The zombie lending channel of monetary policy*

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Abstract

We identify a new channel in the monetary policy transmission to nonfinancial corporates—the zombie lending channel. Our findings show that unviable and unproductive zombie firms are less affected by contractionary monetary policy relative to other firms due to a more muted tightening in credit conditions. We rationalize this result with a strengthening in evergreening motives when interest rates rise: lenders face incentives to extend loans to zombies to prevent them from defaulting. Strengthening banks' balance sheets and curbing risky lending behavior could help mitigate zombie lending practices when financial conditions tighten.

Keywords: Monetary policy; Corporate investment; Zombie firms; Zombie lending

JEL classification: C33, C36, D22, E22, E52, G18, G33

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1 Introduction

The rise in the number of unviable and unproductive (zombie) firms raises an important question amid the tightening in global financial conditions:[1] how does the presence of zombie firms impact the transmission of monetary policy to nonfinancial firms? Specifically, how do zombie firms' financial performance respond to tighter financial conditions compared to nonzombies in the same industry? This is our main research question. Answering this question is important for two key reasons. First, zombie firms are known to create congestion effects on other firms in the same industry (Caballero et al. 2008, McGowan et al. 2018, Acharya et al. 2019, Banerjee and Hofmann 2022, Albuquerque and Iyer 2024). This raises the question of whether tighter financial conditions improve resource allocation towards more profitable and viable firms. Second, monetary policy directly influences firms' cost of capital and investment decisions, which is a key driver of business cycle fluctuations.

The response of zombie firms to monetary policy shocks is non-trivial. The financial constraints channel of monetary policy implies a stronger response of zombie firms to monetary policy shocks relative to other firms, as constraints become more binding when the cost of debt goes up (Jeenas 2019, Bahaj et al. 2022, Cloyne et al. 2023, Anderson and Cesa-Bianchi 2024). Similarly, the risk-taking and bank lending channels of monetary policy also suggest that zombie firms would react more strongly, as lenders prioritize lending to firms with better growth prospects. In addition, since zombie firms are more reliant on bank debt, they have less flexibility to secure alternative funding when credit conditions tighten (Becker and Ivashina 2014, Ippolito et al. 2018).

But it is also possible that zombie firms are less responsive to monetary policy. Our conjecture relies on the zombie literature. Banks' incentives to 'evergreen' loans of zombie firms may be stronger when interest rates increase, as banks internalize a higher probability of zombie firms filing for bankruptcy when the cost of debt goes up. In this scenario, it is plausible that banks, especially weak banks, may decide to extend the original loan to zombies to avoid the realization of losses. This is the so-called *zombie lending* channel. Overall, given the competing forces at work, the response of zombie firms to monetary policy shocks remains an empirical question that we tackle in this paper.

[1] Recent work has found the share of zombie firms worldwide to have risen over time, especially since the GFC, reducing overall productivity, investment and employment in the economy (Banerjee and Hofmann 2022, Albuquerque and Iyer 2024, Altman et al. 2024).

To trace out the dynamic effect of monetary policy shocks on firms, we employ a panel data Local Projection Instrumental Variable (LP-IV) approach using Compustat quarterly balance sheet data on nonfinancial listed firms for 47 countries (23 EMs and 24 AEs) over 2000-2019. We use US monetary policy shocks to identify exogenous variation in monetary policy conditions for our large panel of countries. US monetary policy has been shown to drive the global financial cycle, and is arguably exogenous to changes in economic conditions in the rest of the world (Rey 2013, Bruno and Shin 2015, Cesa-Bianchi et al. 2018, Kalemli-Özcan 2019, Bräuning and Ivashina 2020, Miranda-Agrippino and Rey 2020*b*, Cesa-Bianchi and Sokol 2022, Miranda-Agrippino and Nenova 2022). Our mechanism is similar to Morais et al. (2019), who study the international bank lending channel of monetary policy by focusing on the transmission of foreign monetary policy shocks from Europe, the UK, and the US to nonfinancial firms in Mexico.

Cross-border financial linkages in the international transmission of US monetary policy seem to have become more important due to growing globalization trends. To be sure, spillovers originating from US monetary policy via the financial channel, operating mainly through the risk-taking channel and portfolio rebalancing, tend in fact to dominate the trade and exchange rate channels from the Mundell-Fleming canonical model (Fleming 1962, Mundell 1963).[2] This motivates our choice for focusing on the financial channel of unanticipated US interest rate changes, through which US monetary policy affects monetary conditions abroad, after controlling for other channels. A contractionary US monetary policy shock transmits to higher foreign interest rates along the yield curve and leads to lower prices of risky assets, as a result of changes in risk perceptions and portfolio rebalancing by investors.

In our empirical setting, we use US high-frequency monetary policy surprises as the instrument for the country-specific monetary policy indicator, proxied with the local one-year sovereign bond yields (Gürkaynak et al. 2005, Gertler and Karadi 2015, Nakamura and Steinsson 2018). This first-stage IV is carried out separately for each country to allow the cost of borrowing in a given country to respond differentially to US monetary policy shocks. This is consistent with research documenting considerable differences in the transmission of US monetary policy shocks to foreign interest rates across countries (Kalemli-Özcan 2019, De Leo et al. 2023, Kearns et al. 2023). We use the one-year bond yield as the monetary policy indicator, and not shorter rates (policy rates or money market rates), as the former also incorporates changes

[2] See, for instance, Borio and Zhu (2012), Rey (2013), Bruno and Shin (2015), Passari and Rey (2015), Kalemli-Özcan (2019), Bräuning and Ivashina (2020), Miranda-Agrippino and Rey (2020*b*), Degasperi et al. (2023), Kearns et al. (2023), Caldara et al. (2024).

in risk premia. This enables longer-dated yields to more accurately reflect changes in a country's borrowing costs, after accounting for the central bank's potential countercyclical response to tighter financial conditions due to US monetary policy (Kalemli-Özcan 2019, Degasperi et al. 2023, De Leo et al. 2023, Kearns et al. 2023).

In our second-stage IV, we regress several firm balance sheet indicators on the monetary policy shock, i.e., the predicted country-specific local bond yields from the first-stage regression. Our coefficient of interest is the interaction term between the country-specific monetary policy shock and a dummy variable capturing zombie firms. We saturate the specification with firm fixed effects to control for permanent differences between firms, and with country-sector-time fixed effects to control for all time-varying industry-specific shocks within countries that are orthogonal to monetary policy. These fixed effects allow us to estimate the difference in responses between zombie firms and nonzombie firms within the same country, industry and quarter.

Our main findings are as follows. First, we find that zombie firms are less responsive to contractionary monetary policy shocks relative to nonzombie firms: zombie firms' investment and employment growth response at the peak, reached after roughly two years, is around 1.5 p.p. smaller relative to nonzombies. These responses are economically important. Our finding is somewhat surprising: despite weak balance sheets, zombie firms are not as responsive to monetary policy as expected under the financial constraints channel. However, when using a traditional metric for financial constraints—firms with a high probability of default—we find that financially constrained firms do respond more to monetary policy, consistent with the literature (Jeenas 2019, Morais et al. 2019, Bräuning and Ivashina 2020, Bahaj et al. 2022, Cloyne et al. 2023, Anderson and Cesa-Bianchi 2024, Di Giovanni and Rogers 2024).

We show that profitability is key in assessing how zombie firms differ in their response compared to financially constrained firms. If lenders expect a persistently unprofitable zombie firm will not generate enough revenue to repay its debt when interest rates increase, lenders may choose to roll over the zombie loan to prevent the firm from defaulting. This suggests that our findings may be driven by lenders' incentives to evergreen zombie loans—the zombie lending channel of monetary policy. Thus, we hypothesize that zombie firms are less responsive to monetary policy *because* of this zombie lending behavior.

Second, we build on the model from Faria-e-Castro et al. (2024) to rationalize our main finding that zombie firms are less responsive to monetary policy. When interest rates increase, banks may have incentives to offer better credit conditions to zombie firms relative to other firms to prevent them from defaulting. While the evergreening motive may be stronger for weakly capitalized banks—who may have less room to absorb the losses in case a zombie firm defaults—our model suggests that zombie lending takes place irrespective of concerns about bank capital. It is indeed possible that banks expect zombies to recover or to get market financing in the future, as zombies' reputation grows with the length of their lending relationship (Hu and Varas 2021). The mechanism by which lending flows to zombie firms at the expense of other firms highlights the role of zombie lending in mitigating the transmission of tighter monetary policy to zombie firms. We confirm this empirically: credit conditions, debt and the cost of debt, tighten by less for zombies following a monetary policy shock.

Third, we use data on syndicated loans to show that our main result is robust to controlling for lender supply and borrower demand effects. We find that lenders extend more new loans to zombie firms relative to other firms following a contractionary monetary policy shock. Moreover, we confirm the theoretical prediction that zombie lending tends to be more prevalent among under-capitalized banks who may have incentives to engage in evergreening practices to avoid recognizing the losses from zombie lending.

Finally, we find that zombies' financial performance in countries with higher regulatory capital buffers or lower nonperforming loans (NPLs), such as the United States, tend to experience a decline in investment growth relative to nonzombies following a tightening in monetary policy. We also find some evidence that macroprudential policies that target bank loans, and well-prepared insolvency regimes, may help mitigate zombie lending practices when financial conditions tighten. Overall, this suggests that a combination of a highly capitalized banking sector with an efficient resolution of financial distress in the bankruptcy code may help weaken banks' incentives to keep zombie firms alive, thus mitigating the zombie lending channel.

Our results are robust along several dimensions: (i) using alternative zombie definitions from the literature, including on one that relies on a concept of subsidized interest rates (Caballero et al. 2008, Acharya et al. 2019, 2024); (ii) using alternative country-specific monetary policy shocks from Choi et al. (2024); (iii) using longer-dated bond yields—the ten-year rate—as the monetary policy indicator; and (iv) controlling for central bank information effects. Overall, the robustness of our results reinforce the main narrative in this paper that lenders' zombie lending practices affect the monetary policy transmission to nonfinancial firms.

Our paper contributes to two main strands of the literature. Our first contribution to the growing literature on the macrofinancial effects of nonfinancial zombie firms (Caballero et al. 2008, McGowan et al. 2018, Acharya et al. 2019, 2024, Hu and Varas 2021, Banerjee and Hofmann 2022, Albuquerque and Iyer 2024, Faria-e-Castro et al. 2024) is to demonstrate that zombie lending practices play an important role in mitigating the transmission of monetary policy shocks to zombie firms. This misallocation of credit ultimately affects healthy firms' financial performance, with adverse effects on overall productivity and economic growth.

We also contribute to the literature analyzing the heterogeneous effects of monetary policy on nonfinancial firms (Jeenas 2019, Morais et al. 2019, Bräuning and Ivashina 2020, Bahaj et al. 2022, Cloyne et al. 2023, Anderson and Cesa-Bianchi 2024). The paper closest to ours is perhaps Morais et al. (2019), who find that Mexican nonfinancial firms that are financially riskier are more responsive to international monetary policy shocks. Our paper differs from theirs in several ways. First, we examine zombie firms, which differ from traditional financial constraints metrics that do not consider firms' profitability. We show that contractionary monetary policy shocks lead to more favorable credit conditions for zombie firms relative to other firms. In contrast, profitable distressed (nonzombie) firms respond more to monetary policy, echoing the results in Morais et al. (2019). Our key contribution is to show that, after a contractionary monetary policy shock, zombie firms' inherent lack of profitability incentivizes lenders to continue with zombie lending to avoid the realization of losses. Second, Morais et al. (2019) focus on foreign monetary policy shocks to one country (Mexico), whereas our paper covers 47 countries. This allows us to investigate both the heterogeneous effects among firms and countries. For instance, we find that US zombie firms' financial performance is more affected by contractionary monetary policy shocks, possibly reflecting the combination of a highly capitalized banking sector, stringent macroprudential policies, and well-developed insolvency frameworks. Third, while we use US monetary policy shocks to generate exogenous variation in country-specific shocks, our primary focus is on the effects of contractionary domestic monetary policy rather than the international bank lending channel. In addition, we show that our main findings are robust when using alternative country-specific monetary policy shocks from Choi et al. (2024).

2 Data and zombie firms

2.1 Data

Firm-level

We use quarterly balance sheet data from S&P Compustat North America, and Compustat

Global on nonfinancial listed firms for 47 countries, 23 EMs and 24 AEs, over 2000-2019. We exclude financial firms, namely banks, diversified financials, and insurance firms from our analysis. Following standard practice, we clean the data and make other adjustments to minimize measurement errors, and ensure the representativeness of the data (see Appendix A). We deflate nominal variables with the respective country CPI deflator. Our final sample covers an unbalanced panel of 24,333 nonfinancial firms over 2000q1-2019q4, resulting in 811,922 firm-quarter observations. Figure A.1 in Appendix A shows that we have roughly twice as many firms in AEs than in EMs, reflecting greater financial market depth in AEs.

Our main variables of interest to track how firms' financial performance is affected by monetary policy shocks are as follows: (i) investment growth is captured with the log percentage change in the net capital stock, which refers to capital expenditures in physical capital, namely property, plant, and equipment; (ii) employment growth is measured as the log percentage change in the total number of employees; (iii) debt growth takes the log percentage change in total debt (short and long); and (iv) the cost of debt is proxied with the implicit interest rate, computed as the four-quarter rolling sum of interest expenses divided by total debt.

Monetary policy shocks

To identify exogenous variation in monetary policy conditions around the world, we resort to US monetary policy shocks, which have been shown to drive the global financial cycle (Rey 2013). Our measure of US monetary policy surprises follows the high-frequency identification approach that identifies unexpected changes in the Fed policy rate (Gürkaynak et al. 2005, Gertler and Karadi 2015, Nakamura and Steinsson 2018). In particular, we extract the unexpected changes in three-month ahead contracts on Fed funds futures in a 30-minute window surrounding FOMC meetings (10 min before and 20 min after). We then transform these surprises into the quarterly frequency by summing up all daily surprises within the respective quarter.

We then use the countries' one-year sovereign bond yield as the monetary policy indicator to allow for an heterogeneous transmission of US monetary policy to countries' borrowing costs.

Country-level

In Section 7 we merge our dataset with aggregated country-level data to investigate how country-specific characteristics can mitigate or amplify zombie lending practices following a monetary policy tightening. We focus on bank balance sheet indicators, macroprudential policies, and insolvency frameworks. On bank indicators, we resort to banks' NPLs and capital ratios (from the IMF's Financial Soundness Indicators), and capital buffers. To compute regulatory capital buffers, we subtract the minimum required risk-based regulatory capital ratio (from the World Bank's Bank Regulation and Supervision Survey) from the banks' actual regulatory capital to risk-weighted assets. Using regulatory capital buffers is preferable, as the level of capital ratios worldwide may differ widely, complicating the cross-country comparison. Capital buffers may also provide us with a more accurate picture of the underlying resilience of banks, i.e. how much capital banks have to absorb shocks before they breach the regulatory limit.

To capture macroprudential policies, we use the IMF's integrated Macroprudential Policy (iMaPP) database, a comprehensive historical monthly database that combines information from various sources on several macroprudential policy measures in place, and changes in these measures, for 182 jurisdictions over 1990-2020 (Alam et al. 2024). The database covers 17 macroprudential instruments, and for each one of these measures it assigns the value of one for tightening actions, minus one for loosening actions, and zero for no change. These dummies are based on the effective date at which the policy enters into force. We follow Akinci and Olmstead-Rumsey (2018) and sum up the dummy indices for each instrument-country pair by taking the beginning of the dataset in 1990 as the starting point. These cumulative indices will provide a better sense of the stringency of macroprudential actions over time. We group the macroprudential instruments into seven main categories as in Alam et al. (2024).[3]

Finally, we measure the quality of insolvency regimes with the crisis preparedness indicator from Araujo et al. (2022). This indicator measures countries' preparedness to handle a large-scale restructuring of corporates, covering five main areas of the insolvency and restructuring regimes for corporates: out-of-court restructuring, hybrid restructuring, reorganization, liquidation, and the institutional framework. Araujo et al. (2022) find that countries with greater corporate sector vulnerabilities also tend to have less-developed insolvency regimes. The indicator is time-invariant, giving us a snapshot of the legal and institutional status of each country in 2020-21. We match this indicator to 39 countries in our firm-level dataset.

[3] *Demand* instruments include limits to the loan-to-value (LTV) ratio and to the debt-service-to-income (DSTI) ratio; *Supply – loans* instruments impose limits to credit growth (LCG), loan loss provisions (LLP), loan restrictions (LoanR), limits to the loan-to-deposit ratio, and limits to foreign currency loans; *Loan – targeted* measures refer to the sum of the previous two groups; *Supply – general* instruments refer to reserve requirements, liquidity requirements, and limits to FX positions; *Supply – capital* instruments encompass limits on leverage (LVR), countercyclical buffers (CCB), conservation buffers, and capital requirements; *SIFI* measures include capital and liquidity surcharges that aim at mitigating risks from global and domestic systemically important financial institutions; and *OT* instruments refer to other measures such as stress testing, and restrictions on profit distribution.

2.2 Zombie firms

The existence of unproductive and unviable—zombie—firms is not a new phenomenon. It dates back to Japan's lost decade in the late-1980s and 1990s, a period when lending to zombie firms played a key role in amplifying the economic stagnation by misallocating capital away from the most productive firms (Peek and Rosengren 2005, Caballero et al. 2008, Giannetti and Simonov 2013). Congestion effects materialized as the survival of zombie firms crowded out the profits of healthy firms that operated in the same industry. This had the effect of reducing overall productivity, investment and employment in the economy. Similar results have been found for a set of OECD countries over 1980-2017 (Banerjee and Hofmann 2022), and for selected European countries over 2003-13 (McGowan et al. 2018), and during the European sovereign debt crisis in the 2010s, a period when weak European banks 'kicked the can down the road' by evergreening zombie loans (Storz et al. 2017, Acharya et al. 2021, Schivardi et al. 2022, Blattner et al. 2023).

Recent research has shown that the share of zombie firms has been increasing over the last two decades, especially since the GFC (Banerjee and Hofmann 2022, Albuquerque and Iyer 2024, Altman et al. 2024). In this context, a scenario of higher global interest rates combined with the increase in the incidence of zombification raises questions about whether tighter financial conditions will allow a better allocation of resources towards more profitable and viable firms.

