

Publication status: This preprint has not been published elsewhere.

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<https://doi.org/10.1590/1808-057x20262512>

Submitted on: 2026-08-03

Posted on: 2026-08-03 (version 1)

(YYYY-MM-DD)

DOI: 10.1590/1808-057x20262512

e-location: e2512

The hidden cost of zombification: Zombie firms and corporate policy distortions in emerging markets

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Received on 11/02/2025 – Desk acceptance on 11/27/2025 – 3rd version approved on 04/15/2026

Academic Editor-in-Chief: Lucas Ayres Barreira de Campos Barros 

Associate Editor: Pedro Guilherme Ribeiro Piccoli

ABSTRACT

This study examines how zombie status and zombie prevalence are associated with key corporate financial decisions in 25 emerging market economies over 2002-2021. While prior literature focuses on advanced economies, evidence for emerging markets remains limited, particularly regarding cross-country heterogeneity and the systemic effects of zombification on non-zombie firms. Using firm-level data, we estimate three-level hierarchical models (time-firm-country) to disentangle firm- and country-level effects, complemented by robustness checks. Zombie status is associated with lower investment, lower dividends, lower cash holdings, higher borrowing costs, higher market risk, and higher research and development. Importantly, a higher country-level share of zombie firms is also associated with changes in the financial decisions of non-zombie firms, indicating spillover effects. These findings document the hidden cost of zombification, reflected in its impact on otherwise healthy firms. Zombification is associated with broader financial distortions affecting both distressed and healthy firms. By emphasizing its systemic and cross-country nature, the study provides insights for policymakers concerned with financial stability, credit allocation, and corporate governance in emerging economies.

Keywords: zombie firms, emerging markets, corporate finance.

This article is derived from a doctoral dissertation defended by the author Alberto Granzotto, under the supervision of the authors Igor Bernardi Souza and Guilherme Kirch, in 2024.

1. INTRODUCTION

The term zombie firm broadly refers to companies that remain operational despite persistent financial weakness, typically characterized by an inability to generate sufficient earnings to cover debt servicing costs under normal market conditions (Altman, 2020; Banerjee & Hofmann, 2018). Such firms often survive through continued access to subsidized credit, loan evergreening, or implicit government support, giving rise to what Wu and Pan (2021) describe as “rigid but immortal” firms.

The growing academic and policy interest in zombification reflects not only its expansion but also its implications for capital allocation efficiency and financial stability. A prolonged low-interest-rate environment following the Global Financial Crisis facilitated credit access for weak firms that would otherwise have exited the market (Altman, 2020). Empirical evidence documents a marked increase in zombie prevalence across advanced economies in recent decades (Altman et al., 2024; Banerjee & Hofmann, 2018; Ghoul et al., 2021). However, far less attention has been devoted to the structural and cross-country dynamics of zombification in emerging markets.

A central issue in the zombie literature concerns distortions in corporate policies. Prior studies show that zombification is associated with misallocation of credit, depressed productivity, lower investment, altered leverage, and heightened risk (Caballero et al., 2008; Ghorbani, 2025; Ghoul et al., 2021; Hallak et al., 2018). Importantly, these distortions are not confined to zombie firms. The presence of zombies may crowd out healthier firms, alter competition, distort financing conditions, and reshape corporate policies (Banerjee & Hofmann, 2018; Hallak et al., 2018).

Despite this growing body of research, two gaps remain. First, evidence for emerging markets is still limited, particularly regarding how zombification varies across countries with distinct institutional and financial structures. Second, while firm-level differences between zombie and non-zombie firms are well documented, less attention has been given to broader

systemic effects, especially how zombie prevalence within a country shapes the behavior of otherwise healthy firms.

To address these gaps, this study examines how both zombie status at the firm level and zombie prevalence at the country level are associated with key corporate financial decisions in 25 emerging market economies over 2002-2021. Specifically, we analyze whether zombie firms differ systematically in their policies relative to non-zombie firms and whether increases in the country-level share of zombies are associated with adjustments in the financial decisions of non-zombie firms, capturing cross-level spillover effects. These spillover effects are central to what we define as the “hidden cost” of zombification.

In this context, we define the “hidden cost” of zombification as the impact of zombie prevalence on the financial behavior of non-zombie firms. While this interpretation is consistent with a spillover mechanism, it also raises an important identification challenge. Higher zombie prevalence may reflect underlying country-specific characteristics, such as institutional quality or financial development, which can simultaneously affect both zombie and non-zombie firms. To mitigate this concern, our empirical strategy relies on a multilevel framework that separates within- and between-country variation, complemented by country-level controls. This approach allows us to provide evidence consistent with spillover effects, while acknowledging that institutional factors may also contribute to the observed patterns.

To operationalize this empirical strategy, to identify zombie firms, we employ static and dynamic classifications based on interest coverage ratios (ICRs) and Altman’s Z-score framework, following Altman et al. (2024) and Granzotto et al. (2025). To account for the hierarchical structure of the data and disentangle firm- and country-level effects, we use three-level hierarchical linear models (time-firm-country), allowing decomposition of within- and between-country variation.

The results reveal distinct patterns across levels of analysis. At the firm level, consistent with prior literature, zombie firms exhibit weaker financial policies, including lower capital expenditures, cash holdings, dividend distributions, higher borrowing costs, and greater market risk. More importantly, substantial heterogeneity emerges at the country level. A higher share of zombie firms is associated with meaningful adjustments in the financial policies of non-zombie firms, including lower investment, altered liquidity behavior, higher risk, and changes in payout decisions.

These findings highlight the systemic cost of zombification in emerging markets. While zombie firms may remain operational and appear to stabilize employment or credit cycles in the short run, their persistence is associated with broader distortions in corporate behavior that extend beyond distressed firms and affect the overall financial ecosystem.

This study contributes to the literature in three main ways. First, it provides a comprehensive cross-country analysis of zombification in emerging markets, emphasizing structural differences across countries. Second, it distinguishes between firm-level effects and country-level dynamics, showing that zombification is largely driven by cross-country heterogeneity rather than firm-specific or short-term factors. Third, it documents cross-level spillover effects, showing how zombie prevalence distorts the financial behavior of non-zombies.

By highlighting the systemic and cross-country nature of zombification, this paper underscores its broader financial implications and the importance of institutional and credit market structures in shaping corporate behavior in emerging economies.

2. THEORETICAL FRAMEWORK AND HYPOTHESIS DEVELOPMENT

The literature documents that both zombie status and the increasing fraction of zombie firms distort key managerial decisions, affecting investment (Banerjee & Hofmann, 2018), debt

and leverage decisions (Yu et al., 2021), dividend and payout policies (Ghoul et al., 2021), cash retention policies (Feng et al., 2022), risk (Ghorbani, 2025), and innovation and research and development (R&D) investment (Geng et al., 2021; Ma & Dwyer, 2025).

2.1 Zombie Firms and Corporate Investment

A growing literature examines how zombie status affects corporate investment. Zombie firms, characterized by persistent financial distress and high leverage despite continued credit access, tend to invest less than non-zombie firms in both physical and intangible assets. Banerjee and Hofmann (2018) show that zombie firms exhibit lower capital expenditures and reduced investment in R&D and organizational capital, alongside higher leverage, reflecting weak growth prospects and distorted financing conditions.

Lower investment is also linked to broader financial policy distortions. Ghoul et al. (2021) document reduced capital intensity among zombie firms. Moreover, zombification generates spillovers: Caballero et al. (2008) and Hallak et al. (2018) show that a higher industry share of zombie firms distorts competition and reduces employment growth and investment among non-zombie firms. In particular, a 1% increase in the zombie fraction is associated with roughly a 1% reduction in non-zombie firms' capex (Hallak et al., 2018).

Recent empirical studies provide more direct evidence of these crowding-out effects on corporate investment. Tan et al. (2016) show that zombie firms absorb scarce production factors, thereby increasing financing constraints and raising effective financing costs for non-zombie firms. As a consequence, normal firms reduce their fixed asset investment when operating in environments with a higher prevalence of zombies.

