of companies	%
Andalucía	23,464	12.93	24,653	11.20
Aragón	6172	3.40	7731	3.51
Asturias	3786	2.09	4229	1.92
Baleares	5327	2.93	6682	3.03
Canarias	6362	3.50	6986	3.17
Cantabria	2149	1.18	2110	0.96
Castilla y León	8874	4.89	10,405	4.73
Castilla-La Mancha	7764	4.28	8672	3.94
Cataluña	37,000	20.38	41,610	18.90
Ceuta	137	0.08	90	0.04
Comunidad Valenciana	21,794	12.01	27,038	12.28
Extremadura	3146	1.73	2992	1.36
Galicia	12,166	6.70	15,228	6.92
La Rioja	1355	0.75	1860	0.84
Madrid	27,371	15.08	37,534	17.05
Melilla	128	0.07	99	0.04
Murcia	5420	2.99	6046	2.75
Navarra	2252	1.24	3743	1.70
País Vasco	6859	3.78	12,471	5.66
Total	181,526	100.00	220,179	100.00

Note: This table follows the categories of NUTS-2 or Autonomous Communities framework. A more detailed table showing the distribution at the NUTS-3 level can be provided upon request. The treated firms are those that received public guarantees, while non-treated firms did not receive this financial support.

literature predominantly identifies zombie firms through financial distress and unprofitability indicators. Following Álvarez et al. (2023) and standard practice (McGowan et al., 2018), we classify firms with an Interest Coverage Ratio (ICR) below 1 over the previous three consecutive years as 'zombies' (2017–2019). This approach provides a robust indicator of financial health across firm sizes and ages, by directly measuring operational efficiency and debt service capacity, and isolates the pre-pandemic environment avoiding potential biases. It also ensures that our zombie-firm indicator is fully exogenous to the pandemic shock, while the subsequent 2020–2022 observations allow us to trace the post-treatment dynamics of both zombie and non-zombie enterprises.

While ICR-based definitions may occasionally misclassify firms experiencing temporary difficulties that subsequently recover (Nurmi et al., 2022), this limitation does not invalidate the approach, particularly given that alternative market-based measures are unavailable for small companies. To assess de-zombification or recovery status, we adopt the framework developed by Banerjee and Hofmann (2022) and Albuquerque and Iyer (2023). This methodology requires firms to meet at least two of three criteria: ICR above one, leverage ratio below the industry median, or positive sales growth. This multi-criteria approach ensures that recovery reflects substantial improvements in financial health rather than temporary fluctuations, minimizing the probability of misclassifying firms that experience only transient improvements in economic conditions.

Additionally, we include several control variables to isolate the effects of financial interventions from other influences on firm performance. These controls encompass firm age, geographic location at the NUTS3 level, and industry classification according to the NACE Rev. 2 system at the 4-digit level. This comprehensive approach allows us to account for external and operational factors that could impact recovery outcomes beyond the financial interventions under study. By considering these factors, we aim to provide a robust analytical framework that distinguishes between genuine recovery and temporary improvements in firm performance, ensuring the reliability of our findings regarding the effectiveness of financial support measures for MSMEs.

3.4. Econometric approach

To estimate the impact of public loan guarantees on the performance of zombie MSMEs, we face key econometric challenges, notably the non-random allocation of support and confounding influences such as firm size and zombie status. Although these guarantees were broadly available to MSMEs (Hong and Lucas, 2023; International Monetary Fund, 2021), their distribution was shaped by pre-existing firm characteristics, particularly creditworthiness. This raises concerns of endogeneity: firms more likely to receive guarantees may also perform better due to unobserved attributes, biasing results. To mitigate this, we considered multiple strategies —including regression discontinuity, instrumental variables, and difference-in-differences (DiD) models (Békés and Kézdi, 2021; Goodman-Bacon and Marcus, 2020)— and ultimately adopted a DiD approach, well-suited to our dataset's structure of staggered and non-treated firms.

We specified a DiD model in which the outcome variable Y_{it} represents either turnover or employment for firm i in year t. The model includes a treatment indicator (ICO), a post-treatment indicator, and firm-level controls such as age, location, and industry. This allows us to compare outcome changes over time between treated and control firms. The general econometric specification is presented below:

$$log\,(Y_{it}) = \beta_0 + \beta_1 ICO_{it} + \beta_2 post_t + \beta_3 ICO_{it} \times post_t + \gamma_1 age_{it} + \gamma_2 location_i + \gamma_3 industry_i + \varepsilon_{it}$$

This approach helps address time-invariant unobserved heterogeneity, a major concern in observational studies. To further strengthen our design, we apply recent advances in the DiD literature by Callaway and Sant'Anna (2021), which allow for heterogeneous treatment effects and a staggered adoption of treatment across units.

The Callaway and Sant'Anna (2021) estimator improves on traditional DiD by allowing treatment effects to vary across firms and over time. In our context, this is essential given the diversity in firm size, sector, and financial health. Moreover, their framework allows later-treated firms to act as controls for earlier-treated ones, capturing dynamic impacts. We also adopt an event-study design based on Callaway and Li (2023), which estimates how effects evolve before and after treatment. This is especially relevant for *covid-19*-era interventions, where the policy environment and economic conditions changed rapidly (Goodman-Bacon, 2021; Sun and Abraham, 2021). These methodological refinements enhance the credibility and interpretability of our results by explicitly modelling the time-varying nature of treatment effects.

A second major concern is confounding: when firm characteristics influence both treatment assignment and outcomes, leading to biased estimates. As shown in Fig. 1, firm size and zombie status are particularly important confounders. Larger firms tend to have better access to credit, while more viable (non-zombie) firms are often prioritized in public support programs. To mitigate this, we estimate the Average Treatment Effect on the Treated (ATT) within stratified subgroups defined by firm size (Micro, Small, Medium) and zombie status. This stratification allows us to isolate the effect of credit guarantees more accurately and to assess whether impacts differ across these key firm

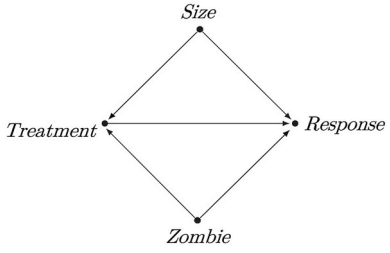


Fig. 1. Conceptual model.

characteristics.

Stratifying the sample also helps prevent issues like Simpson's Paradox, where aggregated effects can mislead or reverse within-group patterns. By analysing ATT within each subgroup, we improve internal validity and uncover heterogeneous treatment effects. This approach is especially relevant for policy, as it reveals which types of firms benefit most —or least— from credit guarantees. Our disaggregated findings allow for more targeted recommendations, enabling policymakers to refine future support measures based on firm characteristics. Moreover, this prevents overgeneralized conclusions and supports better resource allocation. Stratification thus plays a dual role: it strengthens causal inference and enhances the relevance of our conclusions.

Finally, to explore whether guarantees genuinely help firms recover from zombie status over time, we implement a survival analysis by means of the Kaplan-Meier estimator (Kaplan and Meier, 1958). This method estimates the probability of remaining a zombie firm across multiple periods while accounting for right-censoring—cases in which a firm has not yet exited zombie status by the end of the study window. In our context, the Kaplan-Meier estimator enables us to track firms' transition from financial distress to recovery, providing a long-term view of policy impact. This dynamic perspective complements the DiD and ATT estimates by showing not just whether firms improve, but how long they remain as zombies.

4. Results

4.1. Descriptive analysis

Table 3 provides a detailed comparison of the main descriptive statistics for MSMEs, classified according to their size and zombie status, where 'treated' refers to firms that have received a public loan guarantee from the ICO and 'non-treated' to those which have not received support. In addition, the table distinguishes between pre-treatment and post-treatment periods.

For micro-sized firms, treated zombies exhibit a significant decrease in turnover, with approximately €153,715 ($\log_{+1} = 5.040$) in the pre-treatment period to around €74,387 ($\log_{+1} = 4.314$) in the post-treatment period. A similar decline is observed in employee numbers, decreasing from 2.86 employees ($\log_{+1} = 1.350$) to approximately 1.96 employees ($\log_{+1} = 1.085$). Non-treated micro-sized zombies also show a decline, although less severe. In comparison, non-zombie micro firms, whether treated or not, perform better overall, though they too experience a noticeable decline post-treatment. This way, our results support our RQ1, providing evidence of differential impacts of public loan guarantees of zombies and non-zombies.

For small-sized firms, treated zombies experience a decrease in turnover from approximately €999,813 (log+1 = 6.913) in the pre-treatment period to around €426,871 (log+1 = 6.063) in the post-treatment period. A corresponding decline is seen in employee numbers, falling from about 15.36 employees (log+1 = 2.795) to roughly 9.59 employees (log+1 = 2.361). Non-treated small zombies follow a similar downward trend, although they maintain relatively better stability in both turnover and employee numbers compared to their zombie counterparts.

In the case of medium-sized firms, treated zombies see their turnover decrease from approximately €6,111,980 (log+1 = 8.716) in the pre-treatment period to around €1,333,521 (log+1 = 7.204) post-treatment. Employee numbers also decline, dropping from about 77.25 employees (log+1 = 4.360) to approximately 33.95 employees (log+1 = 3.531). However, the difference in performance between zombies and non-zombies in this category is less pronounced, suggesting that medium-sized firms may be better equipped to manage the financial difficulties associated with zombie status. Anyway, the aforementioned results support the interest and opportunity of RQ2 and 3, showing different effects of guaranteed loans (of different size) among companies depending on their size. This is clearly shown by the causal analysis developed in the next section.

Overall, the table underscores the persistent difficulties faced by both zombie and non-zombie firms of varying sizes in maintaining performance after the pandemic. Despite the interventions, non-zombie firms consistently outperform zombies, indicating that the inherent vulnerabilities associated with zombie status could not be fully mitigated by the treatments.

4.2. Causal analysis

Our analysis relies on the DiD framework to estimate the impact of public loan guarantees on MSMEs' financial and operational

Table 3
Descriptive statistics for zombie and non-zombie firms.

Variable		Pre-treatment			Post-treatment			Pre-treatment			Post-treatment		
	Group	Obs.	Mean	S. D.	Obs.	Mean	S. D.	Obs.	Mean	S. D.	Obs.	Mean	S. D.
	Micro-Sized Zombies (No. of firms = 14,741)							Micro-Sized Non-Zombies (No. of firms = 286,174)					
$\text{Turnover}_{(\log+1)}$	Treated	20,010	5.040	1.492	15,666	4.314	2.301	390,898	5.714	1.311	314,924	5.153	2.261
	Non-treated	35,949	4.274	1.917	35,949	3.311	2.436	505,611	5.148	1.689	505,614	4.461	2.392
$\text{Employees}_{(\log+1)}$	Treated	20,010	1.350	0.573	15,666	1.085	0.727	390,898	1.404	0.583	314,924	1.282	0.748
	Non-treated	35,949	1.156	0.551	35,949	0.827	0.661	505,611	1.218	0.565	505,614	1.049	0.694
	Small-Sized Zombies (No. of firms = 3,217)							Small-Sized Non-Zombies (No. of firms = 82,395)					
$\text{Turnover}_{(\log+1)}$	Treated	5,543	6.913	1.356	4,429	6.063	2.669	162,527	7.392	1.077	137,580	6.709	2.542
	Non-treated	4,665	7.111	1.564	4,665	5.751	3.069	97,131	7.463	1.242	97,131	6.665	2.612
$\text{Employees}_{(\log+1)}$	Treated	5,543	2.795	0.608	4,429	2.361	1.113	162,527	2.822	0.584	137,580	2.560	1.060
	Non-treated	4,665	2.887	0.631	4,665	2.261	1.253	97,131	2.834	0.574	97,131	2.524	1.058
	Medium-Sized Zombies (No. of firms = 613)							Medium-Sized Non-Zombies (No. of firms = 11,121)					
$\text{Turnover}_{(\log+1)}$	Treated	745	8.716	1.177	629	7.204	3.508	18,937	8.824	1.077	15,987	9.091	1.259
	Non-treated	1,191	8.975	1.230	1,191	7.492	3.539	17,243	7.869	3.074	15,988	7.942	3.263
$\text{Employees}_{(\log+1)}$	Treated	745	4.360	0.631	629	3.531	1.752	18,937	4.243	0.649	15,987	4.365	0.691
	Non-treated	1,191	4.425	0.743	1,191	3.649	1.775	17,243	3.786	1.534	15,988	3.823	1.611

Note: The table provides descriptive statistics for firms categorized by their 'zombie' status. A firm is classified as a 'zombie' if its Interest Coverage Ratio (ICR) has remained below 1 for the three years preceding the treatment. The dataset includes logarithmic values of turnover and employees. Firm sizes are defined based on the number of employees in 2019: micro-sized firms have fewer than 10 employees, small-sized firms have between 10 and 49 employees, and medium-sized firms have between 50 and 250 employees. The treated firms are those that received public guarantees, while non-treated firms did not receive this financial support. For treated firms, the pretreatment period refers to the years prior to the treatment event (2020 or 2021), and the posttreatment period follows the event. For non-treated firms, the pretreatment period is before 2020, and the posttreatment period is after 2020.

performance. For the validity of this DiD approach, we accomplished the following checks.