The literature has come up with several definitions to capture these unproductive and unviable zombie firms, ranging from a concept of subsidized interest rate from lenders (Caballero et al. 2008, Acharya et al. 2019, 2024), to old firms that do not generate enough operating revenues to meet their interest payment obligations (McGowan et al. 2018), and combined with lack of growth opportunities (Banerjee and Hofmann 2022), and to firms with low profitability and high default risk (Schivardi et al. 2022, Altman et al. 2024).

In this paper, we follow Albuquerque and Iyer (2024), who identify zombie firms on a large set of listed and private firms worldwide. They use three balance sheet indicators to capture firms that are most likely in financial distress and are persistently unprofitable: zombie firms are firms whose interest coverage ratio (ICR) is below one, the leverage ratio is above the median firm in the same country-industry pair, and whose real sales growth are negative. All of these conditions need to be observed for at least two consecutive years. Moreover, this definition only allows zombie firms to exit the zombie status once at least one of the indicators is reversed for two years in a row. The two-year horizon in the entry to, and exit from, zombie status minimizes misclassification from cyclical fluctuations. The two indicators of financial distress, the ICR and leverage ratio, are relatively standard in the literature; but using negative real sales growth ensures that we define zombie firms as firms that are also persistently unprofitable.[4]

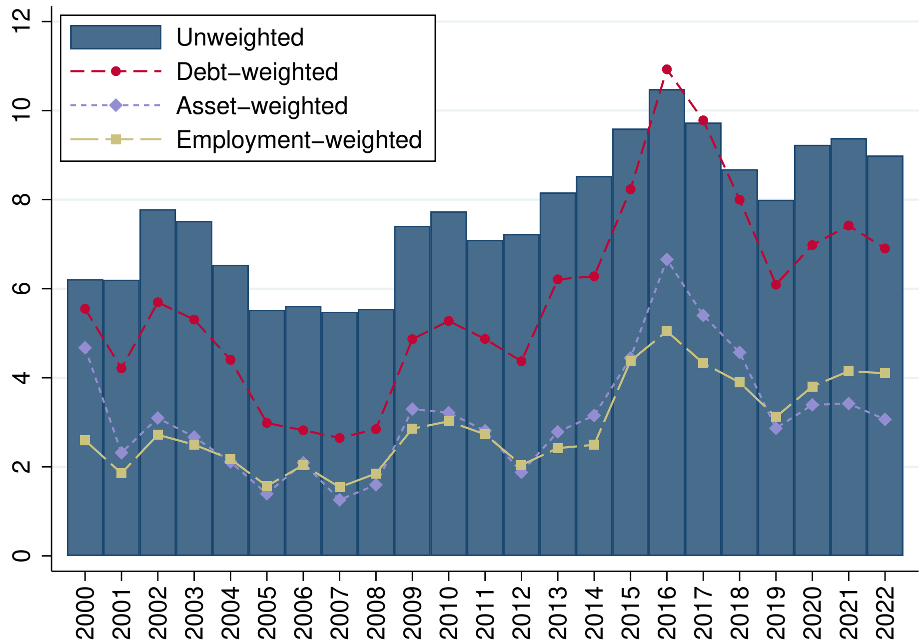
The definition used in this paper does not require zombie firms to be charged a lower interest rate than high-rated firms. However, Albuquerque and Iyer (2024) show that this definition is still consistent with the concept of subsidized interest rates: although zombie firms face a slightly higher cost of debt relative to other firms, the interest rate that zombies pay is lower than what their risk implied cost of debt would suggest, consistent with a *weak* form of subsidization by lenders. This is in line with emerging evidence that zombie firms tend to pay relatively higher interest rates than high-rated peers, although lenders may still offer an interest rate subsidy (Havemeister and Horn 2023, De Jonghe et al. 2024, Faria-e-Castro et al. 2024, Favara et al. 2024). Overall, the zombie definition used in this paper strikes a good balance between simplicity in its implementation and accuracy in capturing zombie firms, while remaining consistent with the notion that zombie firms benefit from an interest rate subsidy.

Figure 1, reproduced from Albuquerque and Iyer (2024), shows an upward trend in the share of listed zombie firms for a sample of 68 countries over the last 20 years. This is especially evident after the GFC, possibly motivated by a prolonged period of low interest rates, ample liquidity, and search for yield behavior. After the temporary downward trend from 2016 to 2019, the share of zombie firms picked up again since the Covid-19 pandemic, presumably on account of the unprecedented policy support and easy financing conditions. Albuquerque and Iyer (2024) show that zombie shares vary widely across countries and industries (Figures A.2 and A.3 in Appendix A). In particular, zombies tend to be more prevalent in nontradable industries, such as in energy, real estate, materials, information technology, and consumer discretionary. These industries tend to be more financially vulnerable, less productive, experience more debt booms, and face weaker growth opportunities (Albuquerque 2024, Müller and Verner 2024).

Zombie firms are typically characterized by substantially weaker balance sheets than non-zombies within the same industry and country (Table 1). For instance, zombie firms are less productive and profitable, as shown by a lower asset turnover ratio and ROA, invest less, hold limited liquid assets, tend to be smaller, are at a higher risk of default, and are more dependent on bank loans. Moreover, and in line with our previous remarks, zombie firms seem to pay a slightly higher interest rate relative to other firms.

[4]Sales growth is a strong predictor of future productivity (Goyal and Yamada 2004, Whited and Wu 2006).

Figure 1: World share of listed zombie firms



Source: Figure A.1 reproduced from Albuquerque and Iyer (2024).
Notes: The blue bars refer to the unweighted percentage share of zombie firms, while the different lines refer to zombie shares weighted by total debt, total assets, or employment.

Table 1: Characteristics of zombie firms

Panel A

	(1) Log K	(2) ΔK	(3) ΔIntan	(4) ΔEmp	(5) Liq.asset	(6) Debt	(7) ΔDebt	(8) Int.rate
Zom	-0.518***	-2.684***	-3.568***	-9.492***	-19.243***	17.946***	-2.543***	0.111*
	(0.010)	(0.051)	(0.052)	(0.102)	(0.118)	(0.084)	(0.079)	(0.057)
Observations	1,862,721	1,764,326	1,402,058	991,606	1,858,882	1,867,008	1,704,450	1,311,453
R^2	0.270	0.096	0.149	0.094	0.157	0.181	0.054	0.159

Panel B

	(1) ΔSales	(2) Turnover	(3) Log Assets	(4) ICR	(5) ROA	(6) PD	(7) Age	(8) Loan shr
Zom	-3.811***	-14.975***	-0.630***	-27.863***	-9.440***	0.793***	-1.298***	2.025***
	(0.053)	(0.270)	(0.009)	(0.756)	(0.081)	(0.011)	(0.106)	(0.130)
Observations	1,417,732	1,473,869	1,867,008	1,255,150	1,399,335	1,440,321	1,221,385	1,866,004
R^2	0.144	0.225	0.271	0.111	0.165	0.307	0.326	0.170

Source: Table 1 reproduced from Albuquerque and Iyer (2024).
Notes: All regressions include country-industry-quarter fixed effects. Standard errors in parentheses clustered by country-industry-quarter. Asterisks, *, **, and ***, denote statistical significance at the 10%, 5%, and 1% levels.

3 Empirical strategy: LP-IV approach

In this section, we describe our identification and empirical strategy. The goal of our empirical analysis is to estimate the dynamic causal effect of monetary policy shocks on a large sample of non-US nonfinancial firms' financial performance, with a predominant focus on corporate investment. We are particularly interested in investigating the differential effects of monetary policy on zombie firms compared to nonzombie firms.

3.1 Identification

We face two challenges in the identification of the effects of monetary policy shocks. The first one is a potential reverse causality issue: interest rates respond to the economy but can also affect it. We resort to US monetary policy shocks to identify exogenous variation in monetary policy conditions around the world, as US monetary policy drives the global financial cycle, and is arguably exogenous to changes in economic conditions in the rest of the world. Our approach is similar in spirit to Morais et al. (2019). This paper studies the international bank lending channel of monetary policy by focusing on the transmission of foreign monetary policy shocks from Europe, the UK, and the US to Mexican nonfinancial firms.

Specifically, we follow the recent literature that uses a high-frequency identification of monetary policy surprises as proxies for the true monetary policy shocks (Gürkaynak et al. 2005, Gertler and Karadi 2015, Nakamura and Steinsson 2018). The idea is to isolate the interest rate surprises using the movement in three-month Fed Funds Futures within a 30-minutes window around FOMC policy announcements. The identifying assumption is that no other factors could drive both the private sector behavior and monetary policy decisions within this short interval.

To estimate the dynamic causal effects from the firm-level data, we use a panel data Local Projection Instrumental Variable (LP-IV) setup, following Jordà et al. (2020) and Cloyne et al. (2023). This specification flexibly estimates the impulse response functions on firm-level panel data using monetary policy surprises as instruments for a variable capturing the monetary policy indicator. We use the country-specific one-year sovereign bond yield as the relevant indicator of monetary policy. As shown in Stock and Watson (2018), the LP-IV estimation automatically imposes the unit-effect normalization, allowing us to interpret the size of the shock in terms of the units of the endogenous variable, i.e. the monetary policy indicator.

Since US monetary policy can affect monetary policy conditions abroad through several channels, the second challenge involves the identification of the different channels in the international transmission of US monetary policy. According to the standard Mundell-Fleming model, the international transmission of monetary policy operates through two (offsetting) factors (Fleming 1962, Mundell 1963): contractionary US monetary policy reduces US domestic demand towards home and foreign goods (the demand-reducing channel), but it also causes a depreciation of the local currency against the US dollar. The latter makes a country's exports more competitive, thus increasing a country's foreign demand for its goods and services (the expenditure-switching channel). These channels are also sometimes referred to as the trade channel and the exchange rate channel. Research has broadly found that the demand-reducing channel predominates over the expenditure-switching channel, so contractionary US monetary policy leads to negative spillovers to the rest of the world.

The Mundell-Fleming model is useful to understand how monetary policy in one country spills over to another country. But the increasing globalization and financialization of the world economy has brought to the fore the key role played by cross-border financial linkages in the international transmission of US monetary policy. In fact, US monetary policy spillovers to capital/financial flows via the financial system, operating mainly through risk-taking and portfolio rebalancing, have been shown to dominate over the traditional Mundell-Fleming channels (Borio and Zhu 2012, Rey 2013, Bruno and Shin 2015, Passari and Rey 2015, Kalemli-Özcan 2019, Bräuning and Ivashina 2020, Miranda-Agrippino and Rey 2020*b*, Degasperi et al. 2023, Kearns et al. 2023, Caldara et al. 2024). For simplicity, we refer to this channel as the *financial channel* in the international transmission of US monetary policy shocks. Empirically, a contractionary US monetary policy shock transmits to higher foreign interest rates along the yield curve and causes the prices of risky assets to fall, as a result of changes in risk perceptions and portfolio rebalancing by investors. In a world with integrated financial markets, where economic agents rely on international markets for their funding, the co-movement in interest rates supports the predominant role of the financial channel in the transmission of US monetary policy to the rest of the world.

Against this background, we focus on the financial channel of unanticipated US interest rate changes, specifically by isolating the exogenous impact of US monetary policy on foreign interest rates, after controlling for other channels. We then study how the tightening in monetary conditions abroad driven by tighter US monetary policy affects firms' financial performance. The financial channel of interest rate changes should be important for all nonfinancial firms in our sample, as changes in sovereign borrowing costs determine the prevailing local credit conditions at which all firms with external finance borrow from financial markets. By contrast, while the indirect effects of monetary policy through other channels may certainly be important, the direct effects of the exchange rate channel should be confined to firms with foreign-currency debt, while the trade channel should be more directly relevant for exporting firms.

3.2 First-stage regression

The first-stage specification is given by the following:

$$R_{c,t} = \alpha_c + \delta_c S_t + \Gamma_c' \mathrm{X}_{c,t-1} + u_{c,t}, \quad \text{for each c} \tag{1}$$

where $R_{c,t}$ denotes the one-year government bond yield in each country c at time t, and S_t denotes the US monetary policy surprises. Controls $X_{c,t-1}$ include four lags of real domestic and US GDP growth, consumer price inflation, current account balance as a percentage of GDP, and the real effective exchange rate. Although we focus on the financial channel (via changes in interest rates) through which US monetary policy transmits to foreign nonfinancial firms, our specification allow us to control for the other two main channels of monetary policy: the current account balance captures the trade channel, and the real effective exchange rate the exchange rate channel. Adding domestic and US GDP growth controls for demand effects. We allow for fully heterogeneous coefficients across countries by running the first-stage regression separately for each country.[5]

We then collect the predicted value $\hat{R}_{c,t}$ as the identified monetary policy shocks for each country. Running country-by-country regressions instead of pooling the data across countries is predicated on research showing that the transmission of US monetary policy shocks to foreign interest rates varies substantially across countries (Kalemli-Özcan 2019, De Leo et al. 2023, Kearns et al. 2023). For instance, Kearns et al. (2023) explain that differences in financial openness, speaking to the financial channel of US monetary policy, account for a large share of the heterogeneity in the responses of local interest rates to US monetary policy.

We choose the one-year government bond yield as our monetary policy indicator for the following reasons. First, it is fairly standard in the literature studying the effects of monetary

[5]This approach is similar to a Bartik-type instrument, where all countries face a common shock from US monetary policy but the sensitivity of the response is allowed to be different across countries. The identification in our setting relies on the exogeneity of the monetary policy surprises instead of the exogeneity in the sensitivities.

policy on the real economy (Gertler and Karadi 2015). In addition, it also has the advantage of capturing forward rate guidance. Second, using shorter rates, such as the central bank's policy rate, the one- or three-month rates, may not accurately capture how a country's monetary conditions actually respond to US monetary policy. The international spillovers of US monetary policy, to both AEs and EMs, seem indeed to be more important for longer-dated bond yields, as these also incorporate changes in risk premia, both term premia and credit risk premia (Kalemli-Özcan 2019, Degasperi et al. 2023, De Leo et al. 2023, Kearns et al. 2023). In turn, shorter rates in the rest of the world do not typically respond to US monetary policy news (Kearns et al. 2023), or actually decline as central banks respond countercyclically to a contraction in economic activity (Kalemli-Özcan 2019, Degasperi et al. 2023, De Leo et al. 2023). All in all, by focusing on one-year rates, we are able to more accurately capture how local financial conditions or borrowing costs change due to US contractionary monetary policy.[6]

3.3 Second-stage regression

We employ an indirect IV approach instead of running the two-stage least squares (2SLS) directly with firm-level data as controls. The advantage of using the indirect IV approach is the following. In a standard 2SLS regression, all firm-level controls of the second-stage regression are automatically part of the first-stage regression, leading to a weak-instrument issue. Since it is likely that US interest rates will not be affected by foreign firms' characteristics, it is presumably not necessary to add firm-level controls in the first-stage regression. This will not affect the consistency and efficiency of the estimators, as discussed in Baltagi (2011), pages 265-66. Our first-stage regression is thus more in the spirit of the related literature using country-level data to identify monetary policy shocks (Gürkaynak et al. 2005, Gertler and Karadi 2015, Nakamura and Steinsson 2018, Cloyne et al. 2023). While the weak instrument issue with micro data is well-known, our average F-statistic in the first-stage specifications across all countries is fairly strong, of around 13.

The general expression of the second-stage regression, where we investigate the effects of monetary policy shocks on nonfinancial firms, is given by the following:

$$\Delta_h Y_{i,t+h} = \beta^h \hat{R}_{c,t} + \Gamma_h Z_{i,t-1} + \Theta_h X_{c,t-1} + \alpha_i^h + \alpha_t^h + \epsilon_{i,t}^h, \quad h = 1, 2, ..., 16 \tag{2}$$

where the dependent variable $\Delta_h Y_{i,t+h}$ is defined as the cumulative change from period h to $t+h$,

[6] Our results are robust to using ten-year rates. We opted to use one-year rates due to the larger sample size.

with $h \in 0, 1, ..., 16$ quarters ahead, of selected balance sheet variables of firm i. We use growth rates for investment, employment, and debt, defined as the cumulative percentage change in the logarithm of the respective variables: $\Delta_h Y_{i,t+h} = (\log Y_{i,t+h} - \log Y_{i,t-1}) \times 100$. For the implicit interest rate, we take the first difference in the level. We add four lags of several firm-level variables $Z_{i,t-1}$, namely the lagged dependent variable, the log of total assets to proxy for firm size, the debt-to-asset ratio to control for leverage, and the net liquid asset position, computed as current assets net of current liabilities as a ratio of total assets. We also include the same set of country-level controls $X_{c,t-1}$ as in the first-stage regression to avoid biasing the IV estimation (Baltagi 2011). We add firm fixed effects α_i^h to control for permanent differences between firms that may affect how firms respond to monetary policy, and time fixed effects α_t^h to capture unobserved global shocks. Our coefficient of interest is β^h, which measures the average effect on foreign nonfinancial firms' financial performance of an identified tightening in monetary policy, calibrated to increase country-specific borrowing costs $\hat{R}_{c,t}$ by one-percentage point, or 100 basis points (bps). We double-cluster the standard errors by firm and time.