H₁: zombie status is negatively associated with corporate investment, and a higher share of zombie firms is negatively associated with investment among non-zombie firms.

2.2 Zombie Firms and R&D Investment

Zombie firms are not only characterized by low investment capacity but also by restricted and inefficient use of resources, which can significantly undermine innovative activity. Empirical evidence suggests that zombie firms exhibit substantially weaker innovation performance than their non-zombie counterparts. Geng et al. (2021) show that zombie firms receive disproportionately higher financial resources and government subsidies relative to their efficiency, yet display significantly lower innovation capability. This resource mismatch reflects the allocation of credit and subsidies toward low-efficiency firms, reducing overall innovative output and hindering industrial modernization.

Beyond direct effects on zombie firms themselves, the authors provide evidence that zombies weaken the innovation incentives of healthy firms by absorbing scarce credit resources and distorting competitive conditions. As a result, these firms reduce their R&D, particularly in environments characterized by financial constraints and limited access to external finance.

More recently, Ma and Dwyer (2025) offer an alternative perspective by showing that zombie firms may, in fact, invest more in R&D than non-zombie firms. Furthermore, they demonstrate that industry-level zombie congestion affects R&D investment behavior, indicating that zombie prevalence can reshape firms' innovation incentives rather than uniformly suppress them. These findings suggest that zombie firms may engage in R&D as a strategic survival mechanism.

Taken together, the literature presents mixed and context-dependent evidence regarding the relationship between zombie status, zombie prevalence, and firm-level R&D investment. While some studies emphasize resource misallocation and innovation suppression, others

highlight strategic adjustment and heterogeneous innovation responses. This inconclusive evidence motivates a dual-hypothesis approach to empirically examine how zombie status and zombie prevalence affect corporate R&D investment in emerging markets.

H_{2a}: zombie status is negatively associated with firm-level R&D investment, and a higher share of zombie firms is negatively associated with R&D among non-zombie firms.

H_{2b}: zombie status is positively associated with firm-level R&D investment, and a higher share of zombie firms is positively associated with R&D among non-zombie firms.

2.3 Zombie Firms and Cash Holding

A growing body of evidence shows that zombie firms adopt conservative corporate policies in terms of investment and dividends while maintaining high leverage and elevated idiosyncratic risk (Ghoul et al., 2021). However, the effects of zombie status and, more importantly, the prevalence of zombie firms on corporate cash holdings remain relatively underexplored.

From a corporate finance perspective, cash holdings are commonly interpreted as a precautionary buffer against financing frictions, investment uncertainty, and volatile future cash flows. In financially constrained scenarios, firms tend to accumulate cash to smooth investment and reduce external financing. Whether zombies follow this logic is theoretically ambiguous. On the one hand, persistent financial distress and uncertainty could increase precautionary savings. On the other hand, zombie firms often benefit from easier access to external credit and repeated debt rollovers, which may weaken incentives to retain internal liquidity.

Direct empirical evidence on this issue is scarce. Ghoul et al. (2021) find no statistically significant differences in cash holdings between zombie and non-zombie firms, despite substantial differences in leverage, dividend, and investment policies. This result suggests that zombie firms' conservative payout and investment behavior do not necessarily translate into higher cash accumulation, potentially reflecting their structural dependence.

A more systemic perspective is offered by Feng et al. (2022), who document that zombie firms exhibit lower operating efficiency and lower corporate savings, despite easier access to external credit. Building on a theoretical model, the authors show that an increase in the share of zombie firms raises external financing costs for non-zombie firms by distorting credit allocation. As a result, non-zombie firms respond endogenously by increasing cash holdings to finance future investment, particularly when investment projects are risky and financial constraints are severe. Their empirical evidence supports this precautionary savings channel, especially among private, small and medium-sized, and financially constrained firms.

Taken together, existing studies suggest that the relationship between zombification and corporate liquidity is nuanced and potentially heterogeneous across institutional environments. While zombie firms themselves do not appear to systematically accumulate more cash, prior evidence predicts that a higher prevalence of zombies should induce greater cash retention among non-zombie firms through tighter financial conditions.

H₃: zombie status is negatively associated with corporate cash holdings, and a higher share of zombie firms is associated with higher cash holdings among non-zombie firms.

2.4 Zombie Firms and Corporate Risk

Empirical evidence consistently shows that zombie firms exhibit higher risk than their non-zombie peers. Ghoul et al. (2021) document that zombie firms adopt conservative corporate policies in terms of dividends and investment, yet display significantly higher idiosyncratic risk. Their findings suggest that the risk-increasing effects of aggressive leverage dominate any risk-reducing effects associated with lower investment and payout.

This risk profile is closely linked to the financing environment in which zombie firms operate. A growing literature explains the persistence of zombie firms through the “evergreening” of loans to financially weak borrowers and the broader risk-taking incentives faced by banks in prolonged low-interest-rate environments (Banerjee & Hofmann, 2018). Access to subsidized credit weakens market discipline and distorts the traditional relationship between risk and the cost of capital. As a result, zombie firms may engage in riskier activities than would be optimal under market-based financing conditions.

Recent evidence by Ghorbani (2025) provides direct empirical support for this mechanism. The author shows that zombie firms exhibit higher corporate risk-taking than non-zombie firms. Importantly, this higher risk-taking persists even when zombie firms are compared to non-zombie firms with elevated bankruptcy risk or firms approaching market exit. These findings suggest that zombification cannot be understood as passive survival under distress, but rather as an active distortion of firms’ risk incentives.

The evidence on zombie firms contrasts with the broader literature on financially distressed firms, which presents a more ambiguous relationship between distress and risk-taking. Some studies argue that high bankruptcy costs induce distressed firms to adopt conservative investment and operational strategies (Kirti, 2024). Other studies emphasize asset substitution and “gambling for resurrection” incentives, whereby distressed firms increase risk exposure in an attempt to restore firm value (Aretz et al., 2019). Zombie firms represent a distinct case within this literature (Ghorbani, 2025). Unlike typical distressed firms facing market-based financing constraints, zombie firms benefit from persistently subsidized credit at below-market rates, weakening the disciplining role of capital markets and encouraging risk-taking behaviors that would otherwise be curtailed (Ghorbani, 2025).

Taken together, existing studies indicate that zombie status is associated with systematically higher corporate risk, driven by distorted financing conditions and aggressive leverage policies. Moreover, the persistence and prevalence of zombie firms raise broader concerns about the transmission of risk within the corporate sector. By absorbing credit, weakening financial discipline, and contributing to systemic fragility, a higher share of zombie firms may elevate risk not only among zombies themselves but also among non-zombie firms operating in the same financial environment.

H4: zombie status is positively associated with corporate risk, and a higher share of zombie firms is positively associated with corporate risk among non-zombie firms.

2.5 Zombie Firms and Dividend Policy

Empirical evidence directly linking zombie status to dividend policy remains limited. The main contribution in this area is provided by Ghoul et al. (2021), who examine differences in corporate policies between zombie and non-zombie firms. The authors find that zombie firms pay significantly lower dividend rates than their non-zombie counterparts. The lower dividend rates observed among zombies can be interpreted as a response to persistent financial fragility and limited growth opportunities. As a result, dividend conservatism becomes a mechanism to sustain operations and service debt rather than a signal of financial strength or future growth.

Despite the central role of dividend policy in corporate finance, its treatment within the zombification literature remains limited. Most studies focus on investment, leverage, productivity, and survival, while dividend behavior receives comparatively little attention.

Zombification may also affect dividend decisions beyond zombie firms themselves. By absorbing credit and distorting financial conditions, zombie firms can influence the payout behavior of financially healthy firms. Increased uncertainty and tighter effective financing conditions may lead non-zombie firms to adopt more conservative dividend policies, even without firm-level distress. This channel remains largely unexplored, particularly in emerging markets, where financial frictions are typically stronger.

H₅: zombie status is negatively associated with dividends paid, and a higher share of zombie firms is negatively associated with dividends paid among non-zombie firms.