First, the parallel trends assumption is crucial, ensuring that in the absence of treatment, the treatment and control groups would have followed similar trajectories. We tested this assumption using the event study methodology by Callaway and Sant'Anna (2021) and Sant'Anna and Zhao (2020), confirming that treatment and control groups generally followed similar pre-treatment trajectories. In cases where the parallel trends assumption was violated, we applied the general approach from Rambackan and Roth (2023). This method posits that post-treatment deviations from parallel trends can exceed pre-treatment differences but remain bounded by a plausible range informed by the pre-treatment period. This allowed us to conduct robust inference.

Next, the no anticipation assumption requires that units did not change their behaviour in anticipation of the treatment. In our case, this assumption holds since firms could not alter their behaviour before the treatment, as they had no foreknowledge of the *covid-19* pandemic, preventing bias in our estimated effects. Third, since treatment is implemented at different times, we considered staggered treatment adoption, ensuring that, once treated, units remained treated throughout the study, maintaining consistency. Fourth, though traditional DiD methods often assume homogeneity of treatment effects, we accounted for potential heterogeneity using the methods of Callaway and Sant'Anna (2021), capturing variations across subgroups and time. Finally, to ensure there are no spillover effects or interference between units, we checked that the Stable Unit Treatment Value Assumption holds, allowing us to confidently attribute observed outcomes to the treatment itself rather than to interactions between treated and non-treated units.

Figs. 2a and 2b present the results of these event studies through graphs that display the coefficients of leads and lags with 95 % confidence intervals (CIs) for turnover and employment, respectively. These

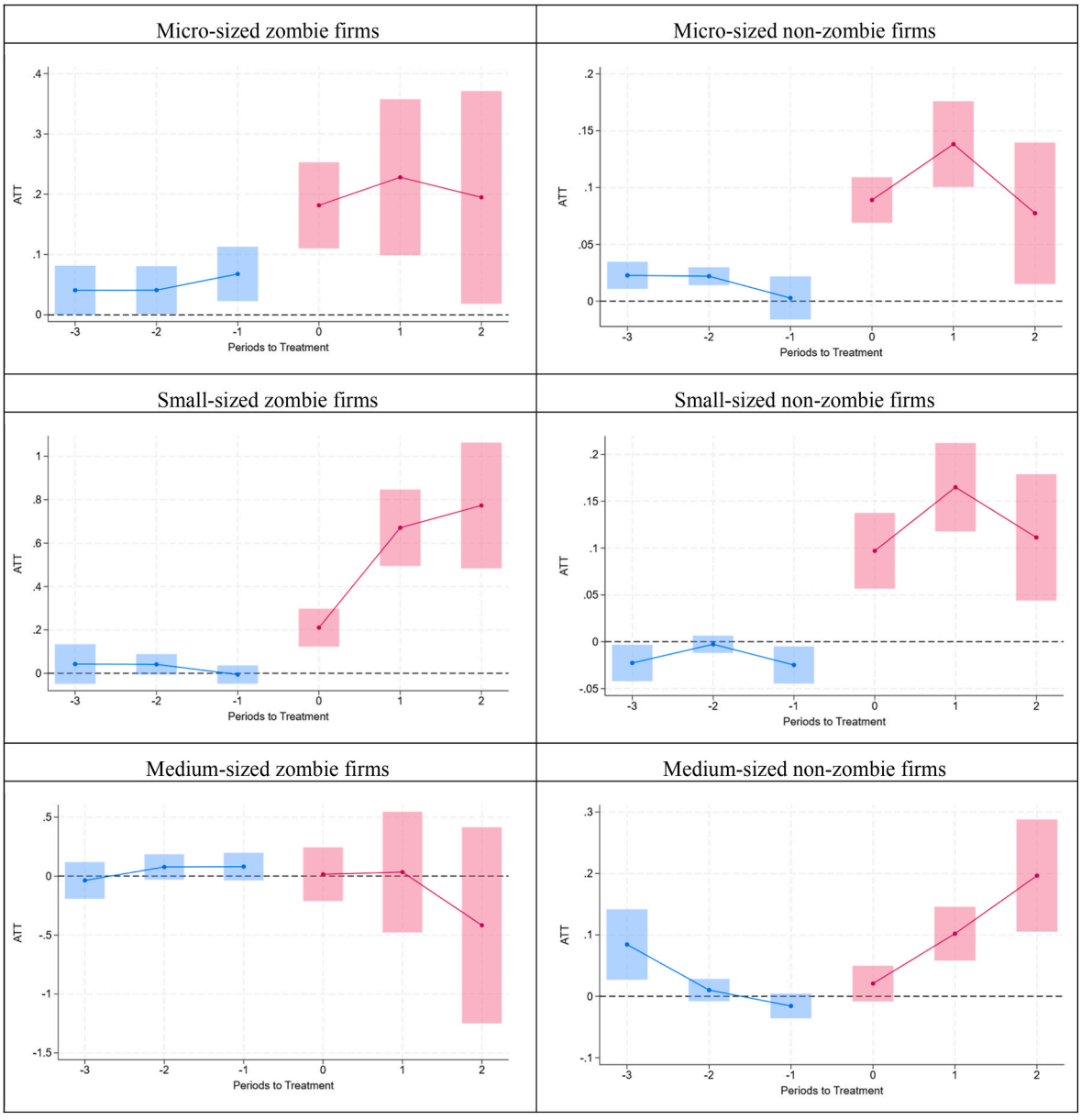


Fig. 2a. Impact of Public Loan Guarantees on Turnover by Zombie Status and Size
Note: The figures show the effect of ICO public loan guarantees on turnover in log base, calculated using Sant'Anna and Zhao's (2020) doubly robust DiD estimator based on stabilized inverse probability weighting and ordinary least squares using observations not yet treated as control group and clustered standard errors at NACE Rev. 2 at four digits. ATTs are estimated for each period relative to the period first treated across all cohorts.

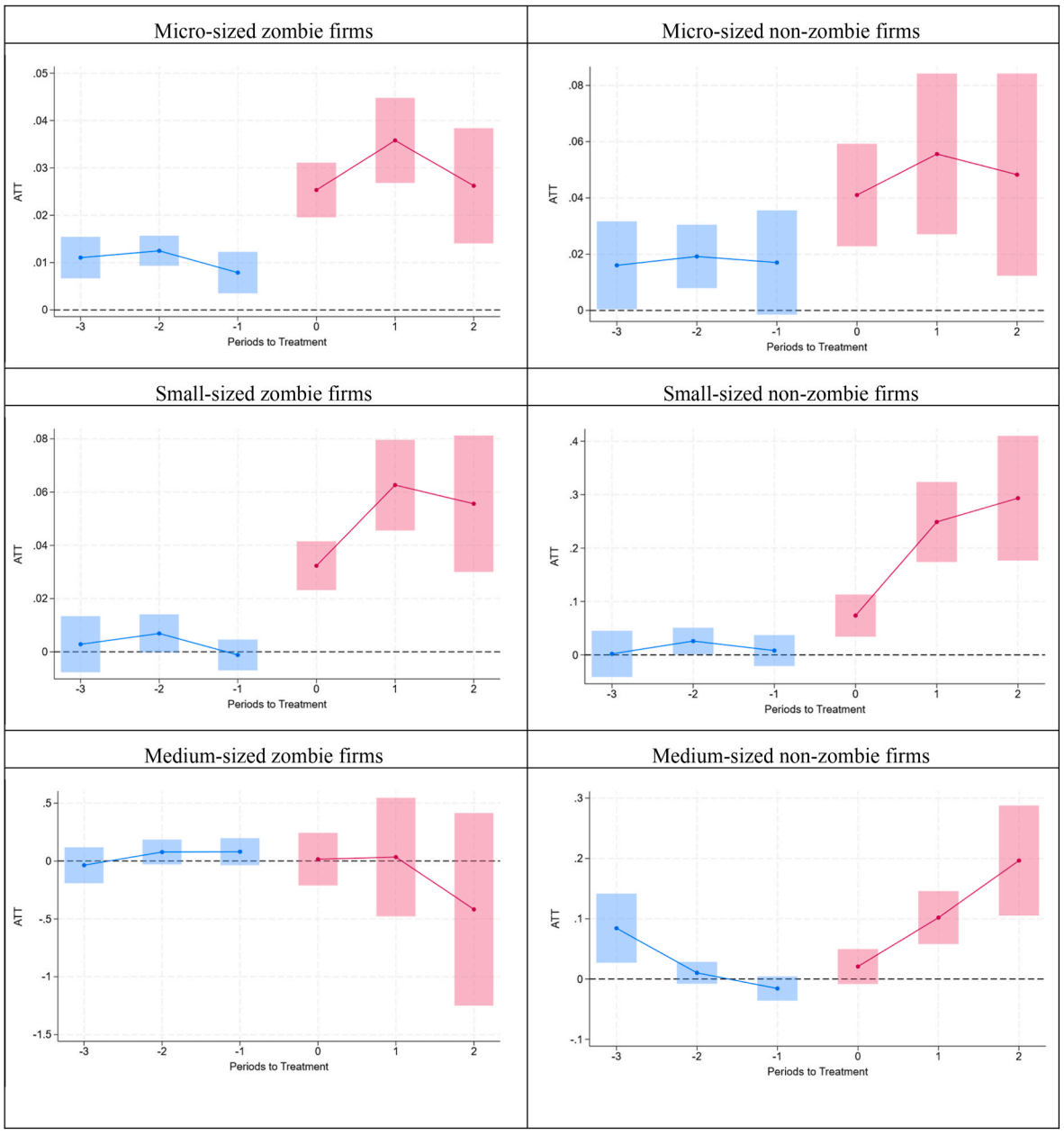


Fig. 2b. Impact of Public Loan Guarantees on Employment by Zombie Status and Size
Note: The figures show the effect of ICO public loan guarantees employment in log base, calculated using Sant'Anna and Zhao's (2020) doubly robust DiD estimator based on stabilized inverse probability weighting and ordinary least squares using observations not yet treated as control group and clustered standard errors at NACE Rev. 2 at four digits. ATTs are estimated for each period relative to the period first treated across all cohorts.

coefficients are calculated relative to the years preceding the receipt of public guarantees. The graphs differentiate between zombie and non-zombie MSMEs, further classifying firms according to their size. This detailed breakdown helps illustrate the temporal dynamics of the intervention's impact, showing how turnover and employment trajectories for treated and control groups have evolved before and after the policy implementation.

For micro firms, the impact of ICO financial aid on turnover varied significantly between zombie and non-zombie firms. Zombie firms that received financial assistance exhibited an increase in turnover of between 20 % and 25 % higher than their non-treated counterparts. In contrast, non-zombie micro firms registered more modest gains, with increases of approximately 10 %–15 % higher than that of those non-treated. These results suggest that zombie micro firms derived substantially more benefit from the financial guarantees compared to their non-zombie counterparts. Additionally, the impact on employment was notably more positive for zombie firms, showing a differential increase of about 5 % between treated and non-treated companies, compared to a 3 % improvement in the case of non-zombie firms.

In small firms, the turnover of zombies exhibited a remarkably higher increase, approximately 80 % more than their non-treated counterparts. This substantial differential effect is echoed in employment data, which indicates a 30 % greater increase in its levels by 2022, two years after the implementation of public guarantees, in comparison with those non-treated. Notably, small zombie firms were distinctly more responsive to the ICO interventions, underscoring the pronounced impact of these measures on both financial recovery and employment growth, and highlighting their critical role in revitalizing underperforming small enterprises.

The analysis of medium-sized firms reveals a distinct trend. In this

group, zombie firms that received ICO assistance exhibited a turnover growth rate approximately 50 % lower than their non-treated counterparts. This divergence is particularly stark in the periods following the intervention, where there is a noticeable decline in turnover for treated zombie firms, in contrast to a sustained increase among non-zombie firms. Similarly, employment outcomes for treated zombie firms were less favourable, showing a 20 % lower improvement in employment than non-treated firms.

Finally, this analysis is consistent with the results presented in Table 4, which shows the Average Treatment Effect on the Treated (ATT) by stratified groups.