4 Main results

4.1 Average effects

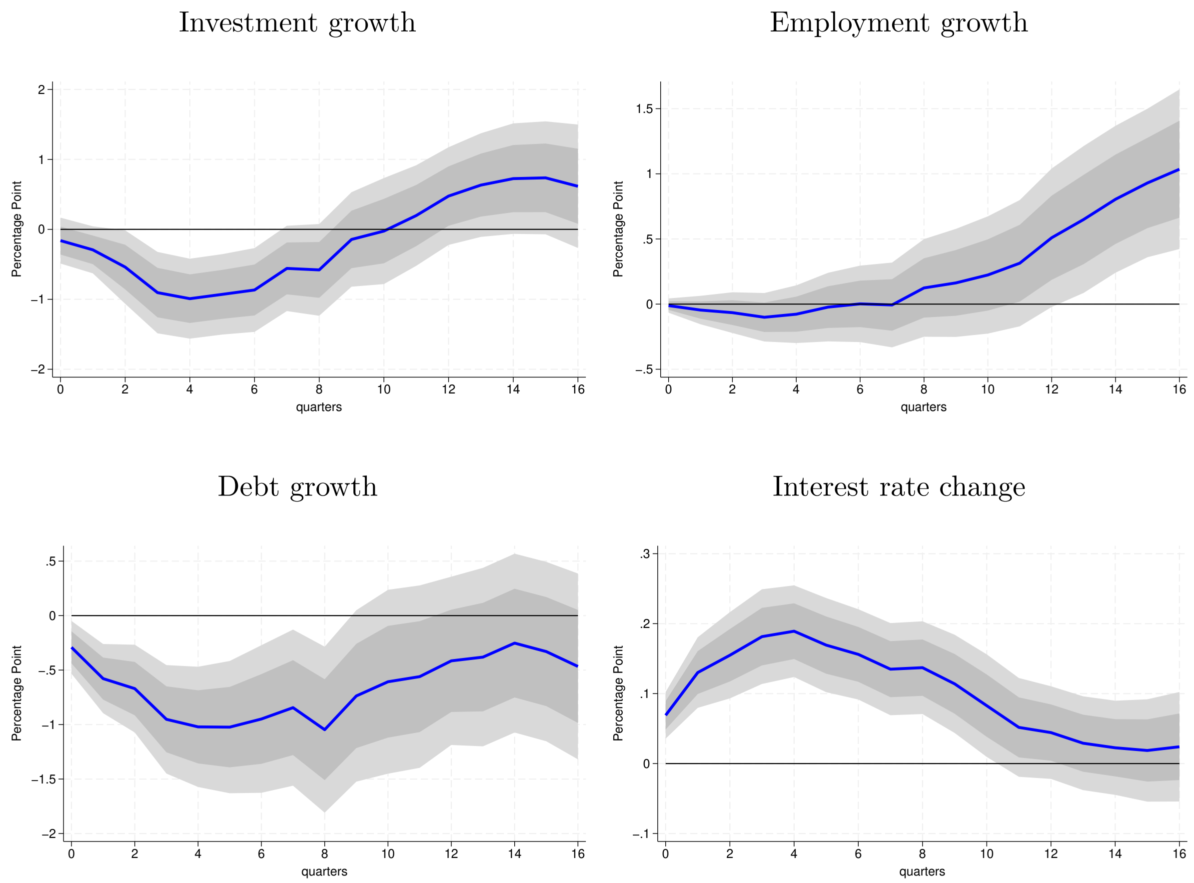
Figure 2 shows the series of β^h from Equation (2). We find that monetary policy has important negative effects on nonfinancial firms. In particular, corporate investment contracts immediately, but the employment response is muted in the short term. The investment growth response reaches a trough of roughly one p.p. after four quarters, and then recovers slowly to the baseline. The magnitude of the decline falls within the estimated range reported in the literature using micro data (Li et al. 2020, Arbatli-Saxegaard et al. 2022, Di Giovanni and Rogers 2024).[7]

Consistent with the fall in investment, we find that credit standards for nonfinancial firms tighten. First, firm debt falls after the tightening in monetary policy, which may reflect a combination of tighter credit supply and lower credit demand (the debt-to-asset ratio also falls). Second, our proxy for the cost of debt—the implicit interest rate as measured with interest expenses divided by the stock of debt—increases over the medium term. These two phenomena are in line with the bank credit channel of monetary policy, whereby higher interest

[7] We show in Figure C.1 in Appendix C that our monetary policy shocks lead to stylized responses of aggregate economic activity, as illustrated by the hump-shaped contraction in real GDP growth, and by the decline in inflation, measured with the log of the consumer price index (CPI).

rates lead to an overall contraction in credit supply in the economy (Bernanke and Gertler 1995, Kashyap and Stein 2000, Jiménez et al. 2012, Ippolito et al. 2018).

Figure 2: Average effects of monetary policy shocks on nonfinancial firms



Notes: Cumulative impulse responses to a monetary policy shock that increases the country-specific one-year sovereign bond yields by 100 bps. The blue line is the average point estimate, and the dark (light) grey area refers to the 68 (90) percent confidence bands.

We find similar results when using the country-specific ten-year bond yields as the monetary policy indicator in the IV specification (Equations 1 and 2)—see Figure C.2 in Appendix C. The effects of monetary policy on investment, debt, and interest rates are somewhat stronger than in our baseline using one-year rates. This is in line with the notion that US monetary policy transmits mainly to the long-end of the yield curve, reflecting the repricing of risk and portfolio rebalancing by investors (Kalemli-Özcan 2019, Degasperi et al. 2023, De Leo et al. 2023, Kearns et al. 2023). By contrast, using country-specific short-term rates (three-month money market rates or treasury bill rates) as the monetary policy indicator leads to weaker and short-lived effects on firms' financial performance (Figure C.3). Our findings are, again, consistent with the same research showing that central banks' policy rates or short-term rates may not accurately capture how a country's borrowing costs respond to US monetary policy, as central banks may possibly want to partially offset the tightening in financial conditions driven by contractionary

US monetary policy. In this context, using longer rates, including one-year rates as in our baseline, is preferable to properly account for changes in local monetary conditions after a US monetary policy shock.[8]

Overall, our results confirm the findings in the literature using aggregated country-level data (Dedola et al. 2017, Kalemli-Özcan 2019, Miranda-Agrippino and Rey 2020*b*, Hoek et al. 2022, Bräuning and Sheremirov 2023, Degasperi et al. 2023) and firm-level data (Morais et al. 2019, Bräuning and Ivashina 2020, Li et al. 2020, Arbatli-Saxegaard et al. 2022, Di Giovanni and Rogers 2024) that US monetary policy shocks have important negative spillovers on firms' financial performance worldwide. This is most likely the result of US monetary policy driving the global financial cycle, as identified in Rey (2013).

4.2 Differential effects of zombies versus nonzombies

We now explore the heterogeneity in the firms' responses to monetary policy shocks; our main research question investigates the differential response of zombie firms relative to other firms. At face value, our prior would be that the risk-taking and bank lending channel would imply a stronger response of zombie firms to monetary policy shocks. Since lenders prioritize lending to projects with higher net present value (NPV), it follows that credit would be curtailed more for zombie firms as these firms are less productive (see Table 1). Zombie firms are also riskier and potentially more borrowing constrained, so the financial constraints channel would imply a stronger response of zombies to a monetary policy shock.

Furthermore, differences in the corporate debt structure of zombie firms, who rely more on bank debt than other firms, as we have seen in Table 1, may also imply a stronger response to monetary policy shocks; zombie firms may have less flexibility to find alternative sources of funding to finance their investment when the shock hits (Becker and Ivashina 2014, Ippolito et al. 2018, Morais et al. 2019, Crouzet 2021). Corporate bonds typically carry a lower interest rate than bank loans, have longer maturities, are issued at fixed rates, and are less exposed to cyclical fluctuations in credit supply (Becker and Ivashina 2014, Ippolito et al. 2018, Crouzet 2021, Holm-Hadulla and Thürwüchter 2021).

But, on the other hand, this financial flexibility channel may work the other way around:

[8] We do not find a statistically significant difference in the average responses between AEs and EMs. This is in line with empirical evidence showing that the response of AEs and EMs to US monetary policy shocks may be more homogeneous than previously thought (Dedola et al. 2017, Arbatli-Saxegaard et al. 2022, Degasperi et al. 2023, Di Giovanni and Rogers 2024), and can potentially be larger for AEs, given that these economies are more integrated in the global capital markets (Kearns et al. 2023). Results available upon request.

banks' informational advantage about borrowers may facilitate loan renegotiation (Berlin and Mester 1992, Hadlock and James 2002, Darmouni et al. 2022). In fact, this literature argues that bank loans tend to offer more flexibility in terms of renegotiating the terms of the loan, especially when financial frictions are high, while bonds are held by several investors, making a renegotiation more complex. According to this view, a contractionary monetary policy shock would imply a weaker response of zombie firms relative to nonzombies.

We draw on the zombie literature to add another layer to the debate. Banks' incentives to evergreen existing debt of zombie firms to keep them alive may be an important mechanism through which banks may shift lending to zombies at the expense of nonzombies (Peek and Rosengren 2005, Caballero et al. 2008, Albuquerque and Iyer 2024, Faria-e-Castro et al. 2024). We posit that the evergreening incentives may be stronger when interest rates increase, as banks internalize that the probability of zombie firms filing for bankruptcy increases as the cost of debt goes up. In this context, banks may decide to extend the original loan to zombies so as to avoid the realization of losses. This incentive may be stronger for weaker banks who may not have enough capital to absorb the losses from zombie lending.[9] Against the background of different channels/theories, whether zombie firms are more or less responsive to monetary policy shocks remains an empirical question.

We modify the equation on the average effects (Equation 2) by adding an interaction term between the (lagged) zombie dummy and the monetary policy indicator:

$$\begin{aligned} \Delta_h Y_{i,t+h} &= \gamma_h Zom_{i,t-1} + Zom_{i,t-1} \times (\beta^h \hat{R}_{c,t} + \delta_h Z_{i,t-1} + \Theta_h X_{c,t-1}) \\ &+ \Gamma_h Z_{i,t-1} + \alpha_i^h + \alpha_{c,s,t}^h + \epsilon_{i,t}^h, \end{aligned} \tag{3}$$

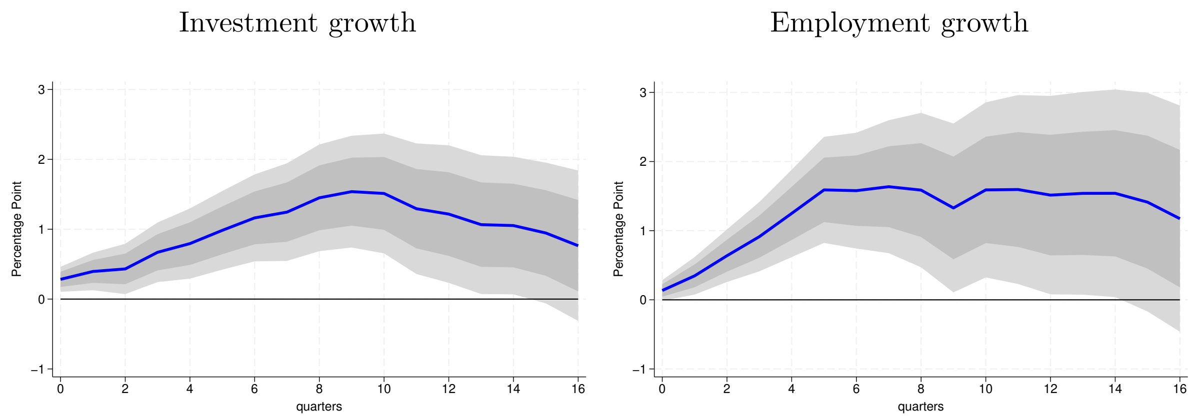
where we add country-sector-time fixed effects to control for all sources of shocks that may affect firms differently depending on time-varying country and industry shocks. Adding these fixed effects allow us to interpret our coefficient of interest β^h as the differential response to monetary policy shocks of zombie firms *relative* to nonzombie firms within the same country, industry and quarter. We also include interaction terms of the zombie dummy with all controls to make sure our results are not driven by time-varying differences between zombie firms and nonzombies. Note that we cannot estimate anymore the average effect. Since in the previous

[9] State ownership also seems to matter. Chari et al. (2024) find that state-owned banks in India typically lend more heavily to weak or zombie firms. Moreover, the authors also find that regulatory forbearance measures implemented by the Reserve Bank of India during the GFC encouraged government-owned banks to increase lending to zombie firms, which led to a significant credit misallocation.

section we have estimated a decline in firms' financial performance (e.g. a decline in investment, employment, and debt growth), we interpret a positive (negative) coefficient as indicating that zombie firms are less (more) responsive to a tightening in monetary policy.

Figure 3 indicates that the responses of investment and employment of zombie firms are positive and statistically significant, suggesting that zombie firms' financial performance is less affected by higher interest rates *relative* to nonzombies. Specifically, we find that the response of zombie firms' investment and employment growth at the peak, reached after roughly 2 years, is around 1.5 p.p. smaller relative to nonzombies. These are economically important results. For instance, the mean sample difference of investment growth between zombies and nonzombies is 2.6 p.p.. A monetary policy shock calibrated to increase bond yields by 100 bps thus leads this gap to shrink by over 50 percent. Our results are not sensitive to using longer-dated yields (ten-year) as the monetary policy indicator (Figure C.4).

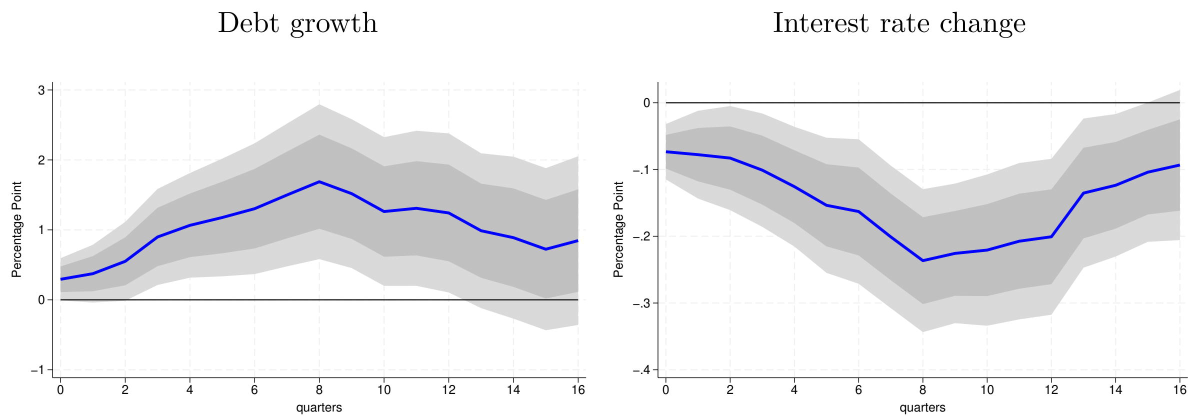
Figure 3: Differential effect of monetary policy shocks on zombies versus nonzombies: investment and employment



Notes: Cumulative impulse responses for zombie firms relative to nonzombies to a monetary policy shock that increases the country-specific one-year sovereign bond yields by 100 bps. The blue line is the average point estimate, and the dark (light) grey area refers to the 68 (90) percent confidence bands.

Figure 4 sheds some light on our main finding that zombie firms' financial performance is less affected by monetary policy shocks than nonzombies. Running again Equation (3), we find a statistically significant and positive coefficient on debt growth, and a negative coefficient on the implicit interest rate of zombie firms relative to nonzombies. This suggests that credit standards tighten by less for zombies following a monetary policy shock. Recall that debt growth falls and interest rates increase for the average firm in the sample, which implies that debt growth falls by less for zombie firms after two years, by 1.6 p.p., while the cost of debt rises by less, by roughly 0.25 p.p. relative to nonzombies. All in all, the fact that zombie firms may get more favorable credit conditions when financial conditions tighten, provides supporting evidence for banks' evergreening practices by shifting lending to zombies. This then allows zombies' financial performance to be less affected—the zombie lending channel of monetary policy.[10]

Figure 4: Differential effect of monetary policy shocks on zombies versus nonzombies: credit conditions



Notes: Cumulative impulse responses for zombie firms relative to nonzombies to a monetary policy shock that increases the country-specific one-year sovereign bond yields by 100 bps. The blue line is the average point estimate, and the dark (light) grey area refers to the 68 (90) percent confidence bands.

Let us now clarify the apparent tension between our results, zombie firms less affected by interest rates increases, and the notion that low interest rates may lead to zombification due to ample liquidity, and search for yield behavior (Gopinath et al. 2017, Acharya et al. 2019, Banerjee and Hofmann 2022, Blattner et al. 2023, Altman et al. 2024). Our focus is on how zombie firms respond to contractionary monetary policy shocks, but taking the existence of zombie firms as given. In this context, our paper is silent on the factors that may have contributed to zombification or the creation of zombies. We focus instead on how interest rate *changes*, irrespective of whether the interest rate increases are coming from a prolonged period of low interest rates, may affect the financial performance of zombie firms through zombie lending. Our results suggest that monetary policy (through increases in interest rates) may not be the right tool to address zombification as long as banks face incentives to evergreen zombie loans. We will see in Section 7 that zombie lending can be mitigated by well-developed insolvency frameworks, and by (macroprudential) policies that strengthen the banking sector.

4.3 Zombie lending and lenders' profitability concerns

Our finding that zombie firms are less affected by contractionary monetary policy shocks is somewhat surprising in light of research finding that financially constrained firms are more

[10]We get mixed results with the three-month rate (Figure C.5). This underscores the importance of using (longer-dated) local interest rates that properly account for the transmission of US monetary policy (Kalemli-Özcan 2019, Degasperi et al. 2023, De Leo et al. 2023, Kearns et al. 2023).

responsive to monetary policy shocks (Jeenas 2019, Morais et al. 2019, Bahaj et al. 2022, Cloyne et al. 2023, Anderson and Cesa-Bianchi 2024). Since zombie firms are riskier, unproductive, and with weaker balance sheets, one would expect zombie firms to respond in a similar fashion to financially constrained firms.

We first check in our dataset how financially constrained firms respond to monetary policy shocks by adjusting the baseline Equation (3) with one additional dummy term (and all relevant interaction terms) capturing firms that are financially constrained. We use the probability of a firm defaulting over the next 12 months, a modified version of Merton's distance-to-default model (Merton 1974) taken from the National University of Singapore's Credit Research Initiative (NUS-CRI). This indicator takes as inputs the firm's equity valuation and leverage, and the volatility of the market value of the firm' assets.[11] Specifically, we define financially constrained firms for each quarter as those firms whose probability of default lies in the upper quartile of the country-specific probability of default distribution.

Figure C.6 in Appendix C shows that both investment and debt growth of financially constrained firms are more responsive than other firms to a tightening in monetary policy, corroborating the results in the literature (Morais et al. 2019, Bräuning and Ivashina 2020, Li et al. 2020, Arbatli-Saxegaard et al. 2022, Cloyne et al. 2023, Di Giovanni and Rogers 2024). We find tentative evidence that our result reflects most likely greater challenges in accessing external finance as credit conditions tighten more relative to other firms (although the responses are not estimated precisely): a larger fall in total debt and a greater increase in the cost of debt. Overall, our results suggest that the behavior of zombie firms is fundamentally different from the conventional response of financially constrained firms.