2.6 Zombie Firms and Corporate Cost of Debt

Zombie firms, characterized by weak profitability and sustained access to credit despite deteriorating fundamentals, provide a relevant context to examine how distorted credit allocation affects borrowing costs.

Empirical evidence suggests that zombie firms tend to operate under abnormal financing conditions. While earlier studies primarily document higher leverage among zombie firms (Banerjee & Hofmann, 2018; Ghoul et al., 2021), more recent research shifts the focus toward debt cost. In particular, Yu et al. (2021) report that the presence of zombie firms increases the cost of debt financing for non-zombie firms. Their results indicate that zombification distorts credit allocation, raising borrowing costs, especially in sectors with high dependence on external finance, among non-state-owned and small firms.

Overall, the literature suggests that zombie status is linked to distorted firm-level financing conditions and that greater zombie prevalence may be associated with higher debt financing costs for non-zombie firms. Examining borrowing costs directly offers clearer evidence on how zombification affects credit markets, particularly in emerging economies with stronger financial frictions.

H₆: zombie status is associated with higher firm-level borrowing costs, and a higher share of zombie firms is associated with higher borrowing costs among non-zombie firms.

3. METHODOLOGICAL PROCEDURES

This chapter aims to describe the methodological procedures adopted in this study.

3.1 Sample and Data Collection

The sample is based on the Morgan Stanley Capital International Emerging Markets Index (2022) and includes publicly traded firms from 25 emerging economies from 2002 to 2021. The countries covered are Brazil, Chile, Colombia, Mexico, Peru, the Czech Republic, Egypt, Greece, Hungary, Kuwait, Poland, Qatar, Russia, Saudi Arabia, South Africa, Turkey, the United Arab Emirates, China, India, Indonesia, South Korea, Malaysia, the Philippines, Taiwan, and Thailand.

The final dataset comprises 18,474 firms and more than 400,000 firm-year observations. The sample is concentrated in larger economies, with China (32.6%), India (21.4%), and South Korea (13.2%) jointly accounting for nearly two-thirds of observations. The remaining countries contribute smaller but economically relevant shares, ensuring cross-country

heterogeneity within emerging markets. The financial data of the companies were obtained from S&P Global Capital IQ (Table 1).

Table 1

Sample distribution by country (firms and firm-year observations)

Country	Firms (n)	Firms (%)	Firm-year observations (n)	Firm-years (%)
China	6,027	32.62	132,592	32.58
India	3,961	21.44	87,142	21.41
South Korea	2,440	13.21	53,680	13.19
Malaysia	1,053	5.70	23,166	5.69
Thailand	730	3.95	16,060	3.95
Indonesia	685	3.71	15,070	3.70
Poland	620	3.36	13,640	3.35
Turkey	367	1.99	8,074	1.98
Brazil	348	1.88	7,656	1.88
Saudi Arabia	270	1.46	5,940	1.46
South Africa	251	1.36	5,522	1.36
Philippines	247	1.34	5,434	1.34
Egypt	211	1.14	4,642	1.14
Russia	210	1.14	4,620	1.14
Greece	205	1.11	4,488	1.10
United Arab Emirates	154	0.83	3,388	0.83
Chile	153	0.83	3,366	0.83
Kuwait	138	0.75	3,036	0.75
Mexico	124	0.67	2,728	0.67
Peru	92	0.50	2,024	0.50
Colombia	53	0.29	1,166	0.29
Qatar	51	0.28	1,122	0.28
Taiwan	37	0.20	814	0.20
Hungary	27	0.15	594	0.15
Czech Republic	21	0.11	462	0.11
Total	18,475	100.00	406,426	100.00

Source: *Elaborated by the authors.*

3.2 Zombie Firms Definition

According to Hallak et al. (2018), the ICR is a standard measure used to assess loan repayment capacity and financial distress, and it is widely applied by credit analysts, rating agencies, and other financial institutions. However, since some firms may continue operating even when their operating profits are insufficient to cover interest expenses, the use of this metric in isolation may overestimate the fraction of zombie firms (Altman et al., 2024).

For this reason, although an ICR below one is a useful starting point to identify potential zombie firms, the literature has proposed complementary criteria to refine the classification (Altman et al., 2024; Banerjee & Hofmann, 2018; Hallak et al., 2018). In particular, Altman et al. (2024) develop a two-stage classification procedure when analyzing G-20 economies. The authors propose a two-stage classification. First, firms are identified as zombies if their 3-year moving average ICR is below one, ensuring persistence rather than temporary distress. Second, the classification is refined by incorporating default risk through the Z-score (or Z''-score). A

firm is considered a zombie only if it simultaneously exhibits a 3-year moving average ICR below one and a 3-year moving average Z-score below 0. This stricter definition reduces misclassification and results in zombie firms representing, on average, 8% to 10% of listed firms.

Following Altman et al. (2024) and the terminology systematized by Granzotto et al. (2025), this study adopts two classifications. The adoption of static and dynamic definitions enhances the robustness of the classification and ensures consistency with recent empirical evidence (Altman et al., 2024; Granzotto et al., 2025). This dual approach allows the analysis to distinguish between contemporaneous zombie conditions and persistent zombification, strengthening comparability with prior studies while mitigating potential measurement bias.

3.3 Model Specification and Data Analysis Method

To estimate the financial consequences of zombie firms in emerging markets, hierarchical linear regressions were employed using Stata-SE[®] software in an unbalanced panel setting. Three levels were established to accomplish the objective regarding financial consequences. The first level corresponds to the time variable, the second level to firm-level variables, and the third to country-level variables. Since three levels were analyzed (year, firm, and country), the model is defined as a three-level hierarchical model.

Our specification follows Banerjee and Hofmann (2018) and Hallak et al. (2018), modeling firm outcomes as a function of (i) a firm-level indicator for non-zombie status and (ii) its interaction with the zombie fraction. This structure captures both the within-firm association (zombie vs. non-zombie) and the spillover effect of zombie prevalence on the corporate policies of non-zombie firms.

Formally, we begin with a null (intercept-only) model to decompose the variance across hierarchical dimensions and motivate the use of multilevel estimation. We then augment the model by including the non-zombie dummy, firm-level controls, time indicators, and the interaction between non-zombie status and the zombie fraction. Given the characteristics of the sample, a longitudinal hierarchical linear model was considered appropriate.

$$Y_{t,i,j} = \delta_{000} + \mu_{oop} + r_{0,i,j} + \varepsilon_{t,i,j} \quad (1)$$

The model can be described as follows: investment ($Y_{t,i,j}$) in year t , for firm i , in country p , is a function of the average investment of the entire sample (δ_{000}); a random error term representing variance across countries (μ_{oop}); an error term representing variance across firms ($r_{0,i,j}$); and an error term representing variance over time ($\varepsilon_{t,i,j}$). After the null model is defined, the independent variables (the ‘non-zombie’ dummy and control variables) are included.

$$Y_{tip} = \delta_{000} + \delta_{001} \times Time_{tip} + \delta_{100} \times Dummy'NonZombie'_{t,ip} + \delta_{120} \times Controls_{ip} + \dots + \delta_{1k0} \times Controls_{ip} + \delta_{110} \times 'ZombieFraction'_j \times Dummy'NonZombie'_{t,ip} + \mu_{oop} + r_{0ip} + \varepsilon_{tip} \quad (2)$$

Thus, investment or any other ($Y_{t,i,j}$) in year t , for firm i in country p , is a function of the average investment of the entire sample (δ_{000}); the time dummy variable ($Time_{tip}$) for each year of the analysis except the first; firm-level variables ($Dummy'NonZombie'_{0ij}$ and $Controls_{0ij}$) and the interaction between the country-level and firm-level variables ($\delta_{110} \times 'ZombieFraction'_j \times Dummy'NonZombie'_{t,ip}$); a random error term representing variance across countries ($\mu_{0,i,j}$); a random error term representing variance across firms ($r_{0,i,j}$) and a random error term representing variance over time ($\varepsilon_{t,i,j}$).