For micro firms, the data in Panel A of Table 4 confirms that zombie micro firms experienced a significant increase in turnover of about 20.2 %, compared to a 10.4 % increase for non-zombie micro firms. The difference between these groups (χ^2 (1) = 14.07) highlights that ICO financial aid was more advantageous for zombie micro firms. Similarly, in small firms, zombie firms registered a substantial turnover increase of 52.4 %, while non-zombie firms saw only a 12.6 % rise, with a notable difference (χ^2 (1) = 31.78), indicating a stronger impact of public guarantees on zombie firms. In contrast, medium-sized firms displayed a different trend, with zombie firms experiencing a negative impact on turnover (−9.5 %), while non-zombie firms recorded a positive effect of 20.9 %; although the difference between these two groups was not statistically significant (χ^2 (1) = 2.61).

Panel B of Table 4 further supports our employment findings, showing that zombie micro firms benefited from a 4.8 % increase in employment, compared to 3.0 % for non-zombie firms (χ^2 (1) = 5.79). This trend was even more pronounced in small firms, where zombie firms saw a 19.4 % rise in employment, sharply contrasting with a 5.0 % increase in non-zombie firms (χ^2 (1) = 25.15). In the case of medium-sized companies, no statistically significant differences in employment are observed between the 4.5 % drop for zombie firms and the 10.2 % increase for non-zombies, similarly to what was commented for turnover. These results underscore the varying impact of public loan guarantees across different firm sizes and zombie statuses, highlighting the importance of tailoring financial interventions to meet the specific needs of different types of firms.

Table 4
Mean average treatment effect on treated by stratified group.

Panel A: Mean ATT on Turnover by Stratified Group						
Group		Coefficient	Robust SE	[95 % CI]		Obs.
(1)	Micro-sized zombie	0.202***	0.025	0.152	0.252	17,929
(2)	Micro-sized non-zombie	0.104***	0.006	0.093	0.116	286,176
Mean ATT_1 – Mean ATT_2			χ^2 (1) = 14.07***			
(3)	Small-sized zombie	0.524***	0.070	0.387	0.660	3,217
(4)	Small-sized non-zombie	0.126***	0.012	0.102	0.149	82,395
Mean ATT_3 – Mean ATT_4			χ^2 (1) = 31.78***			
(5)	Medium-sized zombie	−0.095	0.184	−0.456	0.266	626
(6)	Medium-sized non-zombie	0.209***	0.037	0.137	0.281	11,360
Mean ATT_5 – Mean ATT_6			χ^2 (1) = 2.61			
Panel B: Mean ATT on Employment by Stratified Group						
Group		Coefficient	Robust SE	[95 % CI]		Obs.
(1)	Micro-sized zombie	0.048***	0.008	0.033	0.063	17,929
(2)	Micro-sized non-zombie	0.030***	0.002	0.026	0.032	286,176
Mean ATT_1 – Mean ATT_2			χ^2 (1) = 5.79**			
(3)	Small-sized zombie	0.194***	0.028	0.139	0.250	3,217
(4)	Small-sized non-zombie	0.050***	0.005	0.040	0.059	82,395
Mean ATT_3 – Mean ATT_4			χ^2 (1) = 25.15***			
(5)	Medium-sized zombie	−0.045	0.093	−0.228	0.138	626
(6)	Medium-sized non-zombie	0.102***	0.019	0.064	0.139	11,360
Mean ATT_5 – Mean ATT_6			χ^2 (1) = 2.37			

Note: The table presents the mean Average Treatment Effects (ATT) on turnover (Panel A) and employment (Panel B) for micro, small, and medium-sized firms, stratified by zombie status (Non-zombie and Zombie). The coefficients show the estimated treatment effects, while the 'Robust Std. Error' column provides the precision of these estimates, with 95 % confidence intervals. Chi-squared (χ^2) statistics indicate the significance of differences between Non-zombie and Zombie groups. ***, **, and * denote significance at the 1 %, 5 %, and 10 % levels, respectively. Observations refer to the number of firms analysed in each group.

4.3. De-zombification analysis

Table 5 describes the recovery behaviour of firms classified as zombies in 2019 (year 0) over the 2019–2022 period, differentiating between treated and non-treated firms.

In 2020, the de-zombification progress of firms that received financial aid was virtually indistinguishable from those that did not, with both groups showing a marginal increase in the proportion of de-zombified firms to about 5 %. However, by 2021, a significant divergence emerged, particularly among small firms. The proportion of de-zombified firms who received financial aid increased to 21.1 %, compared to 15.9 % for those without ICO support, underscoring the effectiveness of the financial interventions.

In 2022, our analysis revealed that medium-sized firms did not show significant differences in recovery due to financial aid, with both treated

Table 5
Kaplan-Meier estimator for the de-zombification function.

Micro-sized firms	Non-treated			Treated		
	At risk	Recovery Function	Std. Error	At risk	Recovery Function	Std. Error
T+1	35,949	0.046	0.001	17,838	0.048	0.001
T+2	23,966	0.159	0.002	11,892	0.197	0.003
T+3	11,983	0.325	0.003	5946	0.416	0.005
Small-sized firms	Non-treated			Treated		
	At risk	Recovery Function	Std. Error	At risk	Recovery Function	Std. Error
T+1	4,665	0.038	0.003	4986	0.044	0.003
T+2	3,110	0.159	0.006	3324	0.211	0.007
T+3	1,555	0.349	0.010	1662	0.462	0.010
Medium-sized firms	Non-treated			Treated		
	At risk	Recovery Function	Std. Error	At risk	Recovery Function	Std. Error
T+1	1,191	0.032	0.005	687	0.036	0.007
T+2	794	0.143	0.012	458	0.158	0.016
T+3	397	0.333	0.020	229	0.346	0.026

Note: The table presents survival analysis of de-zombification data for micro, small, and medium-sized firms, supported and non-supported with a public loan guarantee, at various time points after the treatment (T). 'At Risk' indicates the number of firms still zombies at the start of each period. The 'Recovery Function' shows the estimated probability of firms changing from a zombie status to a non-zombie status, while the 'Standard Error' measures the precision of these estimates.

and non-treated firms achieving similar de-zombification levels of 34–35 %. In contrast, micro and small firms exhibited significant improvements with financial aid. Specifically, micro firms receiving financial aid had a de-zombification rate of 41.6 %, compared to 32.5 % for those that did not receive aid. The effect was even more pronounced among small firms: those receiving financial aid achieved a 46.2 % de-zombification rate, significantly higher than the 34.9 % observed in non-treated small firms.

To determine whether these differences were statistically significant, we used the log-rank test, a statistical method commonly applied to compare survival distributions between groups. The log-rank test evaluates whether there are significant differences in the time-to-event data (in this case, de-zombification rates) between the groups. In our case, it compares the observed number of de-zombified firms to the expected one under the null hypothesis of no difference between the treated and non-treated groups.

Additionally, because our analysis was stratified by firm size, we also employed the stratified log-rank test (see Table 6). This variant adjusts for differences in baseline characteristics (such as firm size) by computing separate log-rank statistics for each subgroup and then combining them. This approach ensures that the comparison accurately reflects the treatment effect while controlling for variability across firm sizes. The results from both the standard and stratified log-rank tests confirmed our RQ2 that the observed differences in de-zombification rates were statistically significant (except for medium sized firms).

4.4. Robustness analysis

We have performed several checks to ensure the robustness of our findings. First, we conducted a placebo test to assess the validity of our DiD estimator. Second, we performed the same DiD analysis using alternative definitions of firm size and zombie status. Third, to minimize potential bias effects derived from firms anticipating future aids, we restricted our analysis to firms within the treatment group that received the intervention exclusively in 2020. Fourth, to include in our sample firms zombified by the COVID-19 shock, we examined the effect on those treated only in 2021, relaxing the non-anticipatory assumption.

4.4.1. Placebo test

With the aim of assessing the validity of our DID estimator, we conducted a placebo exercise in which a fictitious treatment in the year 2020 was randomly assigned to a sample of micro, small, and medium-sized firms classified by zombie status. This strategy, inspired by the permutation procedures described by Abadie et al. (2010) in the synthetic-control context, generates a distribution of estimated effects under the null hypothesis of no true treatment. Huntington-Klein (2021) similarly highlights the value of such checks for ruling out bias and confirming the robustness of the parallel-trends assumption in DID analyses. Each firm was assigned a binary indicator (0/1) via a fixed-seed random number generator: firms with an indicator equal to 1 were fictitiously treated in 2020, while the remainder served as controls.

Moreover, to further gauge the credibility of our findings, we juxtaposed the real ATT estimates against those obtained under random assignment. Table 7 displays both the observed and placebo effects on turnover (Panel A) and employment (Panel B). Across all non-zombie cohorts and most zombie subgroups, the real treatment effects are positive and statistically significant at conventional levels, whereas the placebo estimates remain centred around zero and lack statistical significance. Notably, small zombie firms exhibit the largest real effects, yet their corresponding placebo ATTs are negligible. This unambiguous contrast underscores that the empirically detected impacts cannot be attributed to spurious correlations or violations of the parallel-trends assumption. By demonstrating that randomly assigned "treatments" yield null average effects, our placebo exercise reinforces confidence that the genuine estimates reflect causal dynamics rather than methodological artefacts.

Table 6
Log-rank test comparing recovery functions.

Firm size	Non-treated		Treated		χ^2 (1)
	Observed Events	Expected Events	Observed Events	Expected Events	
Micro-sized firms	6,859	7,484.95	4,340	3,714.05	184.57***
Small-sized firms	919	1,083.23	1,322	1,157.77	58.85***
Medium-sized firms	217	222.60	134	128.40	0.45
Total	7,995	8,790.78	5,796	5,000.22	238.88***

Note: The table presents the results of a stratified log-rank test, comparing the survival distributions of firms undergoing de-zombification, stratified by firm size. It evaluates whether there are significant differences in de-zombification rates between treated and non-treated firms within each stratum. The 'Observed Events' column shows the actual number of de-zombification recovery events recorded in each stratum. The 'Expected Events' columns show the number of recovery events expected in each stratum, assuming no difference in recovery rates between treated and non-treated firms. The 'χ^2 (1)' column shows the chi-square statistic with 1 degree of freedom, testing the null hypothesis of no difference in survival functions. Finally, ***, **, and * indicate a significance level of 1 per cent, 5 per cent, and 10 per cent, respectively.

4.4.2. Alternative definitions of firm size and zombie status

To further validate the robustness of our findings, we conducted the same DiD analysis using alternative definitions of firm size (see Appendix, Figures A1 and A2). This involved adjusting the criteria for categorising firms using both conditions of employment and turnover or/assets. Our results did not show any significant deviations from the primary models, indicating that our findings are robust across different definitions and classifications of size.

Additionally, we refined our zombie firm classification by incorporating an age restriction to our existing ICR criterion. Following the OECD approach (Andrews et al., 2017), we now require firms to be at least ten years old to be classified as zombies. This additional requirement has been widely validated in the literature (Hallak et al., 2018; Banerjee and Hofmann, 2018, 2022; Andrews and Petroulakis, 2019; Grieder and Ortega, 2020; Carreira et al., 2022) and let us distinguish between true zombie firms and young firms in distress. The results shown in Appendix Figures B1 and B2 yield similar results to those in the main analysis except for small nuances in the case of micro zombies for turnover.

4.4.3. The impact of the 2020 cohort of guaranteed loans

We restricted our analysis to firms within the treatment group that received aid exclusively in 2020. By doing so, we aim to isolate the treatment impact from any pre-existing expectations or behaviours. It is important to note that the pandemic onset in late 2019 was an unforeseen event unlikely to have influenced such behaviours prior to its actual impact, which further supports the validity of our 2020 analysis. With this new approach, Figures C1 and C2 in Appendix present the same patterns in the effects on turnover and employment previously illustrated in Figs. 2a and b.

4.4.4. Guarantees impact on post-COVID zombies

While the primary aim of this research is to investigate whether financial aid can facilitate a de-zombification process among distressed firms, the COVID-19 pandemic created a unique context that requires specific attention to newly emerged zombie firms. Previous evidence confirms that the COVID-19 pandemic led to an increase in the number of zombie firms (Rojas et al., 2022), which our dataset confirms with an increase of 9.4 % between 2019 and 2020.

Table 7
Mean average treatment effect on treated by stratified group.