An open question is why constrained firms are more responsive than zombie firms. We hypothesize that differences in profitability between the two types of firms may explain this phenomenon. In fact, the previous definition of financial constraints is silent on the firm's underlying profitability. It is therefore perfectly possible that constrained firms are profitable, despite having difficulties in accessing external financing. To further investigate this, we compare zombie firms with other similar firms but we impose that the latter are profitable. As a reminder, we have defined zombie firms as firms in financial distress—an ICR below one and leverage ratio above the median for two consecutive years—and unprofitable—negative real sales growth for two years. We construct a dummy variable taking the value of one for firms that meet only

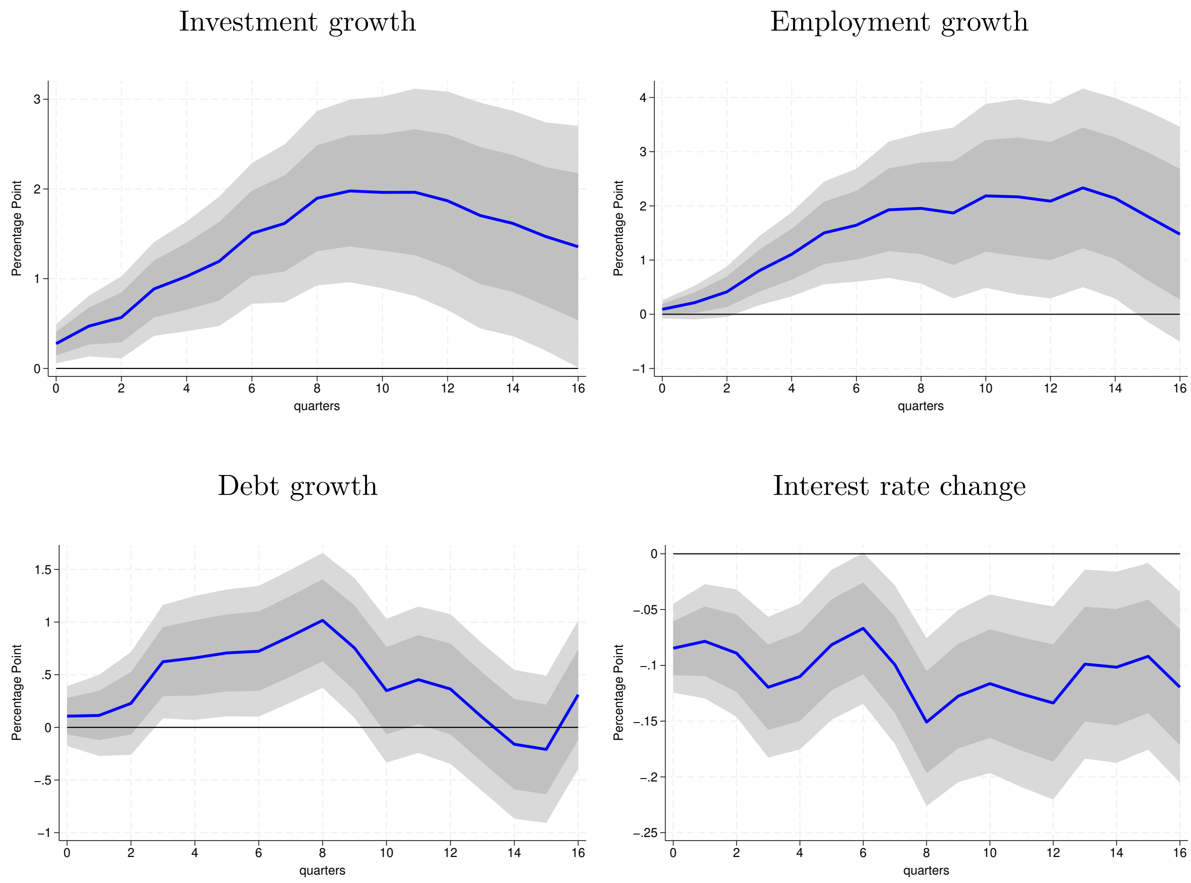
[11] The probability of default has been shown to capture more accurately financial constraints relative to other metrics, such as leverage, firm size, or the age of the firm (Farre-Mensa and Ljungqvist 2016).

the first two zombie criteria/indicators proxying financial distress but we assume that they are profitable, i.e., firms with positive real sales growth. Imposing positive real sales growth for this new group of firms allows us to compare distressed firms with positive and negative real sales growth (zombie firms). The modified version of Equation (3) is as follows:

$$\begin{aligned}\Delta_h Y_{i,t+h} &= \gamma_h Zom_{i,t-1} + Zom_{i,t-1} \times (\beta^h \hat{R}_{c,t} + \delta_h Z_{i,t-1} + \Theta_h X_{c,t-1}) \\ &+ \phi_h DissProf_{i,t-1} + DissProf_{i,t-1} \times (\theta^h \hat{R}_{c,t} + \xi_h Z_{i,t-1} + \Theta_h X_{c,t-1}) \\ &+ \Gamma_h Z_{i,t-1} + \alpha_i^h + \alpha_{c,s,t}^h + \epsilon_{i,t}^h, \end{aligned} \tag{4}$$

where $DissProf_{i,t-1}$ is a dummy variable capturing distressed nonzombie firms that are profitable. The term of interest is the difference between the coefficients $\beta^h - \theta^h$, referring to the differential response of zombie firms relative to $DissProf$ firms. If our conjecture is right, we expect this term to be positive (negative for interest rates), suggesting that zombies' financial performance is less affected relative to distressed but profitable nonzombie firms.

Figure 5: Differential effect of monetary policy shocks: the role of profitability



Notes: Cumulative impulse responses to a monetary policy shock that increases the country-specific ten-year sovereign bond yields by 100 bps. The blue line refers to the differential effect between zombie firms and firms that meet the first two criteria of the zombie definition, i.e., an ICR below one and leverage above the median (but not the third criterion on unprofitability). The dark (light) grey area refers to the 68 (90) percent confidence bands.

We find indeed that distressed firms that are profitable are substantially more responsive to monetary policy shocks than zombie firms (Figure 5): investment, employment, and debt growth decline by less for zombie firms, while the interest rate increases by less compared to distressed but profitable firms. This suggests that the behavior of (unprofitable) zombie firms is fundamentally different from other financially distressed firms that are, however, able to generate positive sales growth. In this context, profitability seems to play a key role in assessing the differential response of zombies relative to other firms. If a lender anticipates that a persistently unprofitable zombie firm will not generate enough revenues to pay back its debt, the lender may have an incentive to rollover the zombie loan to prevent the firm from defaulting. This leads us to conjecture that our baseline result may be explained by the existence of lenders' evergreening incentives. In Section 6 we rationalize our empirical findings from a model that illustrates that evergreening incentives may explain why zombie firms are less affected by monetary policy shocks.

5 Evidence from the syndicated loan market

In this section we use syndicated loan market data to further document that lenders provide more credit to zombie firms relative to other firms in the face of contractionary monetary policy.

In the syndicated loan market, corporates borrow from several lenders, a consortium of banks that provide credit and establish the legal framework for the loan of the borrower. Within a syndicate, there is one or more lead arrangers that negotiate the terms of the loan, recruit other lenders, and act as the primary point of communication between the borrower and the participating banks. We use information on an all issued loan deals from Dealogic over 2000-19. Dealogic provides extensive information on the loan deals, including the syndicate composition, borrower attributes, maturity, the price (all-in spread, including fees, margins, reference rates), as well as the announcement and signing dates of individual tranches within a loan facility.

The participation amounts of each syndicate member are often missing in Dealogic. We thus use a regression-based approach to estimate the missing loan shares for each participant out-of-sample (De Haas and Van Horen 2013). We resort to the coefficients from a model that regresses the observed loan shares on a comprehensive set of loan characteristics: loan amount, type of loan, syndicate characteristics (number of participants, lender role and nationality), loan currency, borrower characteristics (country, and industry), and time dummies.

We aggregate all newly originated loans at the borrower-lender-year level; the analysis will thus focus on the lending behavior between a specific lender and a specific borrower over time. We aggregate the data at the annual level (and compute annual monetary policy shocks), since firms do not typically borrow from the same lender in every quarter of the year. To be sure, syndicated loans are usually issued with a maturity of a couple of years—the median term length in our dataset is five years—which implies that it is uncommon to find firms borrowing from the same lender in the same year. The advantage of the syndicated loan data is that it allows us to add a set of rich fixed effects that control for both supply (lender) and demand (borrower) effects. We then combine Dealogic with our Compustat firm-level dataset to extract borrower characteristics, including the zombie firms classification (we match roughly 3,821 firms from Compustat). We estimate the following IV regression:

$$\begin{aligned} Log(Loans)_{l,i,t} &= \gamma_h Zom_{i,t-1} + Zom_{i,t-1} \times (\beta \hat{R}_{c,t} + \delta Z_{i,t-1}) \\ &+ \Gamma_h Z_{i,t-1} + FE + \epsilon_{l,i,t}, \end{aligned} \tag{5}$$

where the dependent variable is the logarithm of new originated loans of bank l to firm i in year t. Similar to previous regressions, the coefficient of interest is β, which indicates the differential effect of a 100 bps contractionary monetary policy shock on loans extended to zombies relative to other firms. As before, we include firm-specific balance sheet controls in $Z_{i,t-1}$ that help control for firm demand (we also include the same set of country-level controls used in the first-stage regression). FE represent several fixed effects that help separate loan demand from loan supply: (i) firm fixed effects control for unobserved firm-specific characteristics; (ii) bank fixed effects (or bank×year fixed effects) control for unobserved (time-varying) lender characteristics; and (iii) and industry-location-size-time (ILST) fixed effects control for time-varying borrower demand (Degryse et al. 2019). The ILST fixed effects allow us to compare over time borrowers in the same industry (two-digit GICS), country, and of a comparable size, as proxied with the quartile bins of the total borrowing volume in a given country-year pair.[12] We cluster standard errors at the bank level.

In line with our baseline results in Figure 4, the first two columns in Table 2 show that lenders extend more new loans to zombie firms relative to other firms—in the order of 7-8 percent—following a contractionary monetary policy shock. This result is robust to controlling for

[12] In most regressions we cannot use the Khwaja and Mian (2008) firm×year fixed effects since doing so would preclude us from estimating the interaction term between the monetary policy shock and the zombie dummy.

time-varying bank characteristics (column 2). Also in line with Figure C.6, we find that lenders do not extend relatively more loans to high-PD firms, suggesting that lenders' evergreening motives only show up for unviable and unproductive zombie firms (Table B.1 in Appendix B).

The literature has found that under-capitalized banks tend to engage more in zombie lending practices, as these banks may want to avoid breaching the regulatory capital requirements in a scenario of large losses from zombie lending (Caballero et al. 2008, Giannetti and Simonov 2013, Acharya et al. 2021, Schivardi et al. 2022, Blattner et al. 2023). We merge our combined loan-level dataset with bank-level information from Fitch-Connect to test whether weak banks engage more in evergreening zombie loans when monetary policy tightens. The caveat is that our sample is further reduced due to the imperfect matching of banks between Dealogic and Fitch-Connect. This exercise can nonetheless provide important insights.

Table 2: Effect of contractionary monetary policy shocks on new loans

	(1)	(2)	(3)	(4)
Zom_{t-1}	-0.161	-0.090		
	(0.213)	(0.220)		
MP shock × Zom_{t-1}	0.070**	0.077***		
	(0.028)	(0.030)		
MP shock × LC_{t-1}			-0.024	-0.013
			(0.025)	(0.024)
Zom_{t-1} × LC_{t-1}			-0.150	-0.359
			(0.179)	(0.274)
MP shock × Zom_{t-1} × LC_{t-1}			0.150*	0.190*
			(0.087)	(0.099)
Firm controls	✓	✓	✓	✓
Bank controls			✓	✓
Firm FE	✓	✓	✓	
Bank FE	✓		✓	✓
Bank × Year FE		✓		
ILST FE	✓	✓	✓	
Firm × Year FE				✓
Observations	77,348	72,547	11,431	8,557
R^2	0.823	0.843	0.868	0.887

Notes: IV estimates where the dependent variable is the log of new loans. The table shows the differential response of new syndicated loans to zombie firms relative to other firms following a 100 bps monetary policy shock. *LC* refers to a dummy variable capturing low capitalized banks (below the country-specific median of the Tier 1 capital ratio). Standard errors in parentheses clustered at bank level. Asterisks, *, **, and ***, denote statistical significance at the 10%, 5%, and 1% levels.

To assess the differential effect on new loans intermediated by low-capitalized (LC) banks to zombie firms, we run a modified version of Equation (5) where the variable of interest is a triple interaction term between the monetary policy shock, the zombie dummy, and a dummy capturing LC banks. The latter dummy takes the value of one for banks whose Tier 1 capital ratio is below the median in each country-year pair. We also add the following time-varying bank-specific variables to the regression: Tier 1 capital ratio to control for banks' solvency and resilience, the return on assets (ROA) to proxy for profitability, and the log of assets to control for the banks' size.

We find supportive evidence in column (3) of Table 2 that low-capitalized banks seem to extend more credit to zombie firms relative to other banks in response to a contractionary monetary policy shock, of around 15 percent. This finding remains robust to controlling for very granular time-varying demand with the Khwaja and Mian (2008) firm×year fixed effects (column 4). Our evidence is consistent with recent findings in the literature placing the focus on weak banks providing more credit to zombie firms. For instance, Schivardi et al. (2022) find that weak Italian banks cut credit to healthy firms but not to zombie firms during the GFC and the European sovereign debt crisis over 2008-13. Our contribution is to show that a tightening in monetary policy leads weak banks to engage more in evergreening practices.

Overall, the analysis in this section confirms our main results that lenders provide relatively more credit to zombie firms when the cost of borrowing goes up. This allows zombie firms to mitigate the monetary policy tightening shock. In addition, we also find that low-capitalized banks face more incentives to extend credit to zombie firms, presumably to avoid the recognition of losses from zombie lending.

6 Theoretical framework: evergreening model

In this section, we present a theoretical framework based on Faria-e-Castro et al. (2024) that shows that evergreening can arise as a normal feature of financial intermediation. With this model, we can shed more light on our empirical findings, i.e. on the role of zombie firms in the transmission of monetary policy. The loan contract follows a 'Stackelberg' model structure where the firm (the follower) determines the borrowing and investment amount based on the interest rate offered by the lender/bank (the leader), who makes optimal lending decisions considering the firm's reaction.

In this model, the crucial factor in the relationship lending is the presence of existing debt between a firm and the lender from which it seeks to borrow. In this setting, a firm with debt will only borrow new debt from a lender with which it has already an ongoing relationship. In turn, when the firm has no outstanding debt, the lender offers a constant interest rate in a competitive lending market. But if the firm has pre-existing debt from the lender, then the lender's optimal lending decision will take into account the firm's profitability and leverage. This consideration leads to more favorable terms for firms that have higher levels of debt and lower levels of productivity, as these firms are more likely to default; doing so would generate losses to the lenders' books. This phenomenon—whereby a lender rolls over pre-existing debt of highly leveraged and unproductive firms—is referred to as the 'evergreening' motive of lender-firm lending.

6.1 Environment

The model has two types of agents: firms and lenders. Firms are characterized by their pre-existing liabilities b and their productivity z. Lenders are risk-neutral entities with substantial financial resources and the ability to obtain funds from a saving market with infinite elasticity at a fixed interest rate R. Furthermore, lenders differ in the amount of capital they possess, denoted by a. The economic system unfolds over two periods, $t = 0$ and $t = 1$.

6.2 Firm problem

At the beginning of period 0, the firm is faced with a decision: whether to default on its existing debt and receive no value, or to continue its operations in the market by repaying the old debt and borrow new debt to invest in capital and produce, subject to a borrowing constraint. Continuing operations entail a continuation value denoted as $V(z,b;Q)$, which is a function of the existing debt b, productivity z, and the price of new debt Q offered by the lender at time $t = 0$. In this setting, we assume firms to be price takers, and cannot negotiate the loan price with the lender. The firm will opt to default if and only if the value $V(z,b;Q)$ is less than zero. Following Faria-e-Castro et al. (2024), we assume no default at $t = 1$. The profit-maximizing problem at $t = 0$ for the firm that chooses to remain in business is:

$$\begin{aligned} V(z,b;Q) \quad &= \quad \max_{b',k' \geq 0} -b - k' + Qb' + \beta^f [z(k')^\alpha - b'] \\ s.t. \quad & b' \leq \theta k' \end{aligned}$$

In period 0, the firm begins by repaying its current debt level b. It then proceeds to make optimal decisions regarding its investment and borrowing levels for the subsequent period, denoted as k' and b'. These decisions are subject to a borrowing constraint at $t = 0$, specified as $b' \leq \theta k'$. In addition, the firm's discount factor is represented by β^f.

Moving to period 1, the firm employs a technology with decreasing returns to scale, resulting in the production of output given by $z(k')^\alpha$, where $\alpha < 1$. This reflects the firm's ability to generate output based on the capital investment level k' raised during the previous period.

With the assumption that borrowing constraints are binding, i.e. when $Q \geq \beta^f$, it follows that the firm will borrow up to the maximum extent allowed by the constraint, leading to the existence of a minimum price of debt denoted as $Q^{min}(z,b)$ such that the firm tends to default if the offered debt price Q is lower than this threshold, as described by Proposition 1.

Proposition 1 *There exists a minimum threshold for the price of debt $Q^{min}(z,b)$ such that the firm chooses to default if and only if $Q < Q^{min}(z,b)$:*

$$Q^{min}(z,b) = \beta^f + \frac{1}{\theta} - \frac{(\beta^f \alpha z)^{1/\alpha}}{\theta} \left(\frac{1-\alpha}{\alpha b} \right)^{\frac{1-\alpha}{\alpha}},$$

The threshold is:

1. *Strictly increasing in the existing debt b*
2. *Strictly decreasing in the firm's productivity z*

This relationship indicates the critical role that the price of debt plays in determining the firm's decision to default or continue its operations. From the expression above, we see that high-debt and low-productivity firms (resembling our zombie firms in the empirical analysis) tend to default more.

6.3 Lender problem

We assume a continuum of lenders in the market who are risk-neutral and have access to an infinitely-elastic saving market with a constant risk-free interest rate R^k. This means that lenders discount future values in period 1 at a rate of β^k, defined as the inverse of R^k. Furthermore, lenders differ in the amount of capital a they own, implying heterogeneity in the marginal utilities of lending, despite lenders sharing a common utility function denoted as $u(.)$.