Standard errors in the multilevel models account for the nested structure of firm-year observations within countries. As robustness checks, we re-estimate the models using pooled ordinary least squares (OLS) and fixed-effects specifications with heteroskedasticity-robust standard errors, obtaining consistent results. We also report likelihood ratio (LR) tests and the intraclass correlation coefficient (ICC). The LR test evaluates whether random effects improve model fit relative to pooled OLS, while the ICC captures the share of variance attributable to higher-level clustering, supporting the multilevel specification. The variables employed in this study are described in Table 2. To mitigate the influence of extreme values, all variables are winsorized at the 1% and 99% levels.

Table 2
Variable definition

Zombie firms					
Variables	Theoretical definition	Authors		Source	
Static zombie firms (zombie status)	Dummy equal to 1 if the firm is a zombie (ICR < 1 and Z-score < 0), and 0 otherwise ICR equals EBITDA/financial expenses	Altman et al. (2024), Granzotto et al. (2025)		CIQ	
Dynamic zombie firms (zombie status)	Dummy equal to 1 if the firm is classified as a zombie based on a 3-year average ICR < 1 and Z-score < 0, and 0 otherwise	Altman et al. (2024), Granzotto et al. (2025)			
Static non-zombie	Dummy variable equal to 1 if the firm is a static non-zombie and 0 otherwise	Banerjee and Hofmann (2018)			
Dynamic non-zombie	Dummy variable equal to 1 if the firm is a dynamic non-zombie and 0 otherwise	Banerjee and Hofmann (2018)			
Static zombie fraction	Ratio of the number of static zombie firms to the total number of listed firms in the country per year	Altman et al. (2024), Granzotto et al. (2025)			
Dynamic zombie fraction	Ratio of the number of dynamic zombie firms to the total number of listed firms in the country per year	Altman et al. (2024), Granzotto et al. (2025)			
Z-score of emergent markets	$Z' - Score = 3,25 + 6,56 * \left(\frac{AC - PC}{AT}\right) + 3,26 * \left(\frac{LR}{AT}\right) + 6,72 \left(\frac{EBIT}{AT}\right) + 1,05 \left(\frac{PL}{PT}\right)$		Altman et al. (1995), Altman et al. (2024)		
Financial consequences					
Description		Hypothesis	Signal		
Capex	Property, plant, and equipment (fixed assets)/total assets	H ₁	-	Banerjee and Hoffmann (2018), Ghoul et al. (2021)	
R&D expenses	R&D expenses/total assets	H ₂	-	Geng et al. (2021), Ghoul et al. (2021), Ma and Dwyer (2025)	
Cash	Cash + short-term investments/total assets	H ₃	-	Feng et al. (2025), Ghoul et al. (2021)	
Risk	Ratio between the covariance of the firm's returns and the market benchmark, and the variance of the market	H ₄	+	Ghoul et al. (2021)	
Dividends	Dividends paid/total assets	H ₅	-	Ghoul et al. (2021)	
Corporate cost of debt	Represents the average interest rate paid on all short- and long-term borrowings, calculated as total interest expense divided by the average balance of total borrowings	H ₆	+	Yu et al. (2021)	

AC = current assets; AT = total assets; CIQ = capital IQ; EBIT = earnings before interest and taxes; EBITDA = earnings before interest, taxes, depreciation, and amortization; ICR = interest coverage ratio; LR = retained earnings; PC = current liabilities; PL = shareholders' equity; PT = total liabilities; R&D = research and development.

Source: *Elaborated by the authors.*

4. RESULTS ANALYSIS

This section examines the prevalence of zombie firms and their economic and financial implications in emerging markets. First, the evolution and distribution of zombie fractions across countries are presented. Second, descriptive statistics compare zombie and non-zombie firms. Third, multilevel regressions assess the association between zombie status, zombie prevalence, and corporate outcomes. Finally, robustness checks are conducted to evaluate the stability of the results.

4.1 Prevalence of Zombie Firms in Emergent Markets

The descriptive evidence indicates a persistent increase in zombie prevalence over time. Static zombie firms accounted for approximately 5.8% of listed companies in 2002, rising to around 12.3% by 2021. This trajectory implies a compound annual growth rate (CAGR) of roughly 4% over the period. A similar pattern emerges under the dynamic zombie metric, which represented approximately 4% of listed companies in 2002 and increased to 10.05% by 2021. This evolution corresponds to a CAGR of about 5%, suggesting that the dynamic measure captures an even more sustained process of zombification across emerging markets.

These patterns are fully consistent with recent evidence reported by Granzotto et al. (2025), who document that dynamic zombie firms represented 3.87% of listed firms in 2002 and increased to 9.90% by 2021, with the maximum average share reaching 10.05%. To better understand the evolution of zombie prevalence in emerging markets, it is necessary to examine how this phenomenon unfolds at the country level. The evolution of zombie prevalence across countries in the sample from 2002 to 2021 can be directly observed in Figure 1, which reports the fraction of dynamic zombie firms over time and contrasts country-level trajectories with the average for emerging markets. A more detailed country-by-country evolution over the sample period is provided in Appendix A.

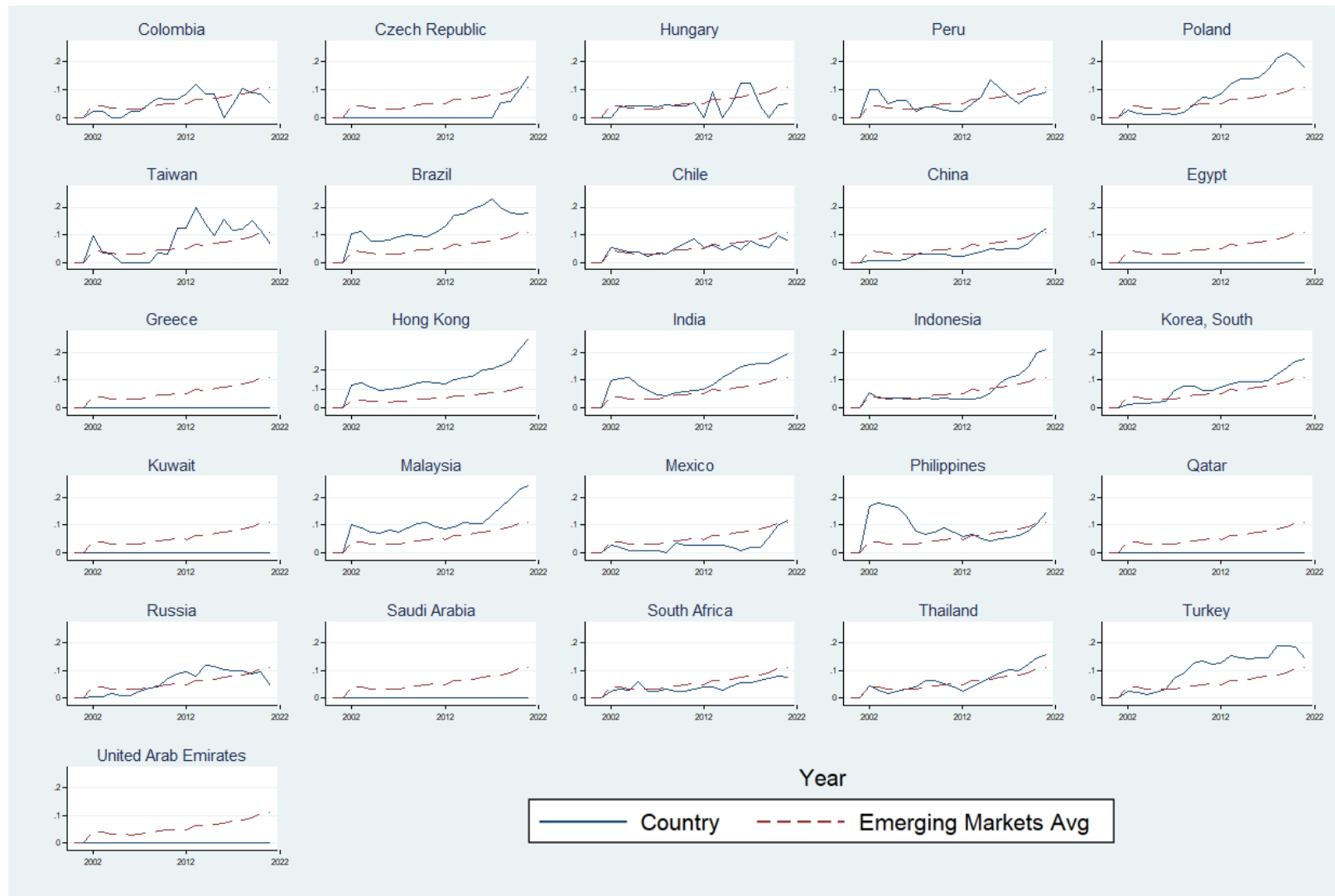


Figure 1 *Zombies in emergent markets*

Source: *Elaborated by the authors.*

Substantial cross-country heterogeneity underlies this aggregate trend. In particular, Brazil, Turkey, Malaysia, and India systematically stand out as the main “zombielands” within the sample, exhibiting persistently higher zombie fractions over time. These patterns closely align with the results of Granzotto et al. (2025), who identify that these countries have the highest average prevalence of zombie firms among emerging markets.