Panel A: Mean Real and Placebo ATT Effects on Turnover, by Stratified Group						
Group		Coefficient	Std. Error	95 % conf. interval		Obs.
Micro-sized non-zombies	Real Effect	0.101***	0.021	0.060	0.142	1,489,122
	Placebo Effect	−0.008	0.007	−0.022	0.007	1,011,222
Micro-sized zombies	Real Effect	0.207***	0.068	0.074	0.339	94,542
	Placebo Effect	0.001	0.032	−0.061	0.063	71,898
Small-sized non-zombies	Real Effect	0.091***	0.016	0.059	0.124	419,525
	Placebo Effect	−0.007	0.018	−0.042	0.029	194,262
Small-sized zombies	Real Effect	0.486***	0.074	0.340	0.631	15,960
	Placebo Effect	−0.139	0.107	−0.347	0.070	9,330
Medium-sized non-zombies	Real Effect	0.171***	0.040	0.092	0.245	63,072
	Placebo Effect	0.037	0.055	−0.071	0.145	31,974
Medium-sized non-zombies	Real Effect	−0.073	0.214	−0.493	0.346	3,408
	Placebo Effect	−0.143	0.232	−0.598	0.313	2,382
Panel B: Mean real and placebo ATT effects on Employment by Stratified Group						
Group		Coefficient	Std. Error	95 % conf. interval		Obs.
Micro-sized non-zombies	Real Effect	0.036***	0.005	0.027	0.045	1,489,122
	Placebo Effect	−0.001	0.002	−0.005	0.004	1,011,222
Micro-sized zombies	Real Effect	0.059***	0.015	0.030	0.087	94,542
	Placebo Effect	−0.003	0.007	−0.017	0.011	71,898
Small-sized non-zombies	Real Effect	0.046***	0.007	0.032	0.060	419,525
	Placebo Effect	−0.006	0.007	−0.020	0.008	194,262
Small-sized zombies	Real Effect	0.184***	0.035	0.115	0.252	15,960
	Placebo Effect	−0.085*	0.043	−0.170	−0.001	9,330
Medium-sized non-zombies	Real Effect	0.088***	0.020	0.050	0.127	63,072
	Placebo Effect	0.020	0.031	−0.040	0.081	31,974
Medium-sized non-zombies	Real Effect	−0.013	0.106	−0.219	0.194	3,408
	Placebo Effect	−0.001	0.131	−0.258	0.256	2,382

Note: Panel A reports the mean Average Treatment Effects on the Treated (ATT) for employment across micro, small, and medium-sized firms, stratified by zombie status (Non-zombie vs. Zombie), showing both the real and placebo estimates. The "Robust Std Error" column gives the clustered standard errors, and "column provides the precision of these estimates, with 95 % confidence intervals. ***, **, and * indicate significance at the 1 %, 5 %, and 10 % levels, respectively. Observations refer to the number of firms included in each subgroup.

To examine how guaranteed loans affected firms that became zombies during the pandemic, we analyze the impact of the 2021 guarantee program on firms classified as zombies at end-2020 that had not previously received treatment in 2020. This approach allows us to shift the time reference to 2020 instead of 2019, thus controlling ICR levels over the three previous years, ensuring that the first pandemic year is included and capturing the potential increase in the number of zombie firms. Our results (Figures D1 and D2 in Appendix) show similar patterns in the case of turnover but reveal differences in employment in the case of micro-firms. This difference can be attributed to the relaxation of the usual non-anticipation assumption since some firms may have adjusted their behavior in anticipation of the guarantees.

5. Discussion

While crucial during crises, providing financial aid to zombie firms raises concerns about the potential for moral hazard and the undermining of natural market selection mechanisms. Traditional economic theories argue that such support might distort credit markets and perpetuate inefficiencies, channelling resources to firms that would typically fail without such help (Cros et al., 2021; Ono and Yasuda, 2017). However, the extraordinary circumstances posed by the pandemic required rapid, decisive measures to prevent a widespread economic downturn, significantly benefiting smaller firms in sectors reliant on in-person transactions (Muñoz-Izquierdo et al., 2024). The prevailing literature remains divided, leaving unresolved whether the benefits of such interventions outweigh potential long-term economic distortions (Hoshi et al., 2023; Laeven et al., 2020). The recent crisis has provided a unique opportunity to reassess these policies' impacts in real time, shedding light on how emergency measures might be optimized for future disruptions.

Our analysis, based on data from 181,526 MSMEs that obtained public loan guarantees, examines the impact of this aid on zombie firms. We observe a clear pattern whereby small firms reap the most significant benefits in turnover, employment, and de-zombification, followed by micro firms, while medium-sized firms show negligible results. This disparity suggests that firm size significantly influences the effectiveness of financial interventions aimed at recovery. Smaller entities, including micro and small firms, often exhibit unique adaptive resilience, leveraging established social networks to survive without formal structures (Kuckertz, 2021; Montserin et al., 2021; Sarkar and Clegg, 2021). In contrast, medium-sized firms, entrenched in established routines, find it challenging to pivot during crises (Core and De Marco, 2023; Martin et al., 2023).

Our data reveal no signs of resource misallocation in an era of significant liquidity injections and lenient monetary policies. On the contrary, small enterprises have adeptly used these resources to facilitate recovery and improvement. Interestingly, zombie firms, often labelled as inefficient, have used the funds more effectively than their healthier counterparts, indicating that financial support can lead to substantial

turnarounds (Acharya et al., 2022). This finding challenges the widespread scepticism about financing such firms and underscores that firms can leverage financial interventions for significant recovery.

Our results also indicate that economic variables such as turnover recover more rapidly than employment in the short term. This pattern aligns with typical responses to economic shocks or financial turbulence since firms prioritize resuming operational normality over workforce expansion, which tends to lag in recovery (Acharya et al., 2019; Banerjee and Hofmann, 2018). During periods like lockdowns, firms focus on maintaining liquidity and operational viability rather than employment, which is often adjusted based on market conditions.

6. Conclusions

This research delves into the zombification risk associated with economic shocks, specifically examining the impact of financial aid on companies facing distress. Drawing on data from 181,526 MSMEs that received public guarantees and other 220,179 counterparts, our study reveals that small and micro firms receiving financial support are not zombified, but rather de-zombified. Furthermore, we found no evidence of resource misallocation, reinforcing the effectiveness of public guarantees in fostering recovery without perpetuating inefficiencies (Acharya et al., 2022; Cros et al., 2021; Ono and Yasuda, 2017).

These findings carry significant implications for policymakers, who may consider adopting similar measures to address other challenges, such as the Ukraine war or the New Green Deal. Such policies could also help scale up firms facing inherent difficulties due to their size, as demonstrated by the resilience and adaptability of smaller firms during the pandemic (Kuckertz, 2021; Montserin et al., 2021; Sarkar and Clegg, 2021). Furthermore, given the complexity of distinguishing between healthy and zombie companies in such contexts, this study provides empirical evidence that supports the provision of financial support to both types of companies without incurring the risk of zombifying the economy. On the contrary, the recovery of zombie firms is promoted.

Managers, particularly those from distressed firms, can gain valuable insights from our analysis. Our results indicate that micro and small firms receiving a public loan guarantee can overcome difficult circumstances, resulting in increased turnover and employment. This form of financial support complements other business strategies, such as downsizing, restructuring, and implementing innovative practices, which have previously proved to have a positive impact (Core and De Marco, 2023; Martin et al., 2023).

For researchers, this study contributes to a growing body of literature on the impact of public guarantees in countries that have been proactive in supporting their economic fabric during significant crises. This research is also intended to provide a preliminary answer to two research questions, aimed at the potential different impact of financial aid on the recovery of zombie and non-zombie firms, and the possibility of such effects being different depending on firms' size.

Our findings underscore the critical role of governmental intervention in not just averting further economic decline but actively facilitating the recovery of vulnerable sectors (Collier et al., 2024). Moreover, by benefiting zombie firms proportionately more, government loan guarantees had positive short-term effects on the economy. However, this support may have caused a negative selection effect, reducing its effect on long-run growth (Carreira and Teixeira, 2016). This issue is not covered by the present research and would require further investigation. Future research could also extend these findings by analysing differences by zombie measurement, sector, exploring spill-over effects, and assessing the impact of continuous treatment on firm performance. Such extensions would provide deeper insights into how different types of firms benefit from public interventions in times of economic distress.

Author statement

Each author has contributed significantly to the research and writing process, ensuring the integrity and quality of the work. Furthermore, all authors declare that there are no conflicts of interest related to this research.

Funding

This work was supported by Grant PID2022-137379NB-I00 funded by MCIN/AEI/10.13039/501100011033 and by 'ERDF A way of making Europe'.

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.

Acknowledgements

We are sincerely grateful to the anonymous reviewers and the editorial team of Economic Modelling for their constructive comments and suggestions, which have significantly improved the quality of this paper. We also thank the participants of ACEDE 2025 for their valuable feedback and insights. Special thanks go to Jaime Gómez-Obregón for developing the raw database that forms the basis of this research. This work was supported by Grant PID2022-137379NB-I00, funded by MCIN/AEI/10.13039/501100011033 and co-financed by the European Regional Development Fund (ERDF), "A way of making Europe." The dataset used in this study is available at: Acebo, Enrique; Gutiérrez López, Cristina; Abad González, Julio; Miguel-Dávila, José-Ángel (2025), "ICO COVID-19 Public Loan Guarantees in Spain (2020–2021)", Mendeley Data, V1, doi: 10.17632/kv78gfs9ny.2.

Appendix

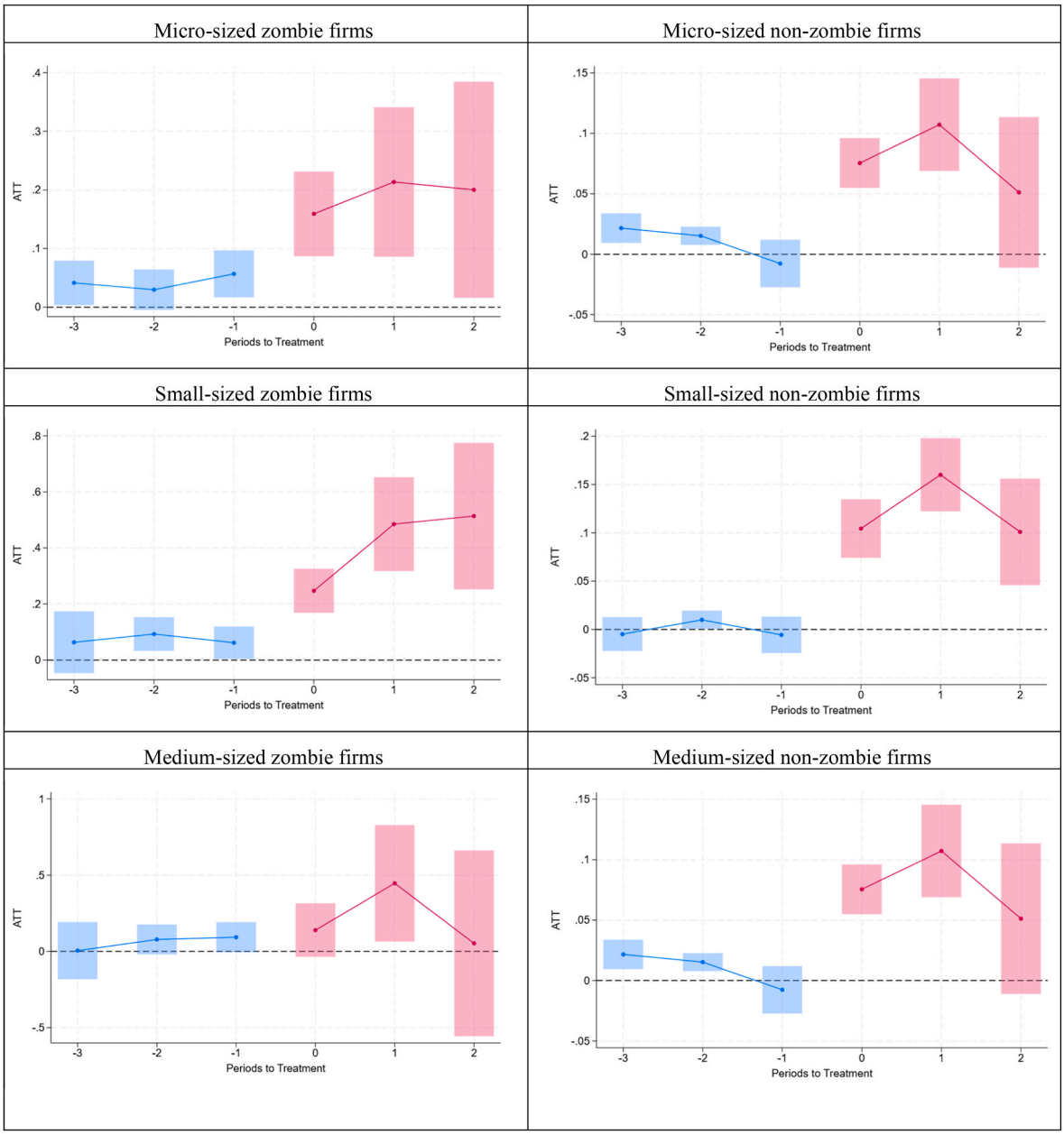


Fig. A1. Impact of Guarantees on Turnover using Alternative Size Definition
Note: The figures show the effect of ICO public loan guarantees on turnover in log base, calculated using Sant'Anna and Zhao's (2020) doubly robust DiD estimator based on stabilized inverse probability weighting and ordinary least squares using observations not yet treated as control group and clustered standard errors at NACE Rev. 2 at four digits. ATTs are estimated for each period relative to the period first treated across all cohorts. Alternative firm size is defined using both conditions of employment and turnover or/assets.