To allow for the possibility of firm default in period 0, we assume that β^k is lower than β^f plus the inverse of the borrowing constraint parameter θ. This default condition ensures that the discount rate applied by lenders is lower than the discount rate used by firms plus the borrowing constraint parameter.

Competitive lending

If a lender does not have any lending relationship with a specific firm, then the lender has no incentive to offer a lending contract with a debt price lower than β^k, provided that the firm will not default at this price. Assuming that the firm does not default in period 0, the firm can always borrow from a competitive lender at price $Q = \beta^k$. In this case, the firm can operate at the following marginal product of capital (MPK):

$$z\alpha(k')^{\alpha-1} \equiv MPK = \frac{1-\theta(\beta^k-\beta^f)}{\beta^f},$$

where the price and quantity offered by the lender is independent of the firm state (z,b).

Relationship lending

Relationship lending refers to a scenario where a lender holds a nonzero level of existing debt from a client firm. In this situation, the lender internalizes the potential impact from the firm's default risk, as a possible default will lead to zero profits for the lender. We can express the lender's problem under relationship lending as follows:

$$W(z,b,a) = \max_{Q\geq\beta^k} \mathbb{1}[V(z,b;Q)\geq 0]\times[u(a+b)-Qb'(z;Q)+\beta^k b'(z;Q)-u(a)],$$

where $\mathbb{1}$ is an indicator function capturing no firm default at time $t=0$. We assume the price of debt Q to be always equal or higher than the inverse of the risk-free interest rate, represented by $\beta^k = \frac{1}{R}$. If this condition is not satisfied, then the firm could always borrow from the competitive market. The lender's willingness to establish and maintain a lending relationship with a particular firm is contingent on the condition that the firm's net worth, denoted as $W(z,b,a;Q)$, is greater than zero. Since $W(z,b,a;Q)$ is decreasing in Q, we can implicitly solve for another cutoff value of the debt price that is characterized as follows:

Proposition 2 *Let $Q^{max}(z,b,a)$ denote the maximum debt price Q at which the lender is willing to lend:*

$$Q^{max}(z,b,a) : W(z,b,a;Q^{max}) = 0$$

$Q^{max}(z,b,a)$ *represents the highest price of debt that a lender is willing to offer within this relationship lending and satisfies the properties:*

1. $Q^{max}(z,b,a) > \beta^k$ *if and only if* $b > 0$
2. *It is increasing in the existing debt* b
3. *It is decreasing in the firm's productivity* z

Combining both markets, the competitive lending and the relationship lending, the lender's optimal relationship lending policy should be consistent with the following:

Proposition 3 *The lender's optimal lending decision can be written as*

$$Q^*(z,b,a) = \begin{cases} \beta^k & if \quad Q^{min}(z,b) \leq \beta^k \leq Q^{max}(z,b,a) \\ Q^{min}(z,b) & if \quad \beta^k \leq Q^{min}(z,b) \leq Q^{max}(z,b,a) \\ 0 & otherwise \end{cases}$$

Let $\bar{b}(z)$ *be the threshold value of existing debt such that the lender is willing to offer a more favorable debt price (*$Q^{min}(z,\bar{b}(z)) = \beta^k$*), and* $\hat{b}(z,a)$ *such that the lender is indifferent between evergreening this firm or forgoing previous debt (*$Q^{min}(z,\hat{b}(z,a)) = Q^{max}(z,\hat{b}(z,a),a)$*). We can verify that:*

1. $\bar{b}(z) < \hat{b}(z,a), \forall z$*;*
2. $Q^*(z,b,a)$ *is increasing in* b*, strictly if* $b \in [\bar{b}(z), \hat{b}(z,a)]$*;*
3. $Q^*(z,b,a)$ *is decreasing in* z*, strictly if* $b \in [\bar{b}(z), \hat{b}(z,a)]$.

Figure 6 illustrates Properties 1 and 2 in Proposition 3 with respect to pre-existing debt b, and for a given firm's productivity z. The figure depicts the relationship between the firm's existing debt level b, and the lender's optimal lending decisions defined in three regions or nodes. The maximum price the lender is willing to offer Q^{max} is given by the dashed curve, while the minimum price Q^{min} below which the firm defaults is given by the solid curve.

When the firm carries a relatively low debt level, specifically $b < \bar{b}(z)$, its default risk is considered to be low. Consequently, the lender does not have a strong incentive to offer a lending contract with a higher price in this scenario, offering a loan price equal to β^k (competitive lending market). On the other hand, if the firm is heavily indebted such that $b > \hat{b}(z, a)$, it is not profitable for the lender to continue extending credit to this firm since Q^{max} is below Q^{min}. In these cases, the lender may find it more beneficial to let the firm default rather than provide further financial support. This is the default region.

Firms with existing debt levels falling between $\bar{b}(z)$ and $\hat{b}(z, a)$ are considered prime candidates for evergreening. If the lender were to offer the competitive lending price β^k, then the firm would default since β^k is below Q^{min}. The lender would have an incentive to offer more favorable lending terms, a higher loan price (lower interest rate), to firms falling in this region to prevent them from defaulting. The lender is thus willing to sacrifice some loan returns, with $Q^* > \beta^k$, but still make a profit, in order to ensure the repayment of the existing debt, i.e., the lender assesses the firm's continuation value to be greater than the exit value. This is the evergreening region.

Figure 6: Illustration of lender decisions within relationship lending by existing debt b

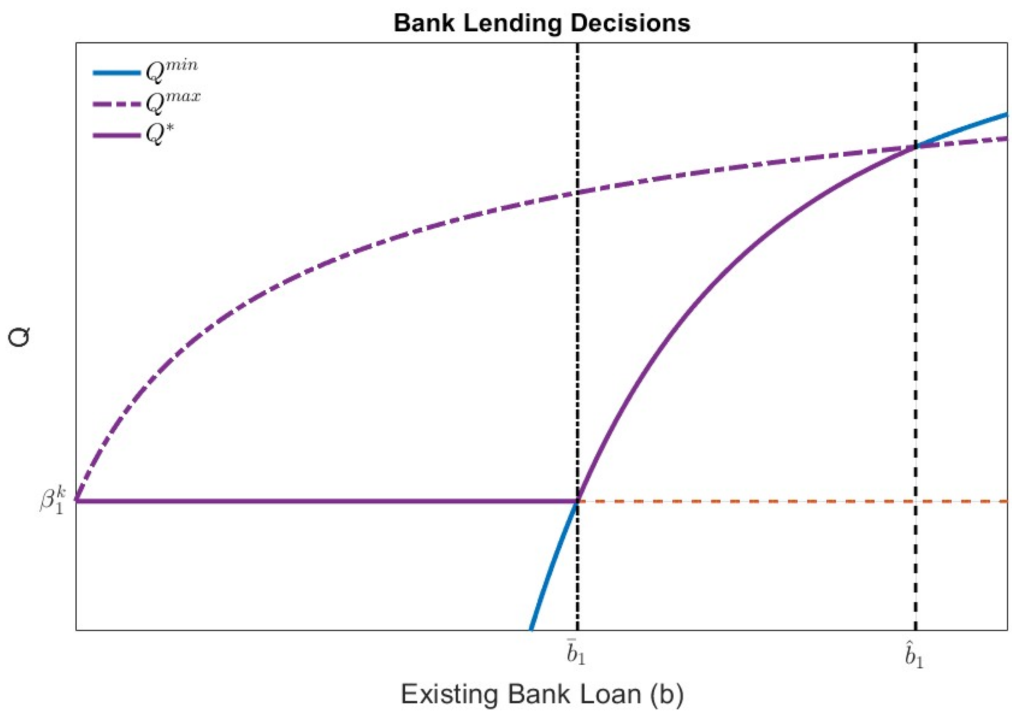


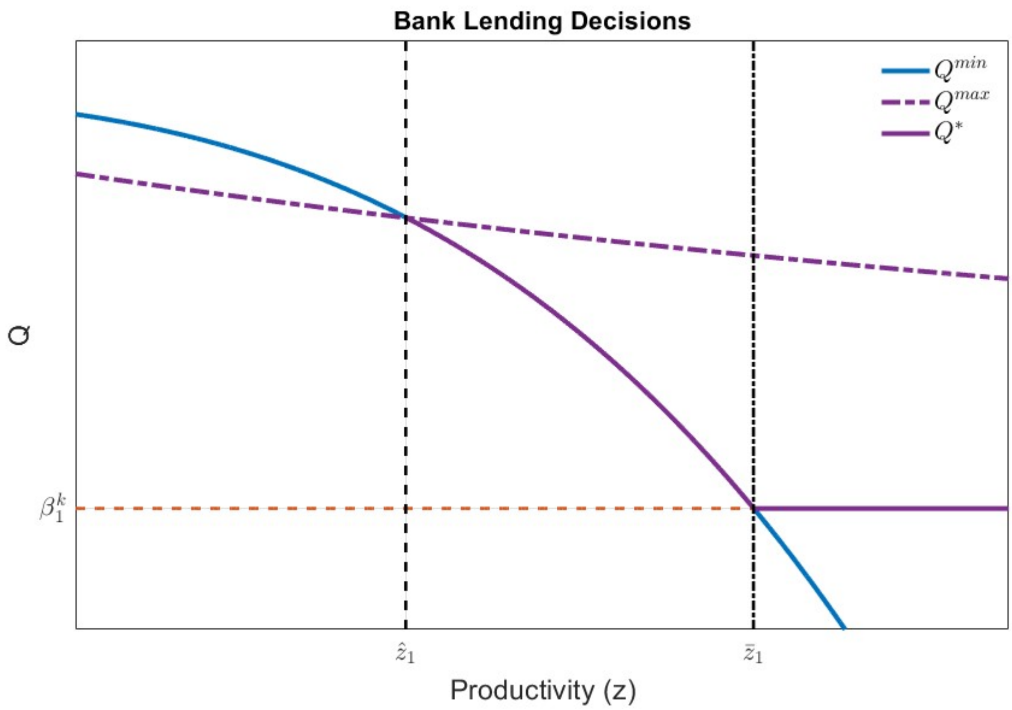
Figure 7 illustrates Property 3 of Proposition 3 regarding the other important determinant of the lender's optimal lending decision, specifically the relationship between a firm's productivity (z) and the lender's optimal lending decisions given a pre-existing debt level (b). We denote

$\hat{z}(b, a)$ as the productivity threshold at which the lender is indifferent between evergreening the firm's debt and foregoing it, and $\bar{z}(b)$ as the productivity level at which the lender is willing to offer a more favorable debt price.

When the firm's productivity is relatively high, specifically $z > \bar{z}(b)$, its default risk is low, and the lender has no incentive to offer a lending contract at a price higher than the competitive rate. Consequently, the firm receives the competitive lending loan price (β^k).

Conversely, if the firm is very unproductive and $z < \hat{z}(b, a)$, lenders find it unprofitable to extend further credit, as Q^{max} is below Q^{min} (default region). Relationship lending occurs when the firm's productivity falls within the middle range $[\hat{z}(b, a), \bar{z}(b)]$, where it remains beneficial for the lender to extend credit. In this range, the benefit of recovering pre-existing debt outweighs the cost of offering a higher loan price.

Figure 7: Illustration of lender decisions within relationship lending by productivity z

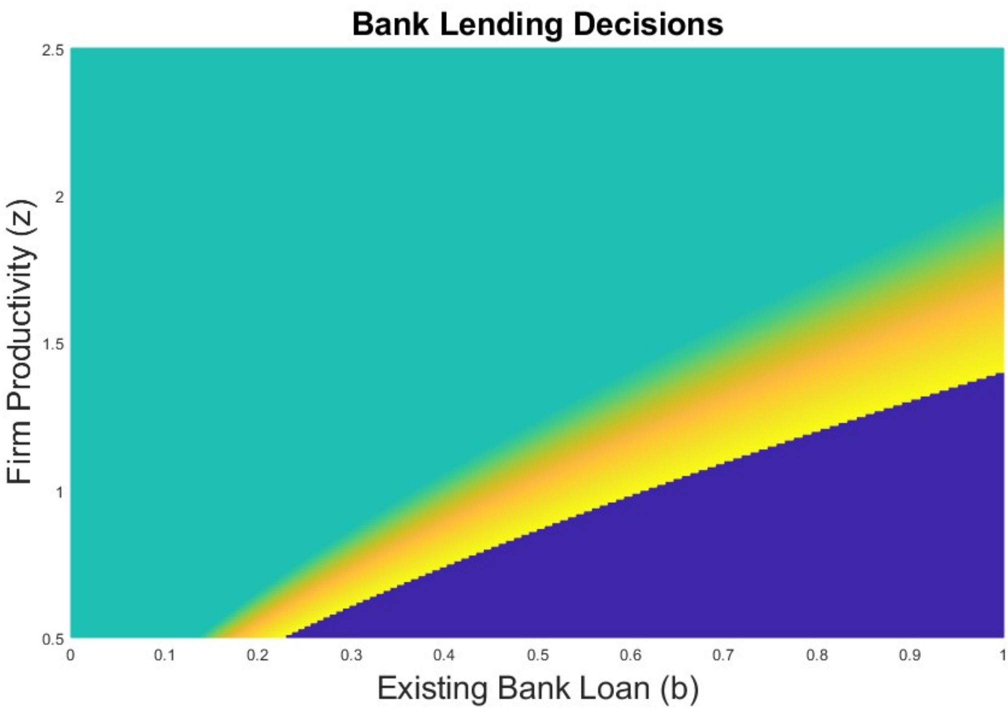


We now look into the lender's optimal lending decision when taking the two dimensions simultaneously, pre-existing debt b and productivity z, which align with our empirical definition of zombie firms. Figure 8 depicts a three-dimensional plot showing the lender's debt price Q for the (b, z) pair. Firms in the dark blue area are characterized by high levels of debt and low productivity and will default given any lending conditions. In this region, there is no lending relationship as lenders do not find it profitable to evergreen the loans of these firms.

Firms situated in the green area, which corresponds to high productivity or low existing debt levels, can operate under a competitive debt price of $Q = \beta^k$. As a result, these firms do not require special considerations or preferential lending terms from the lender.

The middle area, ranging from light orange to yellow, represents firms that heavily rely on relationship lending to sustain their operations. The shade of color in this region indicates the extent of favorable lending conditions and the corresponding debt price. Firms closer to the yellow coloration experience more favorable lending terms and higher debt prices (lower interest rates). These firms falling in the middle area are relatively more indebted and less productive, aligning well with our definition of zombie firms.

Figure 8: Lender's optimal debt price by firm productivity and existing debt level



6.4 The role of bank capital

In our model, bank capital determines whether a lender is inclined to maintain a relationship lending arrangement with a firm. The level of bank capital directly influences the marginal benefit derived from recovering previous debt, implying a decrease in the maximum debt price Q^{max} as bank capital a increases. Consequently, lenders with higher levels of bank capital are less willing to support firms with high levels of outstanding debt. On the other hand, lenders with lower bank capital may be more inclined to extend relationship lending to firms with higher levels of indebtedness, as these lenders may not have enough capital to absorb the losses from a scenario of firms defaulting (as documented empirically in Section 5).

Although the model posits that evergreening motives may be stronger for weakly capitalized banks, zombie lending takes place in our model irrespective of concerns about bank capital. For instance, banks may gamble for zombie firms' resurrection, hoping that these firms recover or obtain market financing in the future, as zombies' reputation grows with the length of their lending relationship. In fact, Hu and Varas (2021) show theoretically that by rolling over bad loans, banks allow zombie firms to remain in business, which in turn increases zombie firms' reputation, thus allowing zombies to access market financing in the future.

6.5 The role of relationship lending in the monetary policy transmission

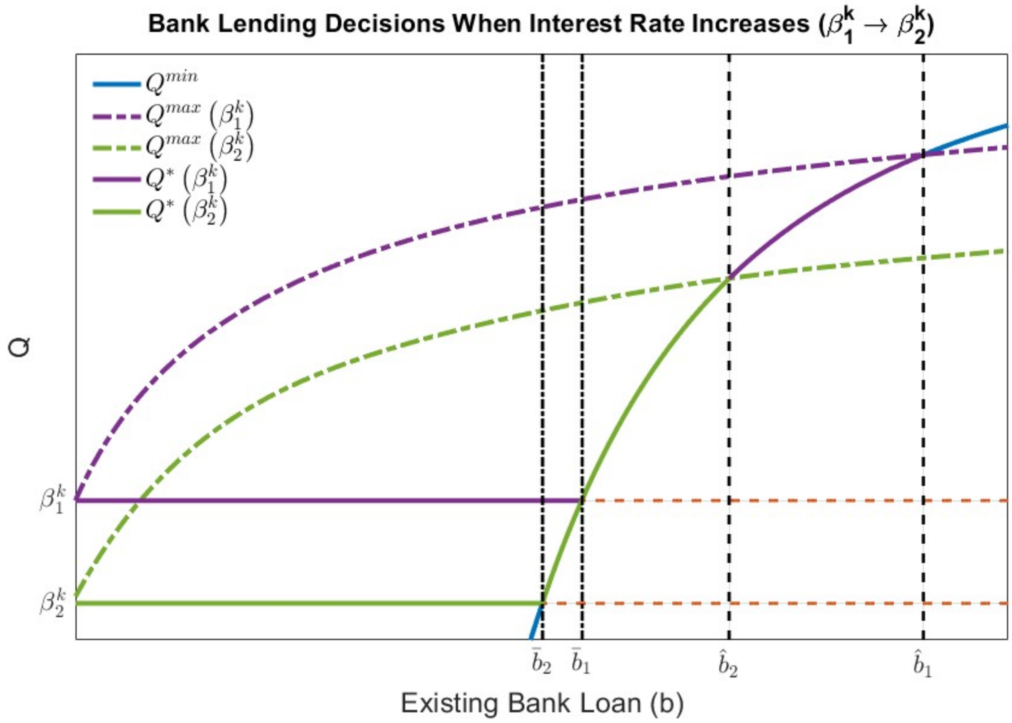
We now simulate how a change in borrowing costs driven by contractionary monetary policy may affect lenders' lending decisions, akin to our empirical specification. For this purpose, we simulate an increase in the risk-free interest rate from R_1 to R_2. This change is equivalent to a decrease in the lenders' effective discount factor, implying a shift from β_1^k to β_2^k (Figure 9).