4.2 Statistical Descriptions of Zombie Firms in Emergent Markets

Table 3 presents the key variables used to define firms as zombies or non-zombies, as well as the main financial consequences associated with these two groups. Specifically, the table reports the ICR and the Z-score alongside firm-level corporate policies such as investment, leverage, cash holdings, dividends, and risk. Focusing first on the ICR and the Z-score, zombie firms are required to simultaneously satisfy two conditions over a 3-year moving window: an average ICR below one and an average Z-score below 0.

Table 31*Descriptive statistics – Financial consequences of the zombie fractions*

	Status zombie dynamic									
	Zombie definition		Financial consequences							
	ICR	Z-score	Total assets	Capex/ta	R&D/ta	Lev/ta	Cost debt	Cx/ta	Div/ta	Risk
Observations	19,538	19,538	19,538	19,401	19,401	19,401	19,534	19,401	19,401	19,538
Mean	-2.19	-3.40	223.82	0.02	0.004	0.40	0.08	0.07	0.002	4.63
Standard deviation	3.12	2.84	786.37	0.05	0.01	0.33	0.07	0.11	0.01	6.25
Minimum	-9.35	-8.28	0.00	-0.02	0.00	0.00	0.00	0.0001	0.00	0.00
p25	-3.75	-5.51	11.57	0.001	0.00	0.15	0.04	0.01	0.00	0.67
p50	-0.88	-2.71	45.86	0.01	0.00	0.33	0.07	0.03	0.00	2.39
p75	0.16	-0.76	151.20	0.02	0.00	0.56	0.11	0.08	0.00	5.93
Maximum	0.99	0.0000	11709.15	0.31	0.09	1.25	0.30	0.67	0.15	32.35
	Status non zombies dynamic									
Observations	336,602	336,602	374,970	236,340	237,166	237,167	378,473	237,167	231,196	364,272
Mean	33.76	11.07	465.40	0.05	0.01	0.22	0.03	0.12	0.01	3.93
Standard deviation	63.86	23.98	1575.73	0.06	0.01	0.21	0.05	0.13	0.03	5.69
Minimum	-9.35	-8.28	0.00	-0.04	0.00	0.00	0.00	0.00	0.00	0.00
p25	3.37	0.00	0.00	0.01	0.00	0.04	0.00	0.02	0.00	0.62
p50	7.76	0.49	20.78	0.03	0.00	0.18	0.00	0.07	0.01	1.97
p75	25.52	8.33	198.98	0.07	0.00	0.34	0.05	0.16	0.02	4.63
Maximum	311.80	100.09	11709.15	0.32	0.09	1.25	0.30	0.67	0.15	32.24
test-t	78.69***	84.39***	21.29***	55.00***	-4.07***	-110.00***	-130***	45.18***	70.06***	-16.75***

Note: *Capex/ta* = capital expenditures scaled by total assets; *Cost debt* = financial expenses divided by total debt; *ICR* = interest coverage ratio (earnings before interest, taxes, depreciation, and amortization divided by financial expenses); *Cx/ta* = cash holdings scaled by total assets; *Div/ta* = dividends paid scaled by total assets; *Lev/ta* = total debt scaled by total assets; *R&D/ta* = research and development expenditures scaled by total assets; *Risk* = firm-level risk measure, as defined in the methodology section; *Total assets* = total assets (in monetary units); *Z-score* = Altman Z-score (financial distress indicator).

***, **, * = statistical significance at the 1%, 5%, and 10% levels, respectively.

Source: *Elaborated by the authors.*

Consistent with this classification strategy, the maximum value of the 3-year average ICR among zombie firms is strictly below one (0.99), while the maximum Z-score is close to 0. These upper bounds confirm the internal coherence and robustness of the zombie identification procedure, as no firm classified as a zombie violates the defining thresholds. In contrast, non-zombie firms exhibit substantially higher upper bounds for both variables, reflecting stronger debt-servicing capacity and overall financial stability.

It is important to note that firms satisfying only one of the two criteria are classified as non-zombies. As a result, the minimum values of the ICR and Z-score are identical across zombie and non-zombie subsamples. This outcome is mechanical and does not indicate misclassification; rather, it reflects the conjunctive nature of the zombie definition, which requires both conditions to be met simultaneously.

The average ICR among zombie firms is -2.19, compared to 33.76 for non-zombie firms, indicating a persistent inability to cover financial expenses from operating earnings. Similarly, the average Z-score for zombie firms is -3.40, substantially below the non-zombie mean of 11.07, highlighting a significantly higher probability of financial distress.

Analyzing corporate policies for firms classified as dynamic “zombies” relative to non-zombie firms reveals systematic and economically meaningful differences. In summary, firms with zombie status present, on average, lower ICRs ($-2.19 < 33.76$) and lower Z-scores ($-3.40 < 11.07$), are smaller in terms of total assets ($223.82 < 465.40$), have lower investment levels ($0.02 < 0.05$), and have lower R&D ($0.004 \approx 0.01$).

Consistent with debt dependence under financial distress, zombie firms display higher leverage ratios ($0.40 > 0.22$), higher costs of debt ($0.08 > 0.03$), while maintaining lower cash holdings ($0.07 < 0.12$) and lower dividend payouts ($0.002 < 0.01$), indicating constrained internal financing and reduced payout capacity. Finally, zombie firms exhibit higher observed risk levels ($4.63 > 3.93$), reflecting subdued investment activity and limited exposure to growth opportunities rather than improved financial stability.

These findings are strongly aligned with the stylized evidence documented by Banerjee and Hofmann (2018), who characterize zombie firms as structurally weaker, smaller, and less dynamic than their non-zombie counterparts. Their analysis shows that zombie firms invest less in both physical and intangible capital, exhibit persistently weak ICRs, and maintain higher leverage alongside lower dividend payouts.

4.3 Financial Consequences of Zombie Status and Zombie Fractions in Emerging Markets

Before conducting the regression analyses, a series of diagnostic tests were performed to assess the adequacy of the panel specification. The Doornik-Hansen test, which evaluates the null hypothesis of multivariate normality of the residuals, rejected normality for all countries. The Wooldridge test for autocorrelation in panel data rejected the null hypothesis of no first-order serial correlation, indicating the presence of autocorrelation. Additionally, the Breusch-Pagan test rejected the null hypothesis of homoscedasticity, revealing heteroscedasticity in the aggregate emerging markets model.

Given these results, the regression models were estimated using multilevel (hierarchical) modeling to account for the nested structure of the data and capture variability across firms and countries. Furthermore, robust standard errors were employed to correct for heteroscedasticity and serial correlation. Finally, the average variance inflation factor remained low across specifications, indicating that multicollinearity was not a concern.