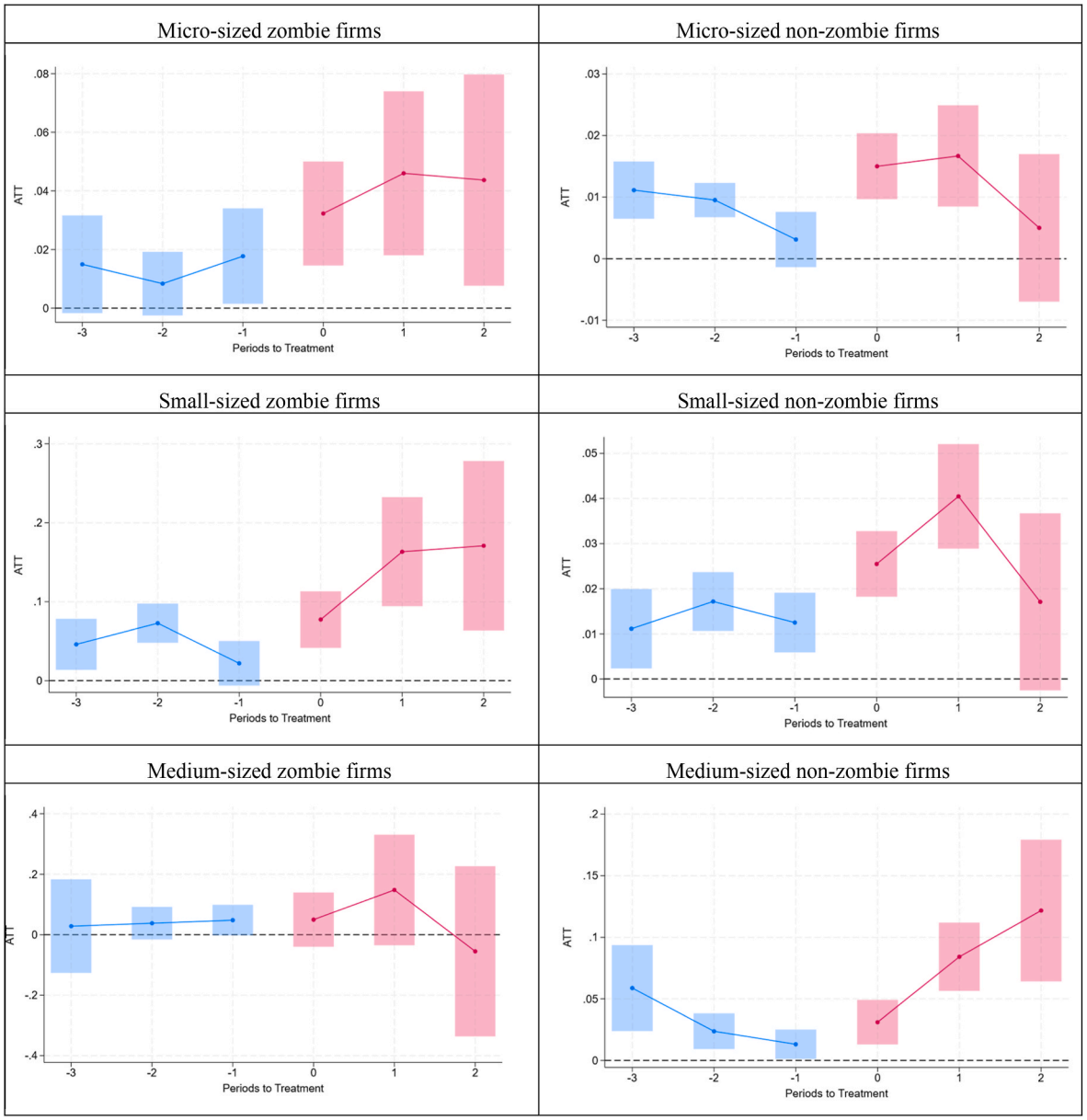


Fig. A2. Impact of Guarantees on Employment using Alternative Size Definition

Note: The figures show the effect of ICO public loan guarantees on employment in log base, calculated using Sant'Anna and Zhao's (2020) doubly robust DiD estimator based on stabilized inverse probability weighting and ordinary least squares using observations not yet treated as control group and clustered standard errors at NACE Rev. 2 at four digits. ATTs are estimated for each period relative to the period first treated across all cohorts. Alternative firm size is defined using both conditions of employment and turnover or/assets.

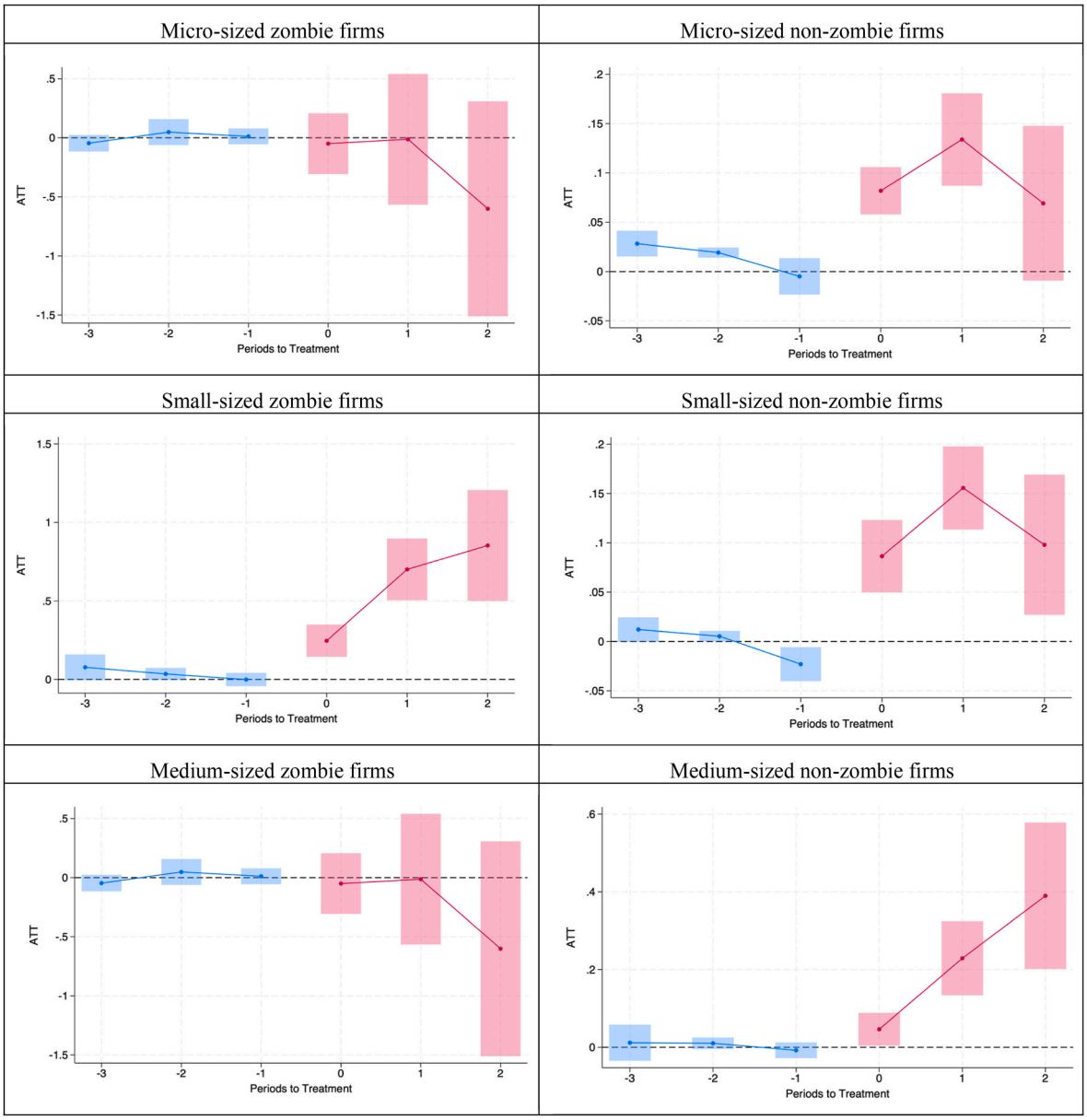


Fig. B1. Impact of Guarantees on Turnover using Alternative Zombie Definition
Note: The figures show the effect of ICO credit guaranteed loans on turnover in log base, calculated using Sant'Anna and Zhao's (2020) doubly robust DiD estimator based on stabilized inverse probability weighting and ordinary least squares using observations not yet treated as control group and clustered standard errors at NACE Rev. 2 at four digits. ATTs are estimated for each period relative to the period first treated across all cohorts. Alternative zombie status is defined as firms whose Interest Coverage Ratio (ICR) has been below 1 for three consecutive years prior to treatment and whose age exceeds 10 years.

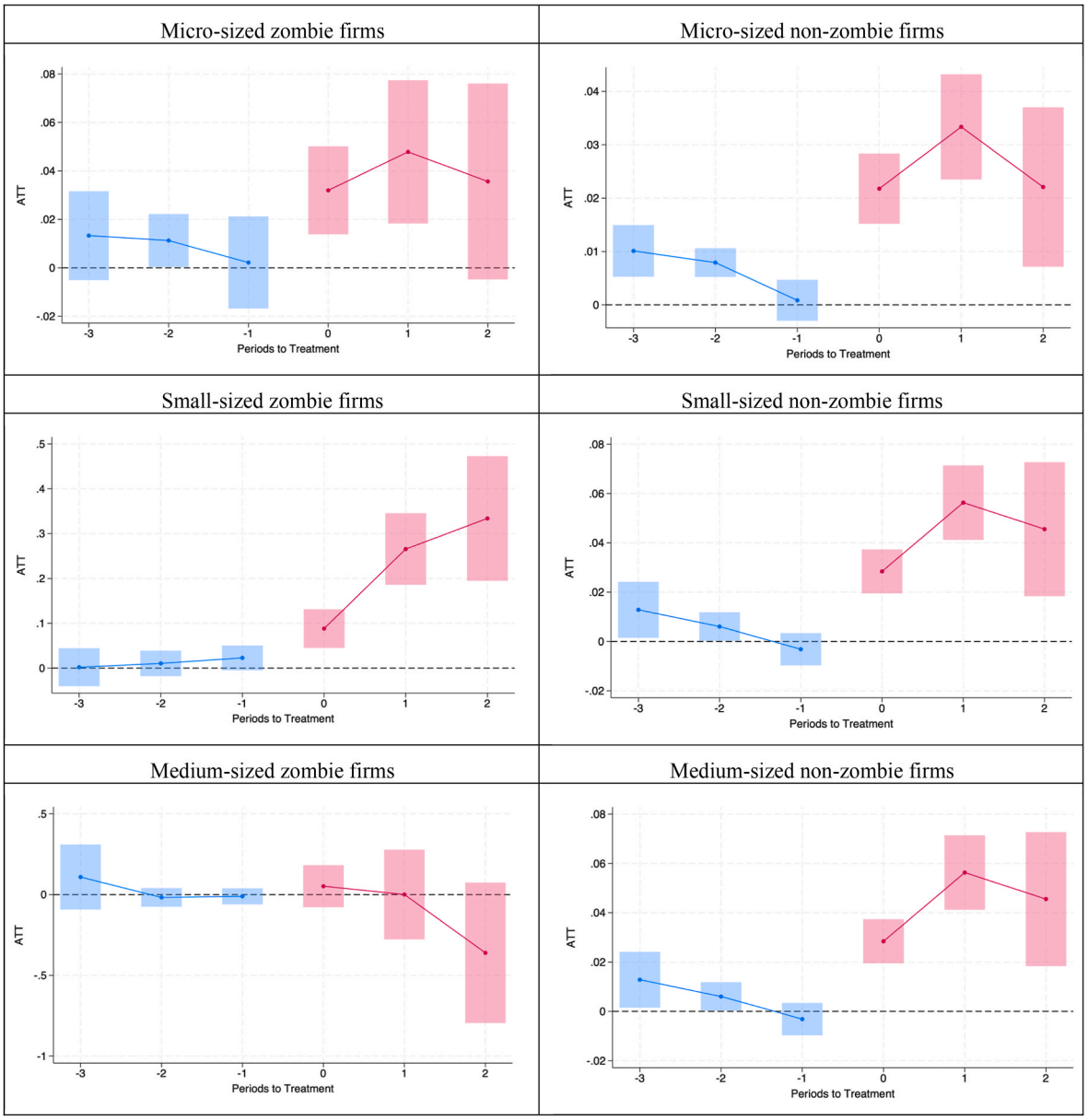


Fig. B2. Impact of Guarantees on Employment using Alternative Zombie Definition
Note: The figures show the effect of ICO credit guaranteed loans on employment in log base, calculated using Sant'Anna and Zhao's (2020) doubly robust DiD estimator based on stabilized inverse probability weighting and ordinary least squares using observations not yet treated as control group and clustered standard errors at NACE Rev. 2 at four digits. ATTs are estimated for each period relative to the period first treated across all cohorts. Alternative zombie status is defined as firms whose Interest Coverage Ratio (ICR) has been below 1 for three consecutive years prior to treatment and whose age exceeds 10 years.