While the minimum debt price Q^{min} remains unaffected by the change in the discount factor β^k, the contractionary monetary policy causes a downward movement of the Q^{max} curve and the β^k horizontal line. Consequently, the levels of $\bar{b}(z)$, the threshold debt level below which the lender does not offer higher debt prices, and $\hat{b}(z, a)$, the threshold debt level beyond which the lender chooses not to evergreen the firm, decrease. In this scenario, more firms rely on relationship lending to survive, particularly those with lower existing debt levels. At the same time, more heavily indebted firms opt to default, as the cost of maintaining the lending relationship becomes less favorable under the higher risk-free interest rate.

In this context, firms that engage in relationship lending are less affected by contractionary monetary policy as their effective debt price $Q^* = Q^{min}$ remains unchanged, implying no passthrough of higher rates to these firms. This is valid as long as these firms were already in a relationship lending arrangement prior to the policy change. In contrast, firms that rely on competitive lending rates experience a higher interest rate resulting from the policy change, as the Q^{min} for these firms is lower than the competitive loan price β_2^k. At the prevailing market interest rate, these firms will not default: lenders thus offer the competitive lending loan price.

We observe a similar pattern along the productivity dimension. Figure 10 shows that firms

Figure 9: Lender's optimal debt price decision under contractionary monetary policy: by existing debt



already in a relationship lending are immune to the contractionary monetary policy shock, except for those firms with extremely low productivity levels; more productive firms are affected more from an interest rate increase, with a full passthrough as they receive the competitive lending loan price.

Overall, our model predicts that relationship lending tends to dampen the transmission of monetary policy to investment of high-debt and low-productivity firms (Figures 11 and 12). When we map the increase in interest rates to firms' investment, we find that the investment of firms engaged in relationship lending remains relatively stable despite the tightening in monetary policy. By contrast, we show that firms relying on competitive lending rates exhibit a decrease in investment due to the increase in interest rates.

Figure 13 provides a comprehensive view of how a firm's investment is influenced jointly by its productivity and pre-existing loan. We observe that firms with relationship lending (yellow to light blue region), are located in the lower-right corner, which corresponds to firms with low productivity and high pre-existing loans. Investment of firms falling in this region are not affected (or only affected minimally) by contractionary monetary policy, while nonzombie firms falling in the dark blue area decrease investment given the full passthrough from higher interest rates. Although this is a simple model, showing extreme cases of interest rate passthrough

Figure 10: Lender's optimal debt price decision under contractionary monetary policy: by productivity

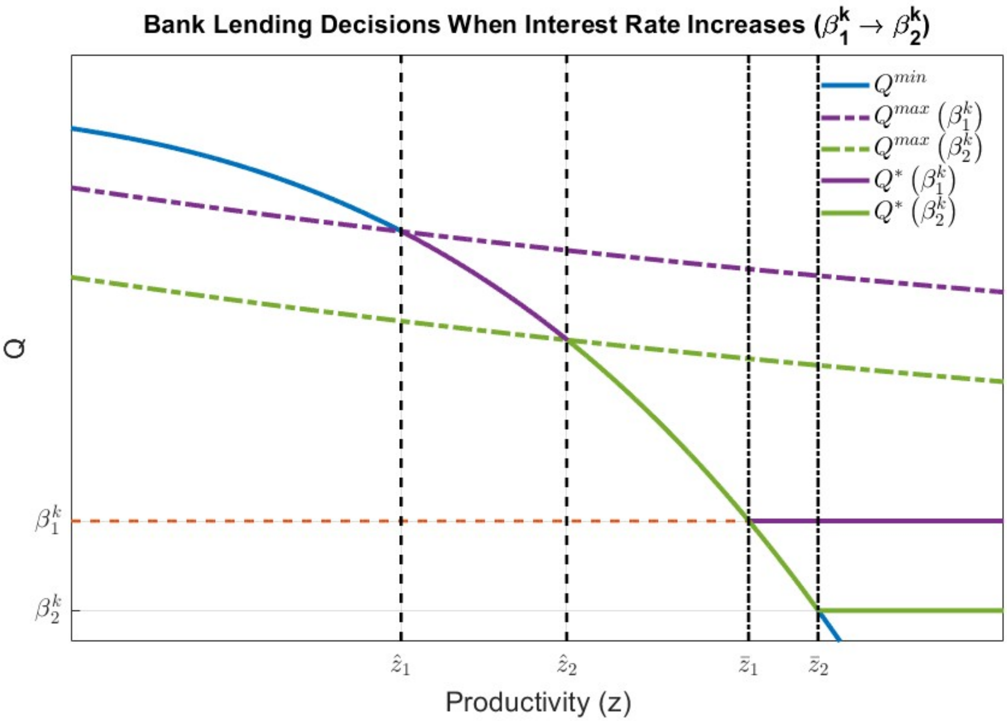


Figure 11: Response of firm investment under contractionary monetary policy (by existing debt)

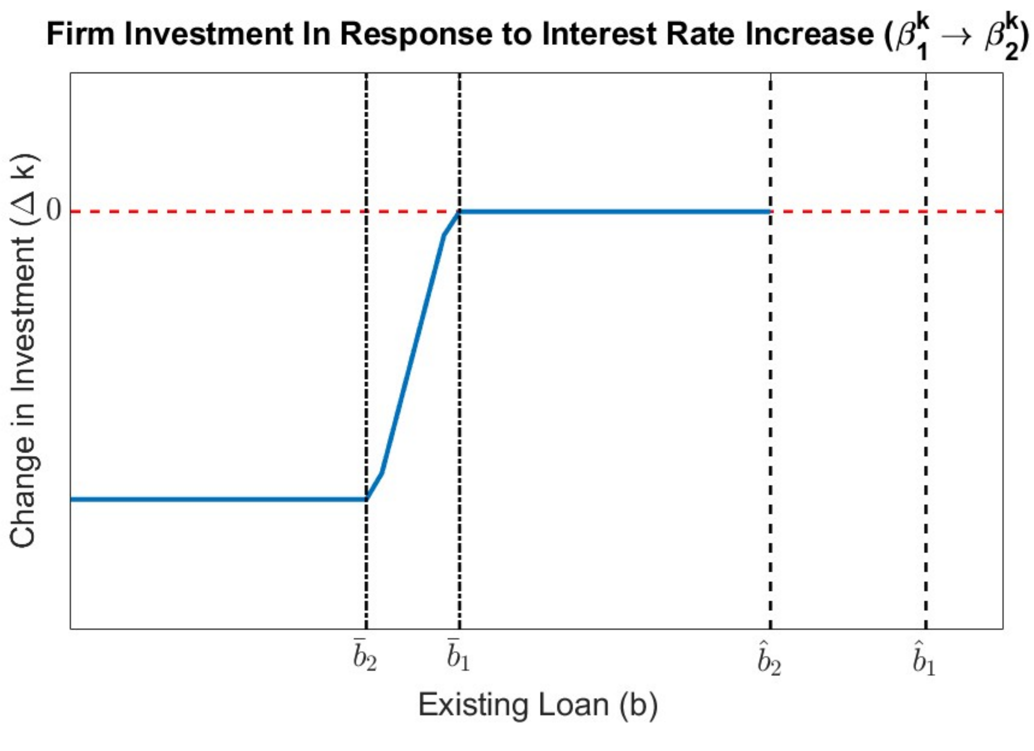
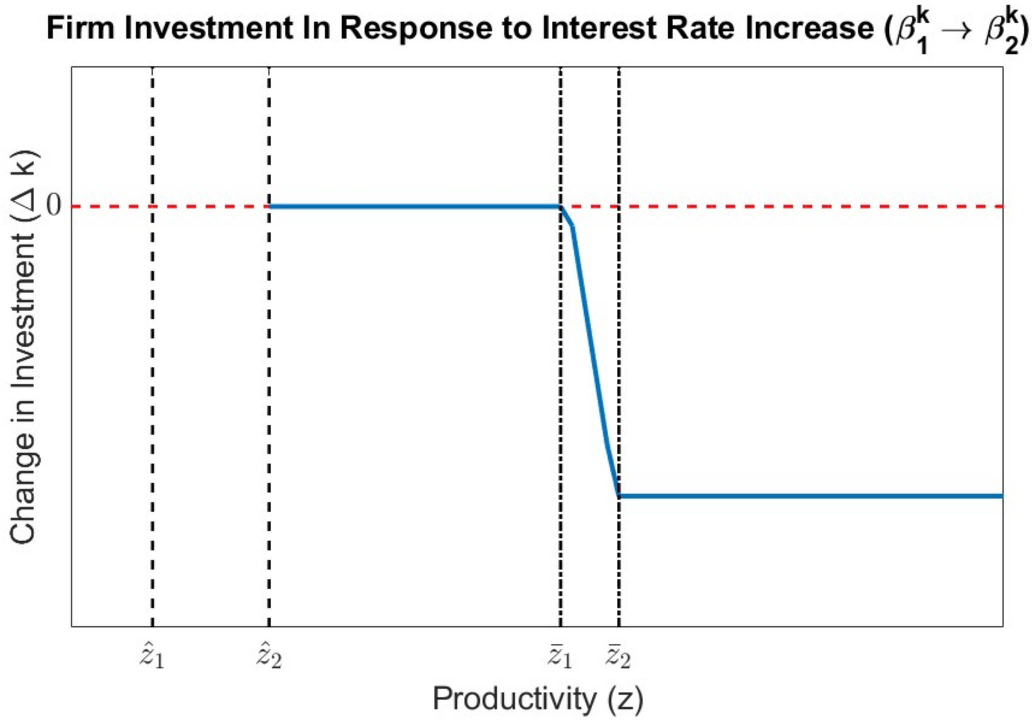


Figure 12: Response of firm investment under contractionary monetary policy (by productivity)



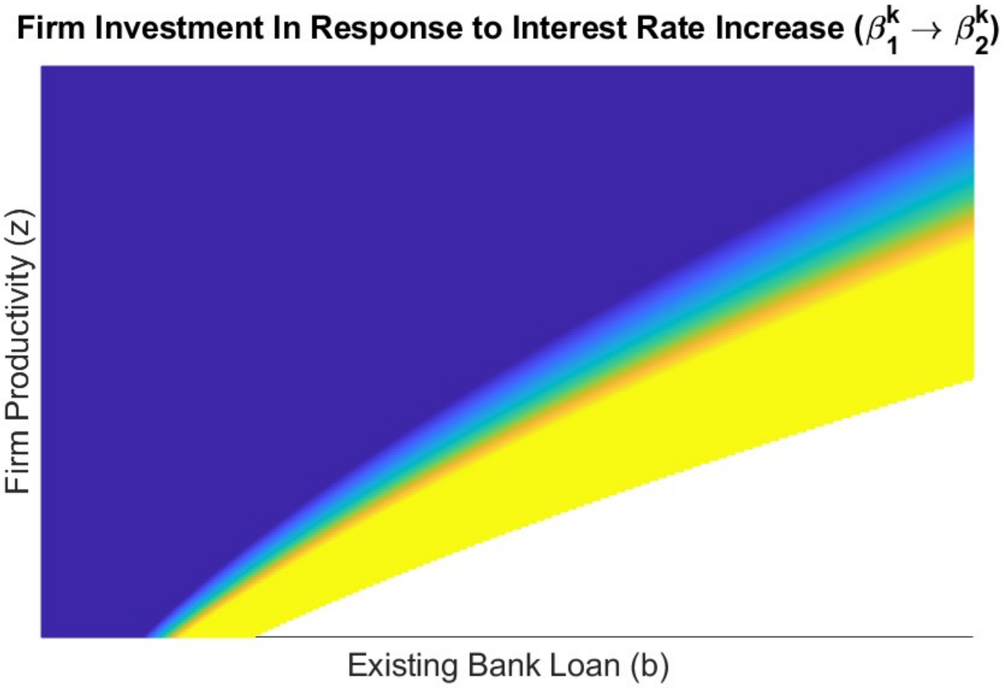
(no passthrough or full passthrough), it helps us nevertheless understand why high-debt and low-productivity firms, akin to our zombie firms in the empirical part, tend to be less responsive to monetary policy shocks.

7 Role of policies in mitigating the zombie lending channel of monetary policy

We have shown empirically and theoretically, that in the presence of higher interest rates, banks, particularly those under-capitalized, may have stronger incentives to offer better credit conditions to zombie firms to prevent them from defaulting. This translates into a lower passthrough of higher interest rates to zombies' cost of debt, and a smaller fall in credit supply toward zombies relative to other firms. The evergreening motive thus rationalizes our empirical findings: more favorable credit conditions relative to nonzombies allow zombie firms to mitigate part of the monetary policy tightening.

Against this background, the survival of zombie firms may create important negative spillovers on nonzombies. The literature has documented that these congestion effects can assume different forms along the intensive and extensive margins, with the overall effect of

Figure 13: Response of firm investment under contractionary monetary policy (existing loan and productivity)



Notes: The different colors refer to the degree of the investment decline following an interest increase, combining the framework from Figures 11 and 12. The dark blue color refers to firms with a larger contraction in investment (where the interest rate passthrough is higher), while the yellow color refers to firms without an investment decline. The colors in between refer to a partial interest rate passthrough.

reducing productivity growth in the economy (Caballero et al. 2008, McGowan et al. 2018, Acharya et al. 2019, Banerjee and Hofmann 2022, Albuquerque and Iyer 2024). For instance, on the intensive margin, zombie firms may distort the competition in the markets in which they operate, ultimately depressing market prices for nonzombies' products, and raising market wages. This would discourage healthy firms from investing further, potentially leading to higher exit rates for healthy firms (extensive margin). In addition, higher wages and lower market prices caused by the presence of zombie firms may prevent new firms from entering because the new entrants would need to clear a higher productivity threshold.

To sum up, by creating congestion effects on healthy firms, the survival of zombie firms tends to negatively affect overall economic growth. In addition, we have previously shown that congestion effects seem to be amplified when interest rates increase as there is a misallocation of capital and credit towards zombie firms. This suggests that overall economic activity may fall in countries with a higher prevalence of zombification. We run regressions with country-level data to show that countries with higher zombie shares tend to experience lower economic growth and lower inflation following contractionary monetary policy shocks (Figure C.7 in Appendix

C).[13] The disinflationary effect in countries with higher zombie shares is consistent with Acharya et al. (2024), who find that the increased zombie lending practices in several European countries around the GFC and the ensuing European sovereign debt crisis implied that the excess supply put downward pressure on prices.

The literature has found that strong banking systems (Storz et al. 2017, Acharya et al. 2019, Andrews and Petroulakis 2019, Blattner et al. 2023, Albuquerque and Iyer 2024), tighter macroprudential policies (Albuquerque and Iyer 2024), and well-prepared insolvency regimes (Andrews and Petroulakis 2019, Becker and Ivashina 2022, Kulkarni et al. 2023) help to tackle zombification. These policies target banks' incentives to engage in risky behavior and discourage evergreening practices, therefore mitigating the negative effects of zombie firms on the real economy. In this section, we expand this literature by also investigating the role that banks' capital buffers, NPLs, macroprudential policies, and insolvency regimes may have in mitigating the differential effect of zombies' financial performance relative to nonzombies when interest rates increase.

We expand our Equation 3 by adding a triple interaction between the monetary policy indicator, the zombie dummy, and selected policy indicators (while also adding an interaction term between the zombie dummy and the policy indicator). We focus on investment growth as the proxy for firms' financial performance:

$$\begin{aligned}\Delta_h Inv_{i,t+h} &= Zom_{i,t-1} \times (\beta_1^h \hat{R}_{c,t} + \beta_2^h \hat{R}_{c,t} \times Pol_{c,t-1} + \beta_3^h Pol_{c,t-1} + \delta_h Z_{i,t-1}) \\ &+ \gamma_h Zom_{i,t-1} + \Gamma_h Z_{i,t-1} + \alpha_i^h + \alpha_{c,s,t}^h + \epsilon_{i,t}^h, \qquad (6)\end{aligned}$$

where our main coefficient of interest is β_2, which measures the additional differential effect of tighter monetary policy on zombies' investment growth relative to nonzombies in countries with a given policy indicator above the median (against countries below the median). The policy variable $Pol_{c,t-1}$ takes the following indicators: (i) banks' regulatory capital buffers, given by banks' actual regulatory capital to risk-weighted assets minus the minimum required

[13] We run country-level weighted least squares panel regressions (with countries' nominal GDP as weights):

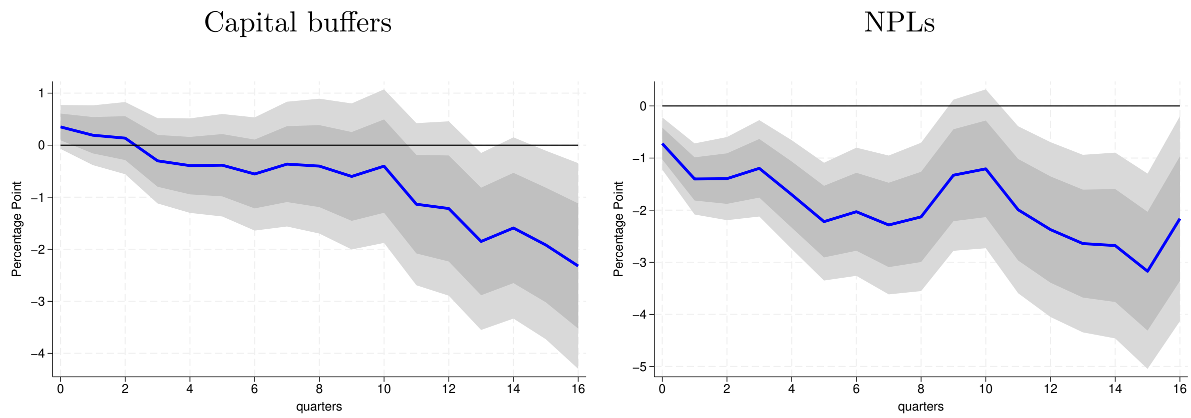
$$Y_{c,t+h} = \beta^h \hat{R}_{c,t} \times ZomShr_{c,t-1} + \delta^h ZomShr_{c,t-1} + \Theta_h X_{c,t-1} + \alpha_c^h + \alpha_t^h + \epsilon_{c,t}^h, \quad h = 1, 2, ..., 16,$$

where the dependent variable is the cumulative change in the log of real GDP growth, or the log of CPI, and $ZomShr$ is the country-specific zombie share, computed by aggregating the firm-level observations to the country level. The coefficient of interest is β^h that measures the differential effect of contractionary monetary policy as the zombie share increases by one percentage point. To facilitate the interpretation, we multiply the β^h coefficients by the sample standard deviation of the zombie shares in Figure C.7. We double-clustered the standard errors by country and time.

risk-based regulatory capital ratio; (ii) banks' NPLs as a ratio of total loans; (iii) the stance of macroprudential policies computed from the iMaPP database (Alam et al. 2024); (iv) and the quality of insolvency regimes from Araujo et al. (2022), which measures how well countries are prepared to handle a large-scale restructuring of corporates.[14] We transform each of these indicators into a binary variable, capturing countries above and below the median sample values for each quarter. Given the positive β_1^h that we have found in Section 4.2, a positive (negative) β_2^h suggests that countries with the specific $Policy_{c,t-1}$ above the median sample tend to have stronger (weaker) evergreening motives relative to countries that stand below the median of that indicator.[15]

Our results show that countries with higher regulatory capital buffers or lower NPLs tend to experience a decline in zombies' investment growth relative to nonzombies (Figure 14).[16] We get relatively similar results if we were to use them as continuous variables in Equation (6)—see Figure C.8 in Appendix C. This is suggestive evidence in line with our theoretical underpinning in Section 6 and loan-level results in Section 5 that banks with higher bank capital (or lower NPLs) are more prone to writing-off zombie loans and absorb the losses.