Initially, a null multilevel model was estimated. This model includes no explanatory covariates and serves to decompose the total variance across hierarchical levels of the data. The ICC indicates that approximately 88.5% of the variance in the static zombie fraction and 89.5% in the dynamic zombie fraction is attributable to country-level differences, while roughly 10%

is explained by time-varying factors. These results suggest that zombie firms are largely driven by structural cross-country rather than short-term temporal dynamics. Accordingly, multilevel modeling is appropriate, as it explicitly accounts for the nested structure within countries and captures unobserved heterogeneity.

Following the null model specification, Table 4 presents the multilevel regression results examining the relationship between zombie status and the effect of increases in the country-level fraction of zombie firms on the corporate financial policies of non-zombie firms.

Table 4*Multilevel regressions: zombie status, zombie prevalence, and firm-level financial policies*

	Capex/ta		PD&I/ta		Cash/ta		Risk		Div/ta		Cost of debt	
Zombie model	Static	Dynamics	Static	Dynamics	Static	Dynamics	Static	Dynamics	Static	Dynamics	Static	Dynamics
Non Z	-0.02	-0.03	-0.001	-0.002	0.02	0.03	-0.43	-0.76	0.06	0.05	-.034	-0.04
z	-5.34	69.00	-22.71	-22.7	42.96	37.73	-9.87	-8.92	41.02	31.94	-12.90	-12.18
p-value	0.00***	0.00***	0.00***	0.00***	0.00***	0.00***	0.00***	0.00***	0.00***	0.00***	0.00***	0.00***
Non Z*fraction Z	-0.001	-0.01	0.0001	0.02	-0.01	-0.04	0.04	0.07	0.01	0.01	0.02	0.02
z	-9.73	-6.15	4.83	62.00	-5.49	-10.55	20.20	4.58	4.04	18.36	21.61	9.83
p-value	0.00***	0.00***	0.00***	0.00***	0.00***	0.00***	0.47	0.00***	0.00***	0.00***	0.00***	0.00***
Constant	0.03	0.03	0.01	0.01	0.10	0.09	27.44	0.47	.009	0.37	0.07	0.07
z	10.22	56.02	62.04	62.04	100.62	90.87	7.26	48.86	50.22	8.93	191.39	174.65
p-value	0.00***	0.00***	0.00***	0.00***	0.00***	0.00***	0.00***	0.00***	0.00***	0.00***	0.00***	0.00***
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	322,920	322,920	224,004	224,004	224,005	209,701	188,761	187,559	218,037	330,529	364,538	362,745
LR test	56647.86	3.8e+05	1.9e+05	1.9e+05	1.2e+05	1.1e+05	1.9e+05	1.4e+05	91262.71	1.7e+05	1.0e+05	1.1e+05
	0.00***	0.00***	0.00***	0.00***	0.00***	0.00***	0.00***	0.00***	0.00***	0.00***	0.00***	0.00***

Note: Levels: year, firm, and country. LR = likelihood ratio; Non Z * fraction = interaction between non-zombie and zombie fraction; Non Z = non zombie.

***, **, * = statistical significance at 1%, 5%, and 10%, respectively.

Source: Elaborated by the authors.

The first corporate policy analyzed is corporate investment. The estimates indicate that non-zombie firms exhibit significantly higher levels of investment compared to zombie firms, both in the static and dynamic specifications. This finding is consistent with the literature documenting systematically lower capital expenditures among financially distressed or persistently weak firms (Banerjee & Hofmann, 2018; Ghoul et al., 2021).

More importantly, the interaction term between non-zombie status and the respective zombie fraction is negative and statistically significant at the 1% level in both models. This suggests that, although non-zombie firms invest more on average, their investment levels are negatively associated with higher zombie prevalence within the country. In other words, in environments where zombification is more pervasive, the investment differential between non-zombie and zombie firms narrows.

These results are closely aligned with the spillover and crowding-out mechanisms described in prior studies. Caballero et al. (2008) and Hallak et al. (2018) argue that the presence of zombie firms distorts competition and resource allocation, weakening investment among healthier firms. Similarly, Chen et al. (2024) show that zombie firms absorb scarce capital and credit, intensifying financing constraints faced by non-zombie firms. Being a non-zombie firm is associated with a 2-percentage point lower CAPEX-to-assets ratio. Additionally, a one-unit increase in the fraction of zombie firms reduces the CAPEX-to-assets ratio of non-zombie firms by an additional 1 percentage-point, reinforcing the crowding-out effect. All coefficients are interpreted in percentage-point terms, consistent with the scale of the dependent variable and the fraction-based regressors.

Turning to intangible investment decisions, Table 4 reports the multilevel regression results examining the association between zombie status and firm-level R&D investment, as well as the moderating role of country-level zombie prevalence. The coefficient associated with non-zombie status is negative and statistically significant in both the static and dynamic specifications, indicating that non-zombie firms exhibit lower R&D intensity relative to zombie firms. In other words, zombie firms allocate, on average, a larger proportion of assets to R&D.

At first glance, this result may appear counterintuitive, as R&D is typically associated with long-term strategic orientation, while zombie firms face persistent financial distress. However, this finding is consistent with the emerging evidence in Ma and Dwyer (2025), who show that zombie firms may exhibit higher R&D intensity and that zombie prevalence can reshape firms' innovation incentives. One possible interpretation is that R&D investment reflects strategic behavior under financial distress, including risk-shifting incentives or attempts to generate future growth opportunities. In addition, the persistence of zombie firms, often supported by continued access to credit or institutional frictions, may allow them to sustain ongoing innovation activities despite weak financial conditions. As discussed in the robustness section, this pattern remains consistent across alternative specifications, reinforcing that the result is not driven by a particular modeling approach.

Regarding spillover effects, the interaction between non-zombie status and the country-level zombie fraction is positive and statistically significant. This indicates that as zombie prevalence increases within a country, non-zombie firms are associated with higher R&D intensity. This pattern contrasts with the crowding-out mechanism emphasized by Geng et al. (2021) but is consistent with the moderating effect documented by Ma and Dwyer (2025), suggesting that zombie prevalence may alter, rather than uniformly suppress, firms' innovation.

Taken together, the evidence supports the view that zombification is associated with heterogeneous and context-dependent innovation responses. Rather than uniformly depressing R&D investment, both zombie status and zombie prevalence appear to be linked to intensified R&D engagement under certain institutional and competitive conditions.

Advancing the analysis of corporate policies, the next dimension examined concerns firms' liquidity management. The estimates indicate that non-zombie firms hold significantly higher levels of cash compared to zombie firms, both in the static and dynamic specifications.

This result is consistent with the structural fragility of zombie firms, which, by definition, face persistent operating weakness and limited internal cash generation capacity.

Regarding the interaction term, the coefficient associated with the interaction between non-zombie status and the country-level zombie fraction is negative and statistically significant. This suggests that, although non-zombie firms hold more cash on average, this liquidity advantage weakens in environments characterized by higher zombie prevalence. These findings partially align with prior evidence while also revealing important nuances. In contrast to the precautionary mechanism suggested by Feng et al. (2022), the evidence for emerging markets indicates that higher zombie prevalence is associated with lower cash retention among non-zombie firms. This pattern may reflect institutional constraints and limited financial flexibility, where firms may lack the capacity to build precautionary liquidity buffers.

The fourth financial outcome examined in Table 4 concerns corporate risk. The results indicate that non-zombie firms are associated with significantly lower levels of risk relative to zombie firms in both models. This suggests that zombie firms display systematically higher risk profiles. Recent evidence by Ghorbani (2025) further supports this interpretation, showing that zombie firms exhibit higher volatility even when compared to distressed but non-zombie firms.

Regarding the interaction between non-zombie status and the zombie fraction, the coefficient is positive and significant, indicating that higher zombie prevalence is associated with greater risk among non-zombie firms. As zombie firms absorb credit and distort financing conditions, the overall risk environment may deteriorate, affecting even healthier firms. In line with Ghorbani (2025), zombification appears to reshape risk incentives beyond firms directly classified as zombies. The fifth decision examined concerns dividend distribution. The estimates indicate that non-zombie firms distribute significantly higher dividends relative to total assets than zombie firms in both specifications.