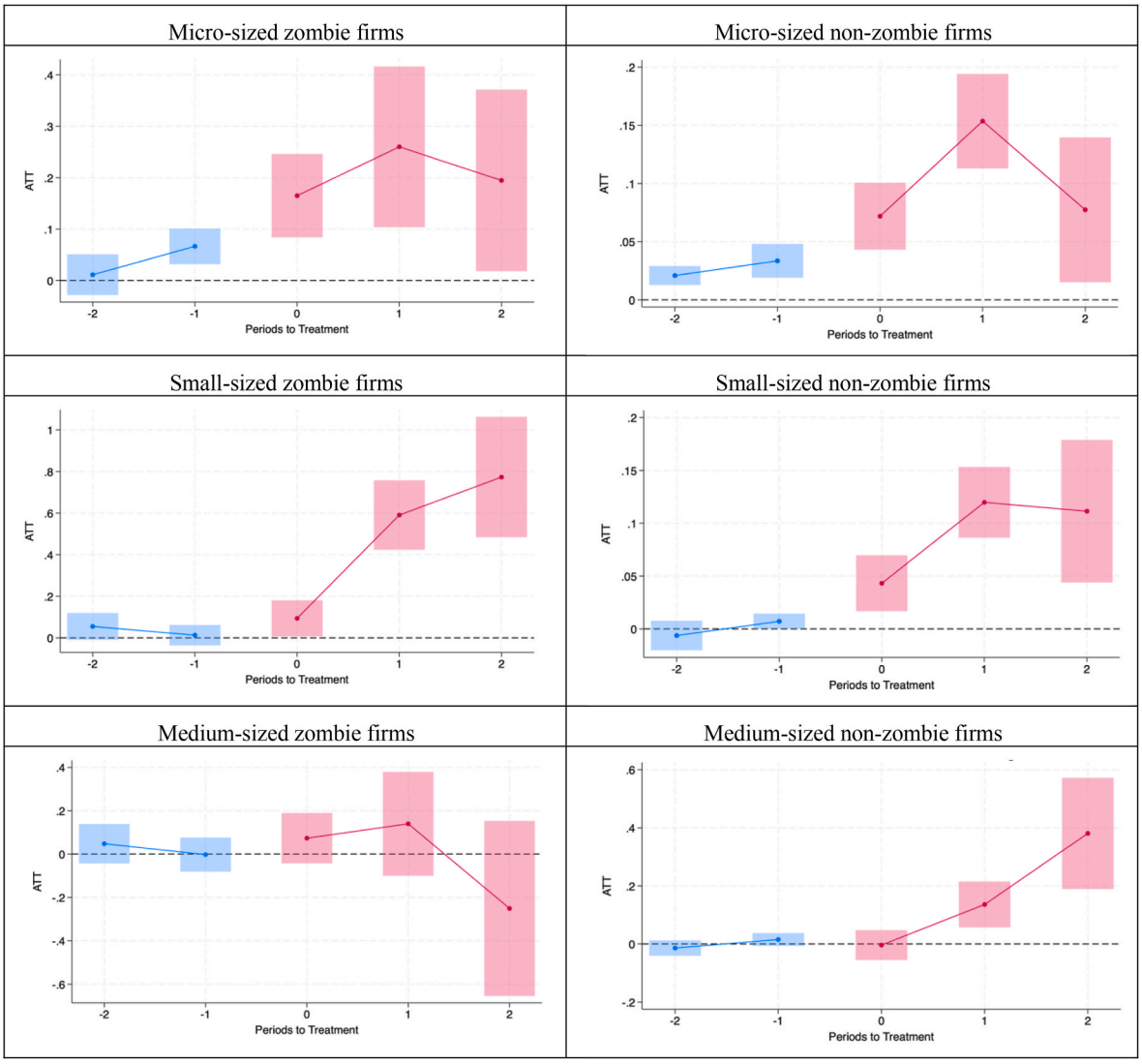


Fig. C1. Impact of 2020 Guarantees on Turnover

Note: The figures show the effect of ICO credit guaranteed loans on turnover in log base, calculated using Sant'Anna and Zhao's (2020) doubly robust DiD estimator based on stabilized inverse probability weighting and ordinary least squares using observations not yet treated as control group and clustered standard errors at NACE Rev. 2 at four digits. ATTs are estimated for each period relative to the period first treated across all cohorts.

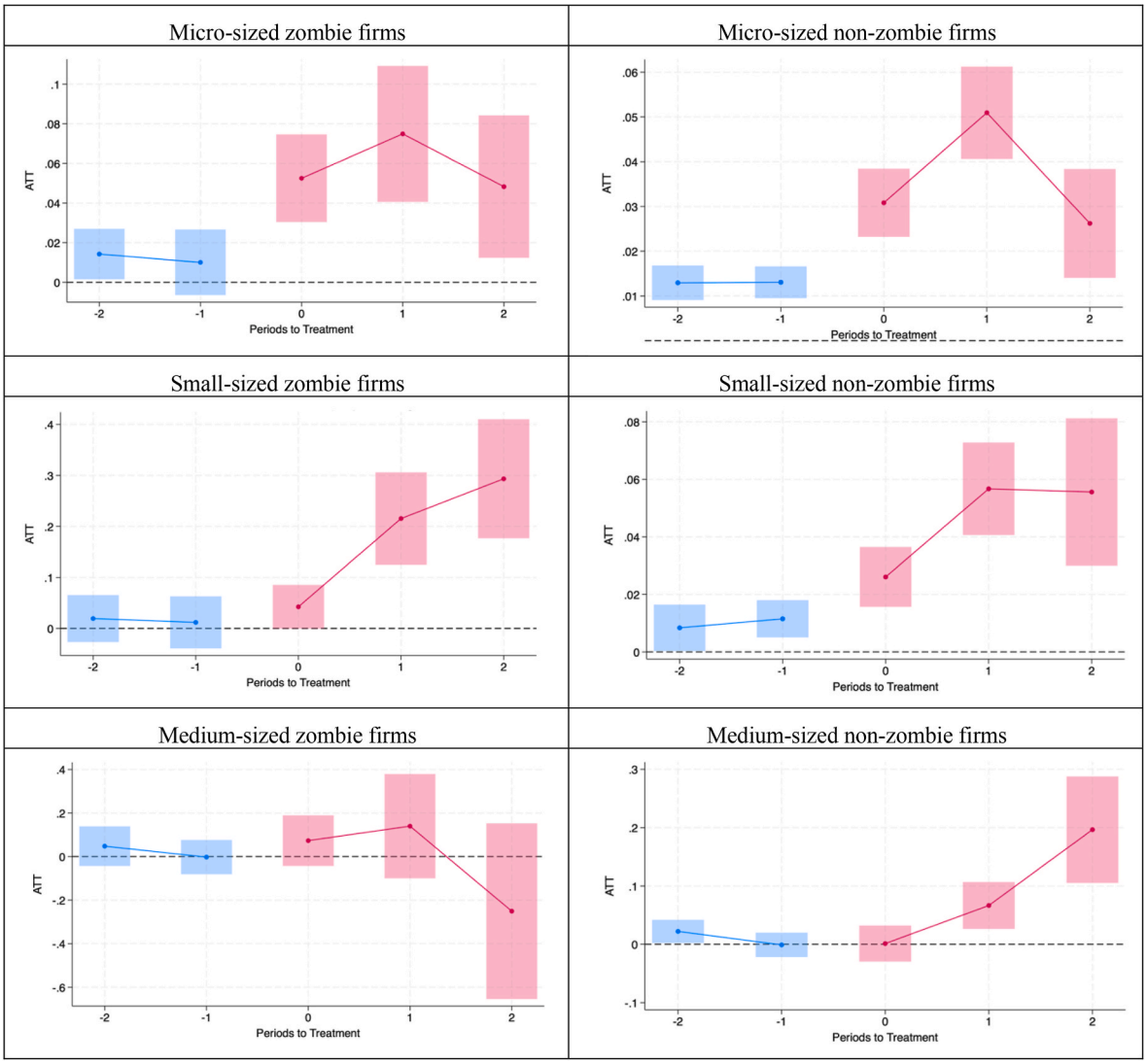


Fig. C2. Impact of 2020 Guarantees on Employment
Note: The figures show the effect of ICO credit guaranteed loans on employment in log base, calculated using Sant'Anna and Zhao's (2020) doubly robust DiD estimator based on stabilized inverse probability weighting and ordinary least squares using observations not yet treated as control group and clustered standard errors at NACE Rev. 2 at four digits. ATTs are estimated for each period relative to the period first treated across all cohorts.

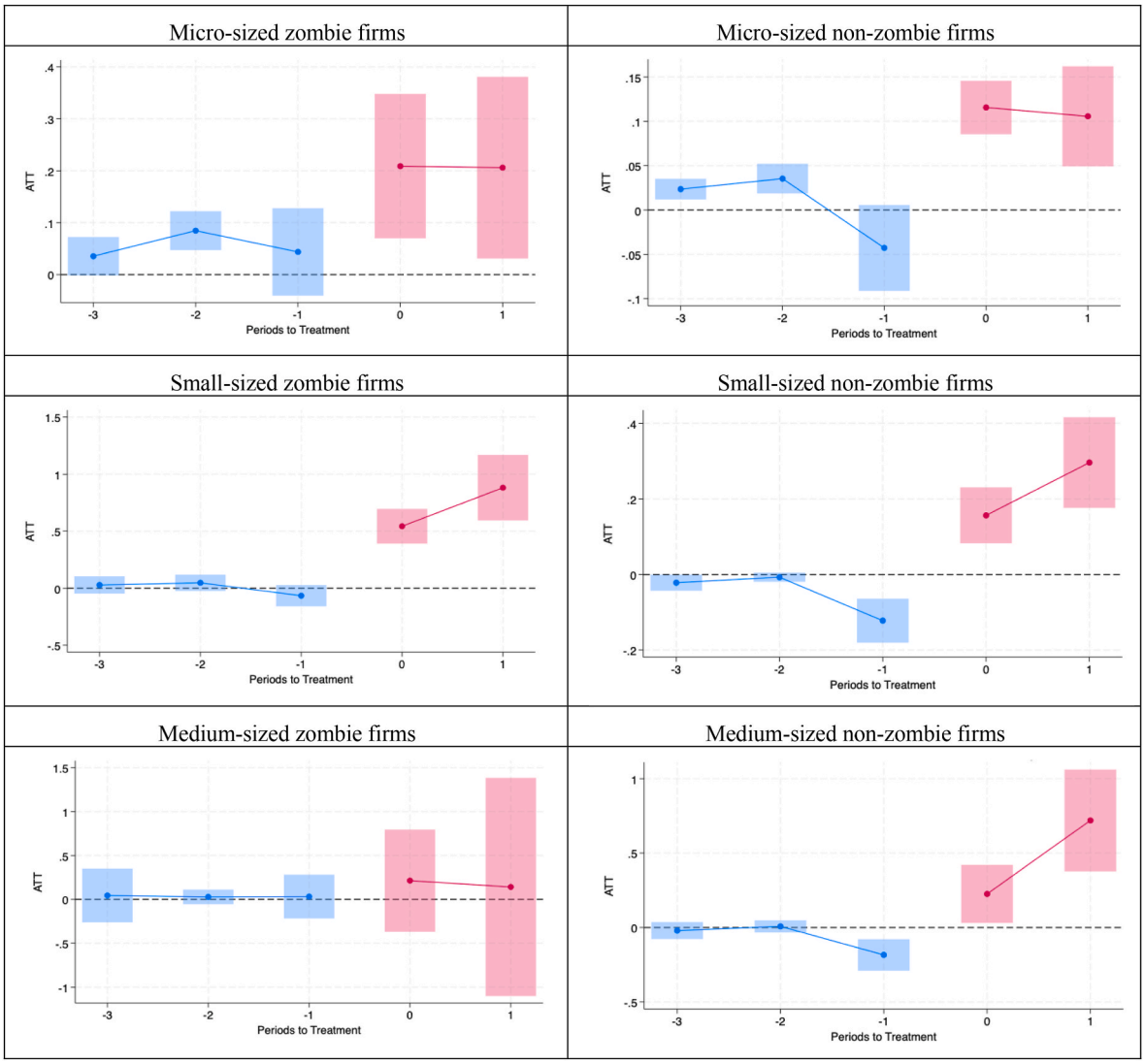


Fig. D1. Impact of 2021 Guarantees on Turnover
Note: The figures show the effect of ICO credit guaranteed loans on turnover in log base, calculated using Sant'Anna and Zhao's (2020) doubly robust DiD estimator based on stabilized inverse probability weighting and ordinary least squares using observations not yet treated as control group and clustered standard errors at NACE Rev. 2 at four digits. ATTs are estimated for each period relative to the period first treated across all cohorts.