Figure 14: Effect of contractionary monetary policy shocks on investment growth of zombies versus nonzombies: marginal effects in countries with stronger bank indicators



Notes: Cumulative marginal effects on investment growth of a monetary policy shock that increases the country-specific one-year sovereign bond yields by 100 bps. The blue line is the average point estimate for zombies versus nonzombies in countries that stand above (below) the median sample of the banks' regulatory capital buffer (NPLs). The dark (light) grey area refers to the 68 (90) percent confidence bands.

[14]The insolvency regime indicator is time-invariant.

[15]Our specification is somewhat different from the *congestion effects* specification, first introduced by Caballero et al. (2008); our specification would involve quadruple interaction terms which are very cumbersome to estimate. We thus take our baseline regression with the differential effect of monetary policy on zombies versus nonzombies as the starting point (Equation 3). We see a link between our specification and the one from Caballero et al. (2008). With Equation (6) we will be able to assess how zombies' financial performance is affected relative to other firms in countries with stronger regulatory frameworks. If the policies we study here were to help reduce zombies' performance, then it is likely that nonzombies operating in the same industry would benefit as a result (lower congestion effects à la Caballero et al. 2008).

[16]We flip the coefficient on NPLs to make it easier to compare it with the coefficient on capital buffers. This way, an increase in $Policy_{c,t-1}$ can be interpreted as an improvement in banks' balance sheets.

On macroprudential policies, we find supporting evidence that overall macroprudential policies may help mitigate zombie lending practices (Figure C.9 in Appendix C). When we unpack the overall macroprudential index, we find that countries with more macroprudential measures targeting loans (*Loan – targeted*) seem to be particularly associated with lower zombie lending. Within this component, we also find some evidence that measures that impose limits to credit growth, loan loss provisions, loan restrictions, and the loan-to-deposit ratio, may help tackle zombie lending (*Supply – loans*).

Finally, we also find some tentative results that insolvency regimes may also play a role in mitigating the negative effects of zombies, including laws that focus on enhancing out-of-court restructuring (Figure C.10 in Appendix C). In particular, zombie firms' investment growth in countries with well-prepared insolvency regimes tends to decline relative to nonzombies over the medium term. The fact that we only find statistical evidence after three years suggests that, although insolvency regimes may matter to minimize zombie lending, this only materializes over longer horizons as presumably, it takes time to restructure firms.

Although the results in this section do not necessarily imply a causal link running from tighter policies or more-developed insolvency regimes to zombies' weaker investment growth, the inclusion of a rich set of controls and country-industry-time fixed effects should be able to minimize confounding factors. In this context, our results suggest that policies that strengthen banks' balance sheets, that limit banks' incentives to engage in risky behavior, and laws that allow an efficient resolution of weak firms, may help mitigate zombie lending when financial conditions tighten. This chimes with the literature that has focused on strengthening bank supervision and regulation to break banks' evergreening incentives (Giannetti and Simonov 2013, Acharya et al. 2021, Schivardi et al. 2022, Blattner et al. 2023, Bonfim et al. 2023).

8 Extensions and robustness checks

We check the sensitivity of our baseline results from Equation 3. All results can be found in Appendix C.

First, we use alternative zombie definitions from the literature. We follow Banerjee and Hofmann (2022) who define zombie firms as distressed firms with weak growth opportunities, i.e., an ICR below one, and a Tobin's q below the median firm in the industry, both over a two-year period. In addition, zombie firms only exit the zombie status when one of the two indicators is reversed for at least two years after a firm is defined as a zombie. The downside of this definition is that the sample falls considerably given data availability issues that prevent us from computing Tobin's Q for several firms. The second definition uses McGowan et al. (2018)'s criterion to define zombie firms as old firms that do not generate enough operating revenues to meet their interest payment obligations—firms with an ICR below one for three consecutive years, and at least ten years old. The last zombie definition is based on a concept of subsidized interest rates, first defined in Caballero et al. (2008), whereby financially fragile (zombie) firms receive favorable financing conditions relative to high-rated firms. We use the modified version of Acharya et al. (2024), who impose that zombie firms are low-quality firms. i.e., BB-rated firms or lower with a two-year average ICR below the median and a leverage ratio above the median (similar in spirit to our baseline definition). The medians are defined at the country-industry-year level. Subsidized credit is captured by the ratio of interest expenses lower than the AAA-rated peers. Since ratings are not available for all firms, we infer them from the ICR as in Acharya et al. (2019).

Illustrating the case for investment growth, we find that our baseline result—zombie firms are less responsive to a contractionary monetary policy shock—remains robust to using alternative zombie definitions, although the responses are estimated less precisely for some horizons (Figure C.11).

Second, we run weighted-least squares regressions using the firms' total assets as weights (all our previous firm-level regressions weight each observation equally). Since firms' size vary considerably within and across countries, we test the sensitivity of our results when we account for the relative importance of each firm (observation). The weighted regression is also better suited to getting at the aggregate impact. Figure C.12 shows that our results remain qualitatively similar, with a quantitatively stronger effect for the weighted regression.

Third, we use alternative monetary policy shocks available at the country-level from Choi et al. (2024) as instruments for the country-specific bond yields. Choi et al. (2024) estimate monetary policy shocks for a large set of countries based on a hierarchical approach regarding shock identification: they take high-frequency surprises from financial market data during monetary policy announcements; if not available, they proxy the monetary policy shock by the daily change in the three-month swap yields or in the short-term domestic government bond yields; if the previous methods are not available, they proxy the monetary policy shock by comparing the realized monetary policy rate with the pre-decision expectations from Bloomberg's survey of financial market participants; finally, if all previous methods are not available, Choi et al. (2024) compute the monetary policy shocks by taking the residuals from estimated Taylor rules. For countries with pegged exchange rates, they take the monetary policy shocks from the anchor country. Our results remain qualitatively similar with the new monetary policy shocks (although the employment response is muted), suggesting that the zombie lending channel of monetary policy that we have uncovered in this paper is not restricted to the international channel of monetary policy (Figure C.13).

Fourth, we drop from our sample countries with low F-tests in the first-stage regression (Equation 1). Specifically, we only keep countries with an F-test of at least five.[17] Figure C.14 shows that our baseline results remain practically the same, but with slightly higher confidence bands, especially for debt growth.

Fifth, we investigate whether the source of the monetary policy shock may play a role in determining the sign and extent of the global spillovers. Recent literature has identified an information effect of monetary policy, whereby financial market participants may react differently to interest rate increases if they are predicated on inflationary concerns or on stronger growth prospects (Miranda-Agrippino and Rey 2020*a*, Miranda-Agrippino and Ricco 2021, Jarociński 2022, Ciminelli et al. 2022, Degasperi et al. 2023, Pinchetti and Szczepaniak 2024, Stavrakeva and Tang 2024). We resort to the *poor man's sign restrictions* monetary policy shock series from Jarociński and Karadi (2020) that strip out central bank information shocks. In addition, we also use the orthogonalized monetary policy shock series from Bauer and Swanson (2023) that also control for information shocks. Illustrating the case for investment growth, we show in Figures C.15 and C.16 that our main results, both the average firm response and the differential response of zombies relative to nonzombies, remain robust to controlling for information shocks.

Sixth, we check how US monetary policy shocks transmit to US zombie firms relative to nonzombies. We follow the same LP-IV method as in the baseline, but use the US one-year government bond yield in the first stage, and add US domestic-specific controls (real GDP growth, CPI inflation, and the Gilchrist and Zakrajšek (2012) excess bond premium). While the differential responses of employment, debt, and interest rates are not precisely estimated, we find that the investment growth of zombie firms falls more relative to nonzombies (Figure C.17). This is indicative of a stronger effect of monetary policy shocks on zombie firms, a result that contrasts with our main baseline findings for firms outside of the United States. One

[17] We drop 15 countries: Japan, Austria, China, Peru, Argentina, South Africa, Jordan, Saudi Arabia, Malaysia, Brazil, Turkey, Russia, Nigeria, Indonesia, and Chile.

possible explanation for this phenomenon may be linked to our previous findings on the role of higher regulatory capital buffers, tight macroprudential measures on loans, and well-developed insolvency regimes, on all of which the US economy ranks high. Our results are also consistent with Favara et al. (2024), who argue that zombie lending is not a prominent feature of the US economy, as zombie firms exit the market through bankruptcy; an efficient resolution of financial distress in the US bankruptcy code may thus weaken banks' incentives to keep zombie firms alive.

Finally, we replicate our results to euro area firms, by instead using ECB monetary policy shocks. This allows us to extend our analysis by focusing on the potentially most relevant (domestic) monetary policy shocks for euro-area countries. We use the high-frequency monetary policy shocks from Jarociński and Karadi (2020), constructed from monetary surprises around ECB monetary policy announcements. In line with our main baseline results, we find that zombie firms' financial performance in the euro area is less responsive to ECB monetary policy shocks (Figure C.18). This suggests that zombie lending plays an important role in the euro area (Storz et al. 2017, McGowan et al. 2018, Andrews and Petroulakis 2019, Acharya et al. 2021, Schivardi et al. 2022, Blattner et al. 2023). Although it is beyond the scope of the paper to compare our findings in detail between the euro area and the United States, we note that bankruptcy laws in the euro area are typically less creditor-friendly than in the United States; this makes it more difficult for a swift resolution and restructuring of unproductive and unviable firms in the euro area. In addition, euro-area firms rely considerably more on bank loans than on market financing to finance their businesses, adding pressure on banks to engage in evergreening practices. These two factors may explain why zombie lending seems to be more prevalent in euro area countries than in the United States.

9 Conclusion

In this paper, we have found that zombie firms are less responsive to monetary policy shocks compared to other firms. We identify exogenous variations in monetary conditions for a large set of countries by exploiting the international transmission of US monetary policy shocks. Using granular balance sheet data on nonfinancial firms, we find that contractionary monetary policy leads to more favorable credit conditions for zombie firms relative to healthier firms. This allows zombies to cut investment and employment by relatively less than nonzombies operating in the same industry and country.

While this result seems counterintuitive at face value, we rationalize our findings through a model with evergreening incentives faced by banks; when interest rates rise, lenders, especially those with lower capital, may have stronger incentives to offer more favorable credit conditions to zombie firms at the expense of other firms, to prevent zombie firms from defaulting.

Overall, zombie lending plays an important role in mitigating the transmission of monetary policy shocks to zombie firms. The flip side, however, is that other, more productive and viable firms, may be hardest hit, with detrimental effects on the aggregate productivity growth of the real economy. This calls for policies that strengthen banks' balance sheets, that limit banks' incentives to engage in risky behavior, including via stronger prudential supervision, and laws that allow an efficient resolution of weak firms.

Appendix A: Sample selection and zombie firms

We use quarterly data on nonfinancial listed corporations for 47 countries, 23 EMs and 24 AEs, from S&P Compustat North America and Compustat Global. Our final sample covers an unbalanced panel of 24,333 nonfinancial firms over 2000q1-2019q4, a total of 811,922 firm-quarter observations. We exclude financial firms (banks, diversified financials, and insurance firms) from our analysis: GICS codes ranging from 4010 to 4030. Following Albuquerque and Iyer (2024), we make the following adjustments to the sample:

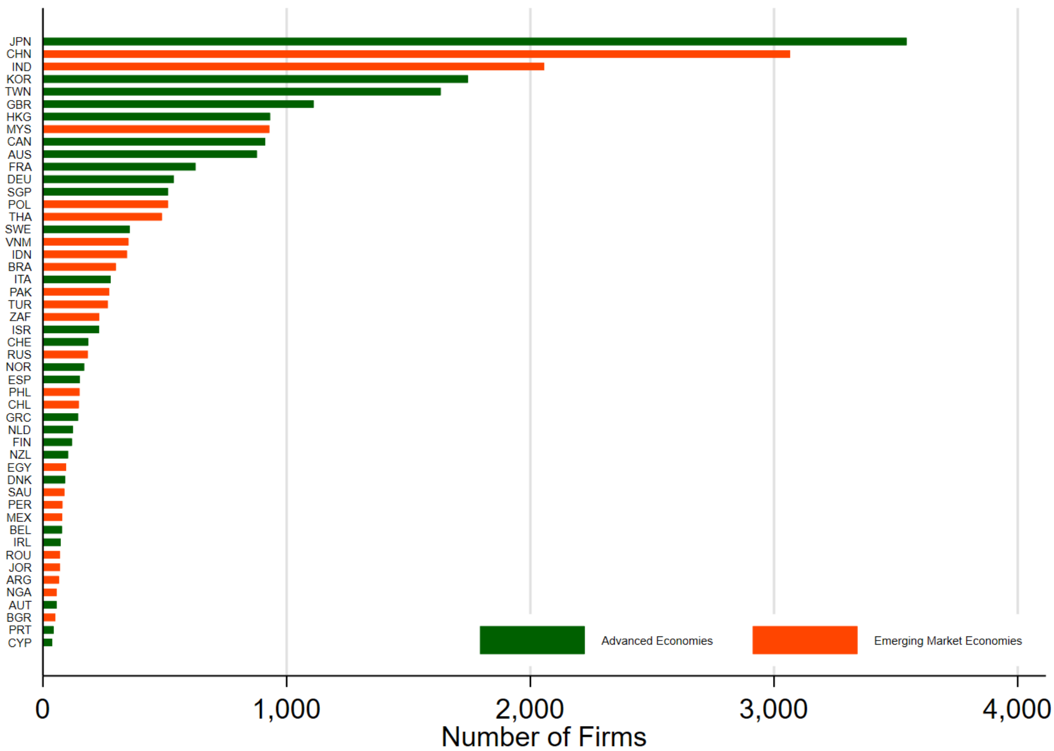
- we convert non-USD to USD for key variables in levels: we use (i) end-of-period exchange rates for stock balance sheet data; and (ii) quarterly average exchange rates for income statement and cash flow data, and for financial market data
- drop observations for missing assets and liabilities
- replace negative values for assets and liabilities with zeros
- drop observations if capital stock or total debt are missing
- drop observations when acquisitions are larger than five percent of total assets to exclude potential mergers and acquisitions
- drop firms with total debt larger than 100 percent of total assets
- drop firms with fewer than three years of data on the leverage ratio, the capital stock, the ICR, and sales
- drop observations for countries with fewer than five firms for each quarter
- winsorize key variables at the 2.5/97.5 percentiles at the country level
- drop countries with fewer than eight years of data on the leverage ratio, the capital stock, and the ICR from 2000 onwards
- compute zombie firms for industries with at least three firms per country-quarter pair
- drop countries with fewer than 12 years of data on zombie shares
- we take four-quarter rolling sums of flow variables—EBIT, sales, interest expenses—before computing ratios when the denominator is a stock variable: e.g. the implicit interest rate
- deflate nominal variables with the respective country CPI deflator

Table A.1: Variable definitions

Variable	Definition	Source
Net capital stock	PPENTQ	Compustat
Employment[b]	EMP	Compustat
Total debt (book value)	DLCQ + DLTTQ	Compustat
Long-term debt (book value)	DLTTQ	Compustat
Short-term debt (book value)	DLCQ	Compustat
Total assets (book value)	ATQ	Compustat
Current assets	ACTQ	Compustat
Current liabilities	LCTQ	Compustat
Net current assets	ACTQ - LCTQ	Compustat
Cash + short-term investments	CHEQ	Compustat
Net income	NIQ	Compustat
Interest payments	XINTQ	Compustat
Depreciation & amortization	DPQ	Compustat
Stock prices	PRCQQ	Compustat
EBITDA	SALEQ - COSGQ - XSGAQ	Compustat
EBIT	SALEQ - COSGQ - XSGAQ - DPQ	Compustat
Debt ratio	(DLCQ + DLTTQ) / ATQ	Compustat
ICR	EBIT / XINTQ	Compustat
ROA	EBIT / ATQ	Compustat
Equity (book value)	SEQQ + TXDITCQ - Preferred stock	Compustat
Tobin's Q	(ATQ + PRCCQ×CSHOQ - Equity) / ATQ	Compustat
Implicit interest rate	XINTQ / (DLCQ + DLTTQ)	Compustat
Sales	SALEQ	Compustat
Acquisitions	AQCY[a]	Compustat
Loan share[b]	(NP + DLTO)/(DLCQ + DLTTQ)	Compustat
Age	Foundation year	Capital IQ
PD in 12 months	PRCQQ	NUS-CRI

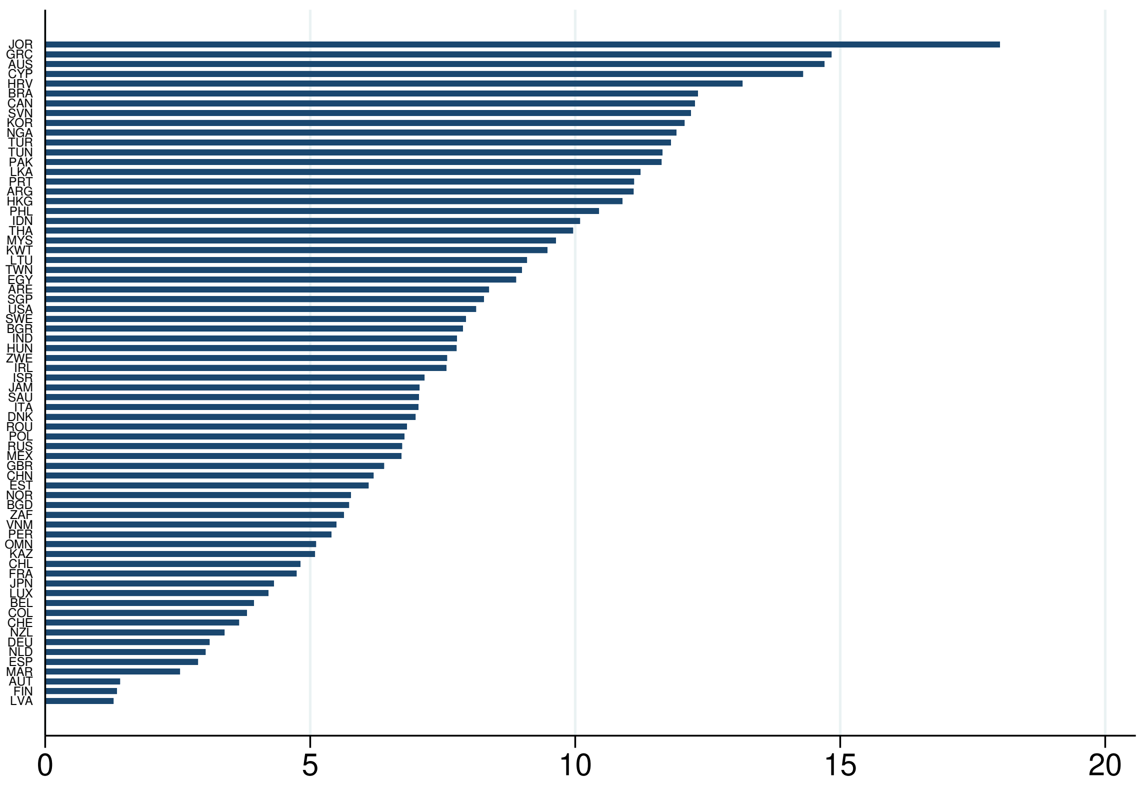
a. Transformation from year-to-date to quarterly. *b.* Annual data interpolated to quarterly.