This finding is consistent with the view that zombie firms distribute lower dividends than non-zombie firms (Ghoul et al., 2021). The coefficient associated with the interaction between non-zombie status and the country-level zombie fraction is positive and statistically significant. This indicates that, in more zombie-like environments, non-zombie firms distribute relatively higher dividends. In settings where zombification is more prevalent, non-zombie firms may increase dividend distribution to differentiate themselves from distressed peers and signal financial strength and solvency to investors, consistent with the signaling interpretation highlighted in the literature.

Advancing to capital structure decisions, Table 4 also reports the results for the cost of corporate debt. The coefficient on the non-zombie dummy is negative and statistically significant in both the static and dynamic specifications, indicating that non-zombie firms are associated with lower borrowing costs compared to zombie firms. Turning to the interaction between non-zombie status and the country-level zombie fraction, the coefficient is positive and statistically significant in both specifications.

These findings are consistent with the mechanism proposed by Yu et al. (2021), who document that the presence of zombie firms is associated with higher debt financing costs for healthy firms. Their evidence indicates that zombification distorts credit allocation and alters the pricing of debt, particularly in financially dependent sectors and among smaller firms. The results reported provide complementary evidence at the firm level, showing that zombification is systematically associated with tighter effective financing conditions for non-zombie firms.

4.4 Robustness Check

To assess the stability of the baseline results, several robustness tests were conducted. First, the models were re-estimated using pooled OLS and firm fixed effects. These results are reported and remain qualitatively consistent with the multilevel estimates. For brevity, only the dynamic specification is presented, as the static results are similar (Table 5).

Table 5*Robustness check – Pooled and fixed effects: zombie status, zombie prevalence, and firm-level financial policies*

	Capex/ta		PD&I/ta		Cash/ta		Risk		Div/ta		Cost of debt	
	Pooled	FE	Pooled	FE	Pooled	FE	Pooled	FE	Pooled	FE	Pooled	FE
Zombie model	Dynamic	Dynamic	Dynamic	Dynamic	Dynamic	Dynamic	Dynamic	Dynamic	Dynamic	Dynamic	Dynamic	Dynamic
Non Z	0.02	0.02	-0.003	-0.001	0.09	0.02	-0.07	-0.07	0.01	0.02	-0.06	-0.03
z	34.55	28.40	-14.14	0.67	47.33	16.33	-8.92	-8.92	64.63	11.74	-55.66	-40.03
p-value	0.00***	0.00***	0.00***	0.50	0.00***	0.00***	0.00***	0.00***	0.00***	0.00***	0.00***	0.00***
Non Z*fraction Z	-0.02	-0.03	0.03	0.001	-0.05	-0.02	0.08	0.08	0.06	0.03	0.17	0.05
z	-3.89	-11.31	21.41	3.47	-41.69	-2.09	4.58	4.58	23.81	2.66	37.49	16.05
p-value	0.00***	0.00***	0.00***	0.00***	0.00***	0.03**	0.00***	0.00***	0.00***	0.00***	0.00***	0.00***
Constant	0.02	0.03	-0.004	0.03	0.02	0.08	0.47	0.47	-0.001	0.01	0.07	0.04
z	26.1	38.23	-1.88	25.31	13.64	49.78	48.89	48.89	-4.34	34.19	64.41	60.42
p-value	0.00***	0.00***	0.06*	0.00***	0.00***	0.00***	0.00***	0.00***	0.00***	0.00***	0.00***	0.00***
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	245,125	245,125	245,841	245,842	224,005	245,842	188,761	188,761	240,079	240,079	364,538	362,745

Note: Levels: year, firm, and country. LR = likelihood ratio; Non Z * fraction = interaction between non-zombie and zombie fraction; Non Z = non zombie.

***, **, * = statistical significance at 1%, 5%, and 10%, respectively.

Source: Elaborated by the authors.

Second, all regressions were re-estimated excluding China and India, given their weight in the sample. Third, cash holdings were re-estimated using an alternative definition following Bates et al. (2009): (cash and equivalents + short-term investments) divided by (total assets minus cash and short-term investments). Fourth, the dividend model was re-estimated excluding Brazilian firms due to the mandatory minimum dividend rule under Brazilian Corporate Law (Lei N°. 6,404, 1976) (Brazil, 1976). For reasons of synthesis, the results of these additional exercises are not tabulated in the manuscript; however, they remain qualitatively consistent with the baseline findings and are available upon request.

5. CONCLUSIONS AND FINAL CONSIDERATIONS

This paper sheds light on how zombie firms in emerging economies relate to corporate policies. First, descriptive evidence shows that zombification has become a persistent feature of emerging markets over the sample period, consistent with recent findings that these economies provide an environment conducive to zombie persistence (Granzotto et al., 2025). Second, the multilevel regressions reveal economically meaningful associations between zombie status, zombie prevalence, and corporate financial policies. At the firm level, consistent with prior literature, zombie firms exhibit lower investment, higher R&D, lower cash holdings, lower dividend distributions, higher leverage and borrowing costs, and greater market risk.

More importantly, these patterns extend beyond zombie firms. A higher share of zombies within a country is associated with significant adjustments in the policies of non-zombie firms. In such environments, non-zombie firms exhibit lower investment, higher R&D, lower cash holdings, changes in dividend policies, and greater exposure to risk and borrowing costs. Taken together, these results point to the hidden and systemic cost of zombification, reflecting its impact on otherwise healthy firms operating within the same economic environment.

This paper contributes to the literature in several ways. Empirically, it analyzes 25 emerging market economies over an extended period, offering a comprehensive cross-country perspective on zombie-related financial effects. Methodologically, it employs a three-level hierarchical model that accounts for time, firm, and country-level variation, allowing decomposition of within- and between-country effects. More importantly, it highlights the role of cross-country heterogeneity and documents spillover effects, showing how zombie prevalence shapes the behavior of non-zombie firms.

Despite these contributions, some limitations remain. First, although the zombie classification follows Altman et al. (2024) and Granzotto et al. (2025), it remains subject to conceptual heterogeneity in the literature, and alternative criteria may yield different classifications and magnitudes. Second, emerging markets are heterogeneous in institutional quality, financial development, and credit structures. Although the multilevel framework captures part of this variation, the observed associations may also reflect underlying country-specific factors that simultaneously influence zombie prevalence and firm behavior. While our approach mitigates this concern by separating within- and between-country variation, it does not fully eliminate potential endogeneity. Future research may further disentangle these effects by exploring institutional moderators, examining firm exit dynamics, or using quasi-experimental designs to strengthen identification.

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Conceptualization: equal;
Data curation: equal;
Formal analysis: equal;
Funding acquisition: equal;
Investigation: equal;
Methodology: equal;
Project administration: equal;
Resources: equal;
Software: equal;
Supervision: equal;
Validation: equal;
Visualization: equal;
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CONFLICT OF INTEREST

The authors declare that there is no conflict of interest.

DATA AVAILABILITY STATEMENT

The dataset supporting the results of this study is not publicly available.

GENERATIVE AI DISCLOSURE

The authors declare that generative artificial intelligence was used in the following stages of the production of this manuscript:

- Formula/Code optimization: Google Gemini.

The author(s) declare(s) that, regardless of the use of the tools mentioned above, all generated content was supervised, verified, and critically validated by humans. The author(s) assume(s) full and exclusive responsibility for the accuracy of the data, integrity of mathematical/statistical formulas, originality of the text, and the conclusions presented in the published article.