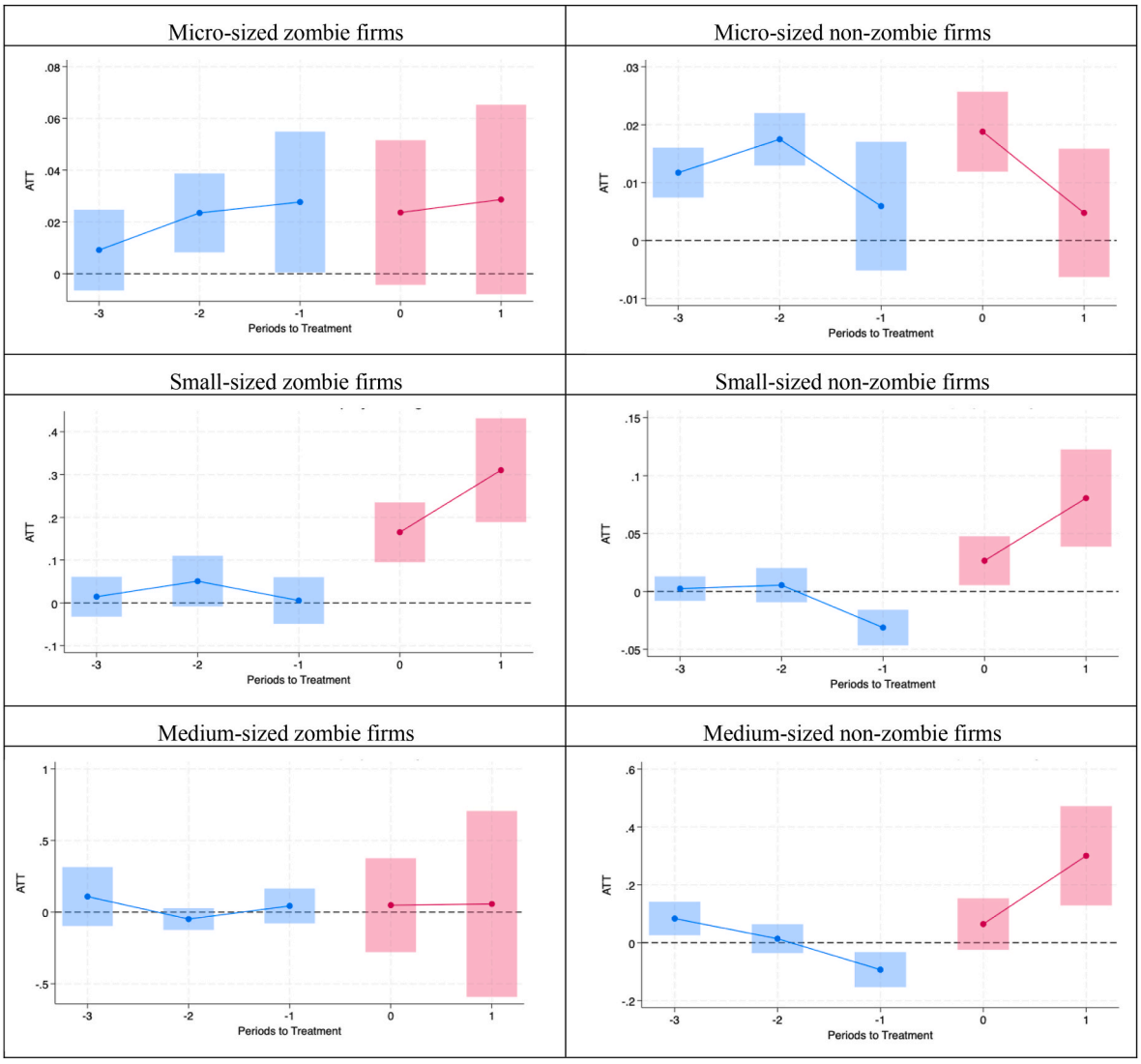


Fig. D2. Impact of 2021 Guarantees on Employment
Note: The figures show the effect of ICO credit guaranteed loans on employment in log base, calculated using Sant'Anna and Zhao's (2020) doubly robust DiD estimator based on stabilized inverse probability weighting and ordinary least squares using observations not yet treated as control group and clustered standard errors at NACE Rev. 2 at four digits. ATTs are estimated for each period relative to the period first treated across all cohorts.

Data availability

ICO COVID-19: Public Loan Guarantees in Spain (2020–2021) (Reference data) (Mendeley Data)

References

Abadie, A., Diamond, A., Hainmueller, J., 2010. Synthetic control methods for comparative case studies: estimating the effect of California's Tobacco Control Program. J. Am. Stat. Assoc. 105 (490), 493–505. https://doi.org/10.1198/jasa.2009.ap08746.

Acharya, V.V., Crosignani, M., Eisert, T., Steffen, S., 2022. Zombie lending: theoretical, international, and historical perspectives. Ann. Rev. Finan. Econ. 14, 21–38. https://doi.org/10.1146/annurev-financial-111620-114424.

Acharya, V.V., Eisert, T., Eufinger, C., Hirsch, C., 2019. Whatever it takes: the real effects of unconventional monetary policy. Rev. Financ. Stud. 32 (9), 3366–3411. https://doi.org/10.1093/rfs/hhz005.

Acharya, V.V., Crosignani, M., Eisert, T., Eufinger, C., 2024. Zombie credit and (Dis-) Inflation: evidence from Europe. J. Finance 79 (3), 1883–1929. https://doi.org/10.1111/jofi.13342.

Albuquerque, B., Iyer, R., 2023. The Rise of the Walking Dead: Zombie Firms Around the World. International Monetary Fund. https://doi.org/10.2139/ssrn.4509345. Working Paper, WP/23/125.

Alekseev, G., Amer, S., Gopal, M., Kuchler, T., Schneider, J.W., Stroebel, J., Wernerfelt, N., 2023. The effects of COVID-19 on U.S. small businesses: evidence from owners, managers, and employees. Manag. Sci. 69 (1), 7–24. https://doi.org/10.1287/mnsc.2022.4327.

Altomonte, C., Demertzis, M., Fontagné, L., Müller, S., 2021. COVID-19 financial aid and productivity: has support been well spent? Policy contribution, 21. Bruegel. https://www.bruegel.org/sites/default/files/wp_attachments/PC-21-031121.pdf.

Álvarez, L., García-Posada, M., Mayordomo, S., 2023. Distressed firms, zombie firms and zombie lending: a taxonomy. J. Bank. Finance 149, 106762. https://doi.org/10.1016/j.jbankfin.2023.106762.

Anderson, J., Papadia, F., Veron, N., 2021. COVID-19 Credit Support Programs in Europe's Five Largest Economies. Peterson Institute for International Economics. https://doi.org/10.2139/ssrn.3826517. Working Paper No. 21-6.

Andrews, D., McGowan, M.A., Millot, V., 2017. Confronting the zombies. In: OECD Economic Policy Paper. No. 21. https://doi.org/10.1787/f14fd801-en.

Andrews, D., Petroulakis, F., 2019. Breaking the Shackles: Zombie Firms, Weak Banks and Depressed Restructuring in Europe, ECB Working Paper, No. 2240. European Central Bank (ECB), Frankfurt. https://doi.org/10.2866/192858.

Banerjee, R., Hofmann, B., 2018. The Rise of Zombie Firms: Causes and Consequences. BIS Quaterly Review, pp. 67–78. September. https://www.bis.org/publ/qtrpdf/r_qt1809g.pdf.

Banerjee, R., Hofmann, B., 2022. Corporate zombies: anatomy and life cycle. Econ. Policy 37 (112), 757–803. https://doi.org/10.1093/epolic/eiac027.

Békés, G., Kézdi, G., 2021. Data Analysis for Business, Economics, and Policy. Cambridge University Press, Cambridge.

Belghitar, Y., Moro, A., Radić, N., 2022. When the rainy day is the worst hurricane ever: the effects of governmental policies on SMEs during COVID-19. Small Bus. Econ. 58 (2), 943–961. https://doi.org/10.1007/s11187-021-00510-8.

Bertoni, F., Martí, J., Reverte, C., 2019. The impact of government-supported participative loans on the growth of entrepreneurial ventures. Res. Pol. 48 (1), 371–384. https://doi.org/10.1016/j.respol.2018.09.006.

Bertoni, F., Colombo, M.G., Quas, A., 2023. The long-term effects of loan guarantees on SME performance. J. Corp. Finance 80 (June 2023), 102408. https://doi.org/10.1016/j.jcorpfin.2023.102408.

Bighelli, T., Lalinsky, T., 2021. COVID-19 Government Support and Productivity: Micro-Based cross-country Evidence. CompNet Policy Brief, pp. 1–18, 14(August).

Blattner, L., Farinha, L., Rebelo, F., 2023. When losses turn into loans: the cost of weak banks. Am. Econ. Rev. 113 (6), 1600–1641. https://doi.org/10.1257/aer.20190149.

Bowman, J., 2022. The life-cycle dynamics of zombie companies amongst listed firms in China. China World Econ. 30 (5), 185–205. https://doi.org/10.1111/cwe.12442.

Caballero, R.J., Hoshi, T., Kashyap, A.K., 2008. Zombie lending and depressed restructuring in Japan. Am. Econ. Rev. 98 (5), 1943–1977. https://doi.org/10.1257/aer.98.5.1943.

Callaway, B., Li, T., 2023. Policy evaluation during a pandemic. J. Econom. 236 (1), 105454. https://doi.org/10.1016/j.jeconom.2023.03.009.

Callaway, B., Sant'Anna, P.H.C., 2021. Difference-in-Differences with multiple time periods. J. Econom. 225 (2), 200–230. https://doi.org/10.1016/j.jeconom.2020.12.001.

Carreira, C., Teixeira, P., 2016. Entry and exit in severe recessions: lessons from the 2008-2013 Portuguese economic crisis. Small Bus. Econ. 46 (4), 591–617. https://doi.org/10.1007/s11187-016-9703-3.

Carreira, C., Teixeira, P., Nieto-Carrillo, E., 2022. Recovery and exit of zombie firms in Portugal. Small Bus. Econ. 59 (2), 491–519. https://doi.org/10.1007/s11187-021-00483-8.

Chetty, R., Friedman, J.N., Stepner, M., 2023. The Economic Impacts of COVID-19: Evidence from a New Public Database Built Using Private Sector Data. National Bureau of economic research. National Bureau of Economic Research Working Paper, w27431. https://www.nber.org/system/files/working_papers/w27431/w27431.pdf.

Collier, B., Howell, S.T., Rendell, L., 2024. After the Storm: How Emergency Liquidity Helps Small Businesses Following Natural Disasters. National Bureau of Economic Research Working Paper, 32326. https://doi.org/10.2139/ssrn.4784537.

Core, F., De Marco, F., 2023. Information technology and credit: evidence from public guarantees. Manag. Sci. 70 (9), 6202–6219. https://doi.org/10.1287/mnsc.2023.4957.

Cros, M.A., Epaulard, A., Martin, P., 2021. Will Schumpeter Catch Covid-19? CEPR Discussion Paper. No. 15834. CEPR Press, Paris & Longon. https://cepr.org/publications/dp15834.

Dai, X., Qiao, X., Song, L., 2019. Zombie firms in China's coal mining sector: identification, transition determinants and policy implications. Resour. Policy 62 (August), 664–673. https://doi.org/10.1016/j.resourpol.2018.11.016.

de Barrón, I., 2020. The Banking Sector Injects €63,000 Million in Loans with ICO Guarantees to self-employed Workers and Companies. El País. June,1.