Appendix A*Historic evolution of zombie fraction*

Country/year		2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
Brazil	ZS	15.54	11.88	7.99	11.60	11.86	11.71	12.67	11.32	10.66	18.22	19.55	18.67	18.31	24.30	24.16	24.00	19.67	21.52	23.10	18.30
	ZD	10.32	11.36	7.87	7.79	8.25	9.35	9.90	9.57	9.39	10.86	13.36	16.94	17.65	19.60	20.58	22.83	19.86	17.81	17.63	17.94
Chile	ZS	6.72	2.92	3.62	5.59	5.15	6.25	10.24	14.18	10.79	9.09	8.80	8.89	6.11	9.30	7.52	7.14	6.98	15.50	22.31	8.82
	ZD	5.22	4.44	3.65	3.68	2.21	3.57	3.03	5.43	7.03	8.53	5.47	6.30	4.65	6.15	4.51	7.63	6.20	5.51	9.84	7.87
China	ZS	0.80	5.70	1.15	5.02	2.95	2.31	4.01	3.04	1.95	3.09	4.40	4.45	4.82	6.14	4.95	5.39	8.74	10.15	13.00	15.29
	ZD	0.57	0.56	0.60	0.76	1.24	3.02	2.92	2.96	2.97	2.42	2.27	3.22	3.97	4.89	4.77	4.86	5.15	6.88	10.05	12.52
Colombia	ZS	2.27	0.00	6.25	2.27	2.44	4.88	7.32	9.52	2.27	11.90	12.00	16.33	8.70	7.32	4.65	8.51	12.77	10.42	15.56	8.16
	ZD	2.27	2.27	0.00	0.00	2.22	2.38	4.76	6.82	6.67	6.52	8.33	12.00	8.33	8.33	0.00	4.55	10.42	8.70	8.51	4.76
Colombia	ZS	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	5.00	5.00	0.00	5.56	15.00	15.00	10.53
	ZD	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	5.26	5.56	10.53	15.00
CZSch Republic	ZS	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	ZD	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Egypt	ZS	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	ZD	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Greece	ZS	3.85	3.85	0.00	4.00	4.00	3.85	8.70	16.67	8.70	18.18	12.00	4.35	16.67	13.04	16.00	11.54	4.55	9.09	5.56	7.69
	ZD	0.00	3.85	4.00	4.17	4.17	3.85	4.55	4.35	4.35	5.26	0.00	9.09	0.00	4.76	12.50	12.50	4.17	0.00	4.55	4.76
Hungary	ZS	14.86	13.06	10.43	8.48	6.41	6.48	6.76	9.89	7.97	8.25	11.51	12.89	14.62	16.72	16.96	17.68	18.36	18.49	24.01	23.87
	ZD	9.67	10.65	10.73	8.01	6.24	4.66	4.20	5.49	5.86	6.10	6.60	8.05	10.95	13.02	14.62	15.40	15.92	16.08	18.04	19.53
Indonesia	ZS	3.94	5.75	5.36	3.90	5.06	2.63	5.02	4.76	4.05	4.06	4.21	4.84	7.40	12.26	14.40	13.92	14.04	16.39	30.72	21.14
	ZD	5.35	3.66	3.68	3.38	3.51	3.16	3.38	3.07	3.52	3.30	2.99	3.02	3.58	5.62	8.95	10.91	11.86	14.61	19.93	21.20
South Korea	ZS	3.20	2.35	2.80	5.74	7.81	8.64	10.34	8.43	6.15	10.72	10.90	10.12	11.25	10.42	11.51	13.36	16.76	19.74	21.55	17.59
	ZD	1.31	1.39	1.61	1.98	2.47	6.09	7.65	7.64	6.19	6.30	7.57	8.45	9.51	9.21	9.27	9.73	12.15	14.56	16.79	17.71
Kuwait	ZS	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	ZD	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Malaysia	ZS	11.32	8.31	7.73	8.61	9.39	9.04	13.10	11.90	10.01	11.00	11.02	10.39	12.03	11.61	15.77	15.82	21.15	23.32	27.28	23.45
	ZD	10.13	9.05	7.35	7.23	8.24	7.55	9.13	10.48	11.11	9.32	8.48	9.50	10.83	10.64	10.73	13.53	16.30	19.48	23.08	24.06
Mexico	ZS	3.54	1.82	0.89	2.59	0.86	4.27	3.81	4.59	2.80	4.63	1.72	4.59	1.89	2.83	3.67	2.80	6.25	8.74	22.94	9.82
	ZD	2.63	1.87	0.93	0.92	0.85	0.89	0.00	3.64	2.86	2.78	2.61	2.73	2.68	1.85	0.93	1.83	1.83	5.50	10.09	11.93

Peru	ZS	9.88	10.00	7.14	5.95	4.60	3.49	9.88	10.71	2.27	3.61	5.88	13.16	11.90	14.10	6.33	8.43	6.25	13.92	20.27	8.54
	ZD	10.00	10.00	5.00	6.17	5.95	2.41	3.61	3.70	2.53	2.35%	2.35	4.88	7.14	13.58	10.26	7.59	5.00	7.50	8.11	9.09
Philippines	ZS	20.39	18.18	15.05	11.68	11.16	7.73	11.11	11.63	8.33	11.40	7.18	9.18	7.58	6.83	8.61	8.82	11.06	11.88	22.01	15.05
	ZD	16.92	18.18	17.33	16.59	13.30	7.80	6.86	7.39	9.09	7.28	5.97	6.50	5.26	4.39	5.00	5.37	6.47	7.92	10.73	14.90
Poland	ZS	3.68	1.69	2.36	2.67	1.85	2.52	8.35	11.69	9.63	15.09	15.25	17.22	15.44	17.32	20.41	23.18	24.81	24.07	25.54	20.33
	ZD	2.71	1.37	1.20	1.17	1.51	1.02	1.77	4.70	7.20	6.98	8.40	11.84	13.99	13.84	14.40	17.29	21.18	23.09	21.41	17.61
Qatar	ZS	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	ZD	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Russia	ZS	3.55	3.68	1.08	3.33	3.91	3.89	7.14	14.29	9.50	7.23	10.44	12.87	13.33	14.71	9.39	9.50%	9.84	10.99	11.93	3.09
	ZD	0.51	0.52	1.55	1.05	1.06	2.62	3.76	4.02	7.18	8.60	9.57	7.95	11.76	11.59	10.12	9.94	9.84	8.89	9.34	4.42
Saudi Arabia	ZS	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	ZD	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
South Africa	ZS	5.17	5.26	6.14	6.49	4.74	3.36	5.44	6.38	4.24	6.17	5.44	6.14	4.44	5.49	6.41	7.56	6.61	8.72	14.22	9.01
	ZD	2.63	3.14	2.75	5.80	2.29	2.61	3.04	2.60	2.61	3.07	3.83	3.86	2.65	4.39	5.70	5.63	6.52	7.14	7.94	7.66
Taiwan	ZS	15.15	43.86	3.03	2.94	0.00	0.00	9.68	10.00	6.06	23.08	23.33	12.50	12.12	12.90	12.90	14.71	11.76	13.33	14.29	8.33
	ZD	9.68	3.45	3.23	0.00	0.00	0.00	0.00	3.33	3.13	12.50	12.50	20.00	13.79	9.68	15.63	11.76	12.12	15.15	11.76	6.67
Thailand	ZS	4.90	1.76	2.57	4.26	5.75	6.78	8.53	7.81	4.64	4.99	6.76	7.37	10.20	11.77	10.53	14.31	11.37	16.10	20.76	17.51
	ZD	4.55	3.03	1.86	2.56	3.32	4.13	6.20	6.24	5.33	4.17	2.54	3.90	5.56	7.53	8.91	10.22	9.84	12.05	14.63	15.87
Turkey	ZS	3.47	0.00	3.52	9.36	9.91	9.61	21.29	19.11	14.68	16.48	16.06	17.94	14.95	15.02	19.65	16.88	20.00	20.32	15.99	10.86
	ZD	2.29	2.00	1.16	2.14	3.42	7.16	9.27	12.42	13.56	12.38	12.46	15.18	14.56	14.10	14.66	14.38	18.81	18.95	18.39	13.97
United Arab Emirates	ZS	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	ZD	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Emergent Markets	ZS	5.00	5.60	3.48	4.18	3.91	3.90	6.53	7.44	4.99	7.49	7.46	7.68	7.67	9.72	9.89	8.94	9.46	11.51	14.64	12.00
	ZD	4.00	3.63	2.98	2.94	2.81	2.89	3.36	4.15	4.42	4.75	4.61	6.14	5.88	6.53	6.86	7.44	7.96	8.62	10.05	10.05

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