Demmou, L., Franco, G., Calligaris, S., Dlugosch, D., 2021. Liquidity shortfalls during the COVID-19 outbreak: assessment and policy responses. OECD Econ. Depart. Work. Paper. 1647, 1–23. https://one.oecd.org/document/ECO/WKP(2021)1/en/pdf.

Deng, M., Wang, J., 2022. Why do zombie firms seldom die or resurrect? The effect of government subsidies on the survival duration of China's zombie firms. Economics 16 (1), 212–228. https://doi.org/10.1515/econ-2022-0029.

Doniger, C.L., Kay, B., 2021. Ten days late and billions of dollars short: the employment effects of delays in paycheck protection program financing. Finan. Econ. Discuss. Series 2021 (3), 1–71. https://doi.org/10.17016/FEDS.2021.003.

Dörr, J.O., Licht, G., Murmann, S., 2022. Small firms and the COVID-19 insolvency gap. Small Bus. Econ. 58 (2), 887–917. https://doi.org/10.1007/s11187-021-00514-4.

Endresz, M., Harasztosi, P., Lieli, R.P., 2015. The impact of the Magyar Nemzeti Bank's funding for growth scheme on firm level investment. In: MNB Working Paper, 2015/2. Magyar Nemzeti Bank. The Central Bank of Hungary, Budapest. https://www.econstor.eu/bitstream/10419/146623/1/823281329.pdf.

Erhardt, E.C., 2017. Microfinance beyond self-employment: evidence for firms in Bulgaria. Labour Econ. 47, 75–95. https://doi.org/10.1016/j.labeco.2017.04.009.

Favara, G., Minoiu, C., Perez-Orive, A., 2021. U.S. Zombie Firms: How Many and How Consequential?, FEDS Notes. Board of Governors of the Federal Reserve System, Washington. https://doi.org/10.17016/2380-7172.2954. (Accessed 30 July 2021).

Fernández-Cerezo, A., González, B., Izquierdo Peinado, M., Moral-Benito, E., 2023. Firm-level heterogeneity in the impact of the COVID-19 pandemic. Appl. Econ. 55 (42), 4946–4974. https://doi.org/10.1080/00036846.2022.2133894.

Fukuda, S., Nakamura, J., 2011. Why did 'Zombie' firms recover in Japan? World Econ. 34 (7), 1124–1137. https://doi.org/10.1111/j.1467-9701.2011.01368.x.

Goodman-Bacon, A., Marcus, J., 2020. Using difference-in-differences to identify causal effects of COVID-19 policies. Surve. Res. Method. 14 (2), 153–158. https://doi.org/10.18148/srm/2020.v14i2.7723.

Goodman-Bacon, A., 2021. Difference-in-differences with variation in treatment timing. J. Econom. 225 (2), 254–277. https://doi.org/10.1016/j.jeconom.2021.03.014.

Granja, J., Makridis, C., Yannelis, C., Zwick, E., 2020. Did the Paycheck Protection Program Hit the Target? National Bureau of Economic Research Working Paper. No. w27095. https://ssrn.com/abstract=3592172.

Grieder, T., Ortega, J., 2020. A Financial Stability Analysis of Zombie Firms in Canada. Financial Stability Department Bank of Canada, Staff Analytical Notes, pp. 2020–2023.

Guerini, M., Nesta, L., Ragot, X., Schiavo, S., 2024. Zombification of the economy? Assessing the effectiveness of French government support during COVID-19 lockdown. J. Econ. Behav. Organ. 218 (February), 263–280. https://doi.org/10.1016/j.jebo.2023.12.013.

Hallak, I., Harasztosi, P., Schich, S., 2018. Fear the walking dead? Incidence and effects of zombie firms in Europe. J. Econ. Sci. Res. 1 (1), 24–40. https://doi.org/10.30564/jesr.v1i1.393.

Hancké, B., Van Overbeke, T., Voss, D., 2020. The revenge of varieties of capitalism. A Comparative Political Economy of Economic Policies After Covid-19. London School of Economics. https://www.dropbox.com/s/sdf0eicbr0zdn4x/VOC%20and%20Covid-19.pdf?dl=0. (Accessed 27 May 2024).

Hong, G.H., Lucas, D., 2023. Evaluating the costs of government credit support programs during COVID-19: international evidence. International Moneraty Fund. https://papers.ssrn.com/sol3/papers.cfm?abstract_id=4351449.

Horvath, A., Lang, P., 2021. Do loan subsidies boost the real activity of small firms? J. Bank. Finance 122 (January), 105988. https://doi.org/10.1016/j.jbankfin.2020.105988.

Hoshi, T., 2006. Economics of the living dead. Jpn. Econ. Rev. 57 (1), 30–49. https://doi.org/10.1111/j.1468-5876.2006.00354.x.

Hoshi, T., Kawaguchi, D., Ueda, K., 2023. Zombies, again? The COVID-19 business support programs in Japan. J. Bank. Finance 147 (February), 106421. https://doi.org/10.1016/j.jbankfin.2022.106421.

Huntington-Klein, 2021. The Effect: an Introduction to Research Design and Causality. CRC Press, New York. https://doi.org/10.1201/9781003226055.

International Monetary Fund, 2021. Policy responses to COVID-19. https://www.imf.org/en/Topics/imf-and-covid19/Policy-Responses-to-COVID-19.

Kaplan, E.L., Meier, P., 1958. Nonparametric estimation from incomplete observations. J. Am. Stat. Assoc. 53 (282), 457–481. https://doi.org/10.2307/2281868.

Kane, E.J., 1987. Dangers of capital forbearance: the case of the FSLIC and "zombie" s&ls. Contemp. Econ. Policy 5 (1), 77–83. https://doi.org/10.1111/j.1465-7287.1987.tb00247.x.

Khan, S.U., 2022. Financing constraints and firm-level responses to the COVID-19 pandemic: international evidence. Res. Int. Bus. Finance 59 (January), 101545. https://doi.org/10.1016/j.ribaf.2021.101545.

Klein, V.B., Todesco, J.L., 2021. COVID-19 crisis and SMEs responses: the role of digital transformation. Knowl. Process Manag. 28 (2), 117–133. https://doi.org/10.1002/kpm.1660.

Kwon, H.U., Narita, F., Narita, M., 2015. Resource reallocation and zombie lending in Japan in the 1990s. Rev. Econ. Dynam. 18 (4), 709–732. https://doi.org/10.1016/j.red.2015.07.001.

Kuckertz, A., 2021. Standing up against crisis-induced entrepreneurial uncertainty: fewer teams, more habitual entrepreneurs. Int. Small Bus. J. Res. Entrep. 39 (3), 191–201. https://doi.org/10.1177/0266242621997782.

Laeven, L., Schepends, G., Schnabel, I., 2020. Zombification in Europe in times of pandemic. No 11, ECONtribute Policy Brief Series. https://www.econtribute.de/RePEc/ajk/ajkpbs/ECONtribute_PB_011_2020.pdf.

Martin, A., Mayordomo, S., Vanasco, V., 2023. Banks vs. firms: who benefits from credit guarantees? BSE Working Paper. No. 1389. https://bse.eu/research/working-papers/banks-vs-firms-who-benefits-credit-guarantees.

McGowan, M., Andrews, D., Millot, V., 2018. The Walking Dead?: Zombie Firms and Productivity Performance in OECD Countries (OECD Economics Department Working Papers No. 1372). OECD Publishing. https://doi.org/10.1787/180d80ad-en.

Montserin, A., Dindial, M., Piperopoulos, P., 2021. Resilience strategies during COVID-19: how informality and social networks can shield SMEs. Acad. Manag. Proc. 1, 16428. https://doi.org/10.5465/AMBPP.2021.16428abstract.

Muñoz-Izquierdo, N., Mazarío, J.M.J., Camacho-Miñano, M.-M., 2024. Zombie firms and disclosures in the expanded audit report. Rev. Manager. Sci. 18, 1519–1555. https://doi.org/10.1007/s11846-023-00666-5.

Nakamura, J., 2017. Evolution and recovery of zombie firms: japan's experience. In: Nakamura, J. (Ed.), Japanese Firms During the Lost Two Decades. Springer, pp. 7–36. https://doi.org/10.1007/978-4-431-55918-4.

Nieto-Carrillo, E., Carreira, C., Teixeira, P., 2022. Giving zombie firms a second chance: an assessment of the reform of the Portuguese insolvency framework. Econ. Anal. Pol. 76, 156–181. https://doi.org/10.1016/j.eap.2022.08.003.

Nurmi, S., Vanhala, J., Virén, M., 2022. Are zombies for real? Evidence from zombie dynamics. Int. J. Ind. Organ. 85 (December), 102888. https://doi.org/10.1016/j.ijindorg.2022.102888.

Ono, A., Yasuda, Y., 2017. Forgiveness versus financing: the determinants and impact of SME debt forbearance in Japan. RIETI Policy Discussion Paper, 17-E-086. https://www.rieti.go.jp/jp/publications/dp/17e086.pdf.

Pedauga, L., Sáez, F., Delgado-Márquez, B.L., 2022. Macroeconomic lockdown and SMEs: the impact of the COVID-19 pandemic in Spain. Small Bus. Econ. 58 (2), 665–688. https://doi.org/10.1007/s11187-021-00476-7.

Peek, J., Rosengren, E.S., 2005. Unnatural selection: perverse incentives and the misallocation of credit in Japan. Am. Econ. Rev. 95 (4), 1144–1166. https://doi.org/10.1257/0002828054825691.

Pelosi, M., Rodano, G., Sette, E., 2021. Zombie firms and the Take-up of support measures during Covid-19. Bank of Italy Occasional Paper No. 650. https://doi.org/10.2139/ssrn.4032687.

Rambackan, Y., Roth, A., 2023. Market design when firms do not know preferences: designing centralized admission systems with limited information. Rev. Econ. Stud. 90 (4), 1502–1544. https://doi.org/10.1093/restud/rdad018.

Rodríguez-Sanz, J.A., Vallelado, E., Velasco, P., 2024. Escaping zombiness: does corporate governance have the elixir of life? Br. J. Manag. 35 (4), 2174–2196. https://doi.org/10.1111/1467-8551.12822.

Rojas, F., del Olmo, F., Aires, D., 2022. Zombie firms: an analysis of business sector vulnerability post-COVID-19. Funcas SEFO 11 (1), 43–52.

Sant'Anna, P., Zhao, J., 2020. Doubly robust difference-in-differences estimators. J. Econom. 219 (1), 101–122. https://doi.org/10.1016/j.jeconom.2020.06.003.

Sarkar, S., Clegg, S.R., 2021. Resilience in a time of contagion: lessons from small businesses during the COVID-19 pandemic. J. Change Manag. 21 (2), 242–267. https://doi.org/10.1080/14697017.2021.1917495.

Sasso, A., Canzian, G., Crivellaro, E., Duso, T., Ferrara, A., Verzillo, S., 2025. The impact of financial support to firms during crises: the case of covid aid in the EU. https://dx.doi.org/10.2139/ssrn.5260779.

Schivardi, F., Sette, E., Tabellini, G., 2020. Identifying the real effects of zombie lending. Rev. Corporat. Finan. Stud. 9 (3), 569–592. https://doi.org/10.1093/rcfs/cfaa010.

Sun, L., Abraham, S., 2021. Estimating dynamic treatment effects in event studies with heterogeneous treatment effects. J. Econom. 225 (2), 175–199. https://doi.org/10.1016/j.jeconom.2020.09.006.

Szücs, C., 2021. The annual shareholder meeting in Austria in times of the COVID-19 pandemic. In: Schneckenleitner, P., Reitberger, W., Brunner-Sperdin, A., Haller, A. (Eds.), Conference Proceedings Trends in Business Communication 2020. Springer Gabler, Wiesbaden. https://doi.org/10.1007/978-3-658-33642-4_9.

Tracey, B., 2019. The real effects of Zombie lending in Europe. SSRN Electron. J. 783. https://doi.org/10.2139/ssrn.3346350.

World Bank COVID-19 Response, 2020. https://www.worldbank.org/en/news/factsheet/2020/10/14/world-bank-covid-19-response.

Zheng, Y., Dong, H., Li, N., 2024. Analysis of the impact of the COVID-19 lockdown on financial technology (FinTech), interest rate liberalization (IRL) and commercial banks' risk-taking: chinese empirical evidence. Appl. Econ. 57 (2), 135–151. https://doi.org/10.1080/00036846.2024.2302934.

Zoller-Rydzek, B., Keller, F., 2020. COVID-19: guaranteed loans and zombie firms. CESifo Econ. Stud. 66 (4), 322–364. https://doi.org/10.1093/cesifo/ifaa014.