Figure A.1: Number of firms



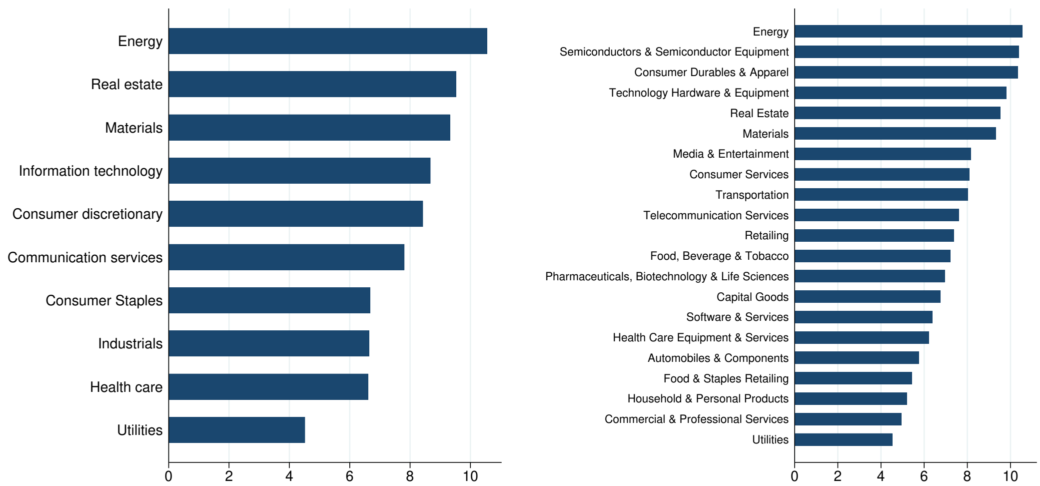
Notes: Number of distinct firms over 2000-19.

Figure A.2: Average share of listed zombie firms by country



Source: Reproduced from Albuquerque and Iyer (2024).
Notes: Average zombie shares for listed firms over the 2000-2022 period.

Figure A.3: Average share of zombie firms by industry



Source: Reproduced from Albuquerque and Iyer (2024).
Notes: Average zombie shares at the industry level over 2000-2022. Left (right) panel shows two-digit (four-digit) GICS.

Appendix B: Tables

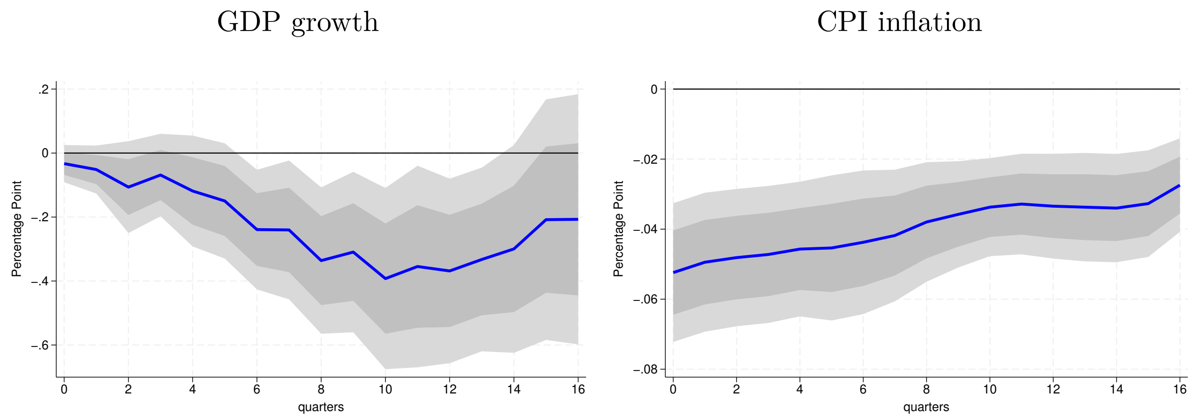
Table B.1: Effect of contractionary monetary policy shocks on new loans: high-PD firms

	(1)	(2)	(3)	(4)
High-PD$_{t-1}$	-0.618***	-0.621***		
	(0.154)	(0.162)		
MP shock × High-PD$_{t-1}$	-0.089***	-0.109***		
	(0.028)	(0.031)		
MP shock × LC$_{t-1}$			0.004	-0.004
			(0.040)	(0.036)
High-PD$_{t-1}$ × LC$_{t-1}$			-0.020	-0.007
			(0.068)	(0.104)
MP shock × High-PD$_{t-1}$ × LC$_{t-1}$			0.002	0.038
			(0.045)	(0.045)
Firm controls	✓	✓	✓	✓
Bank controls			✓	✓
Firm FE	✓	✓	✓	
Bank FE	✓		✓	✓
Bank × Year FE		✓		
ILST FE	✓	✓	✓	
Firm × Year FE				✓
Observations	57,208	53,293	8,284	5,931
R^2	0.838	0.857	0.880	0.907

Notes: IV estimates where the dependent variable is the log of new loans. The table shows the differential response of new syndicated loans to high-PD firms relative to other firms following a 100 bps monetary policy shock. *LC* refers to a dummy variable capturing low capitalized banks (below the country-specific median of the Tier 1 capital ratio). Standard errors in parentheses clustered at bank level. Asterisks, *, **, and ***, denote statistical significance at the 10%, 5%, and 1% levels.

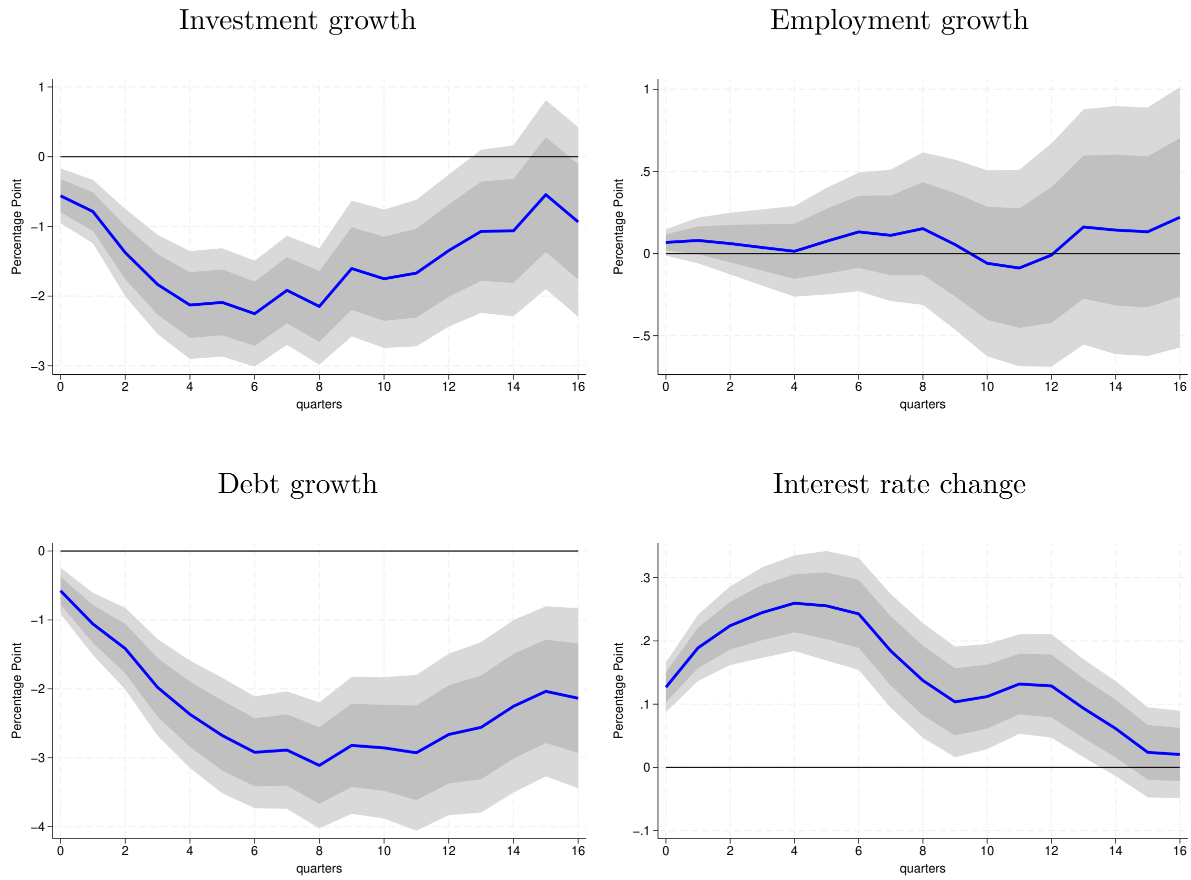
Appendix C: Figures

Figure C.1: Average effects of monetary policy shocks on aggregate outcomes



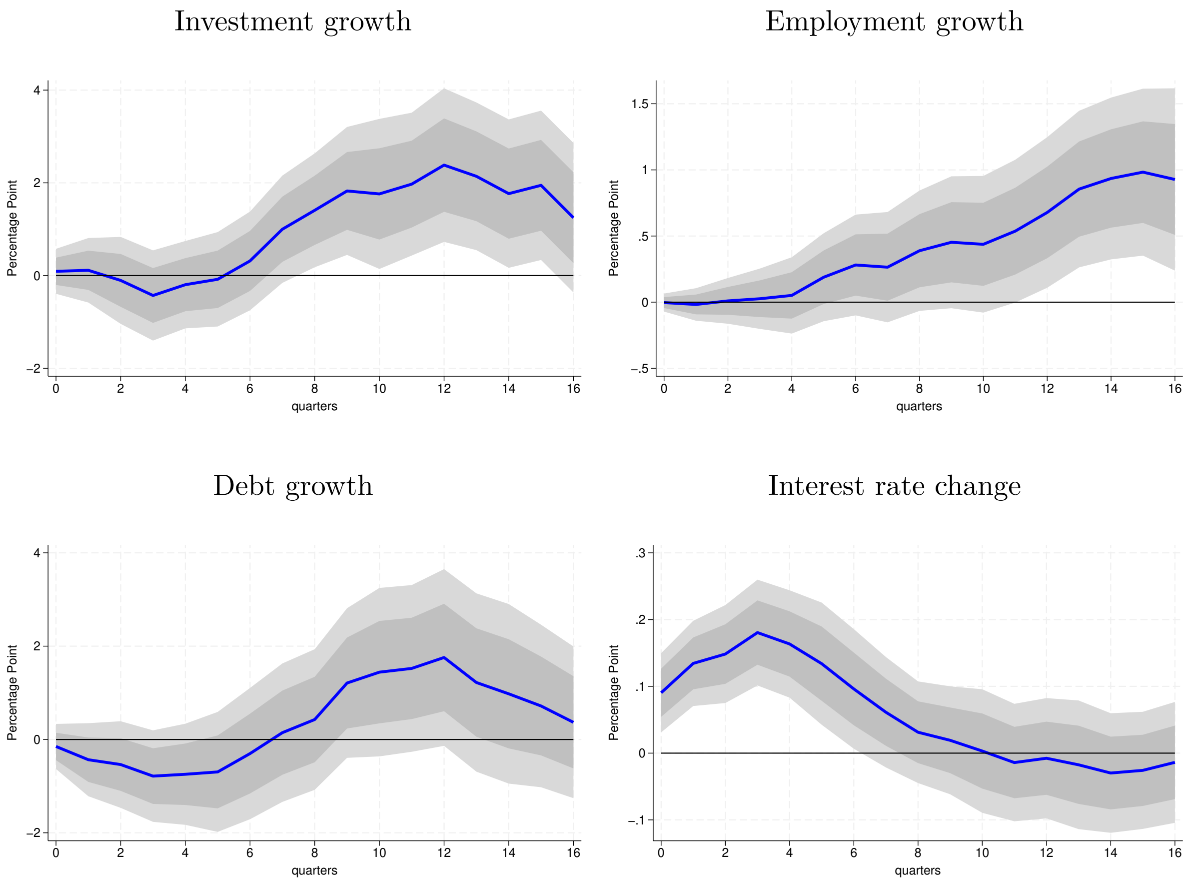
Notes: Cumulative impulse responses to a monetary policy shock that increases the country-specific one-year sovereign bond yields by 100 bps. The blue line is the average point estimate, and the dark (light) grey area refers to the 68 (90) percent confidence bands.

Figure C.2: Average effects of monetary policy shocks on nonfinancial firms: ten-year yields



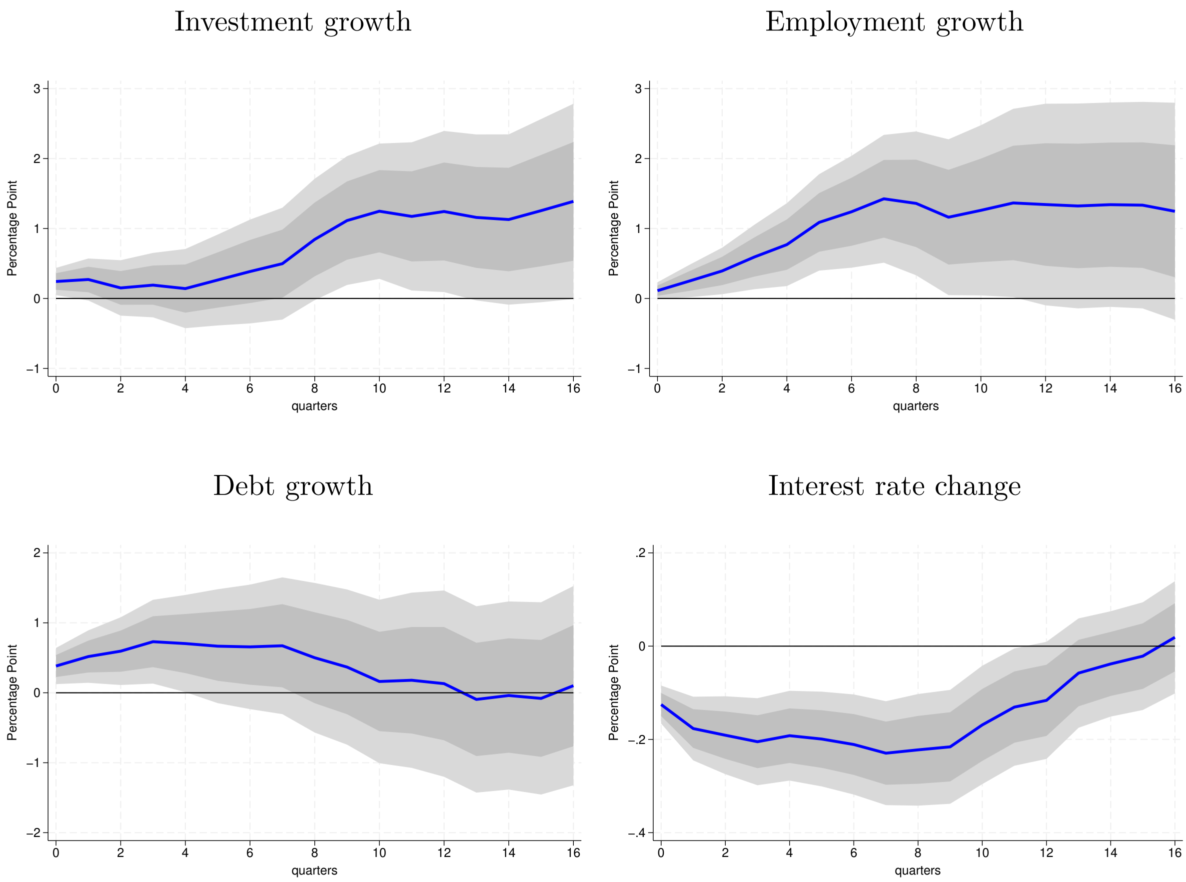
Notes: Cumulative impulse responses to a monetary policy shock that increases the country-specific ten-year sovereign bond yields by 100 bps. The blue line is the average point estimate, and the dark (light) grey area refers to the 68 (90) percent confidence bands.

Figure C.3: Average effects of monetary policy shocks on nonfinancial firms: three-month interest rates



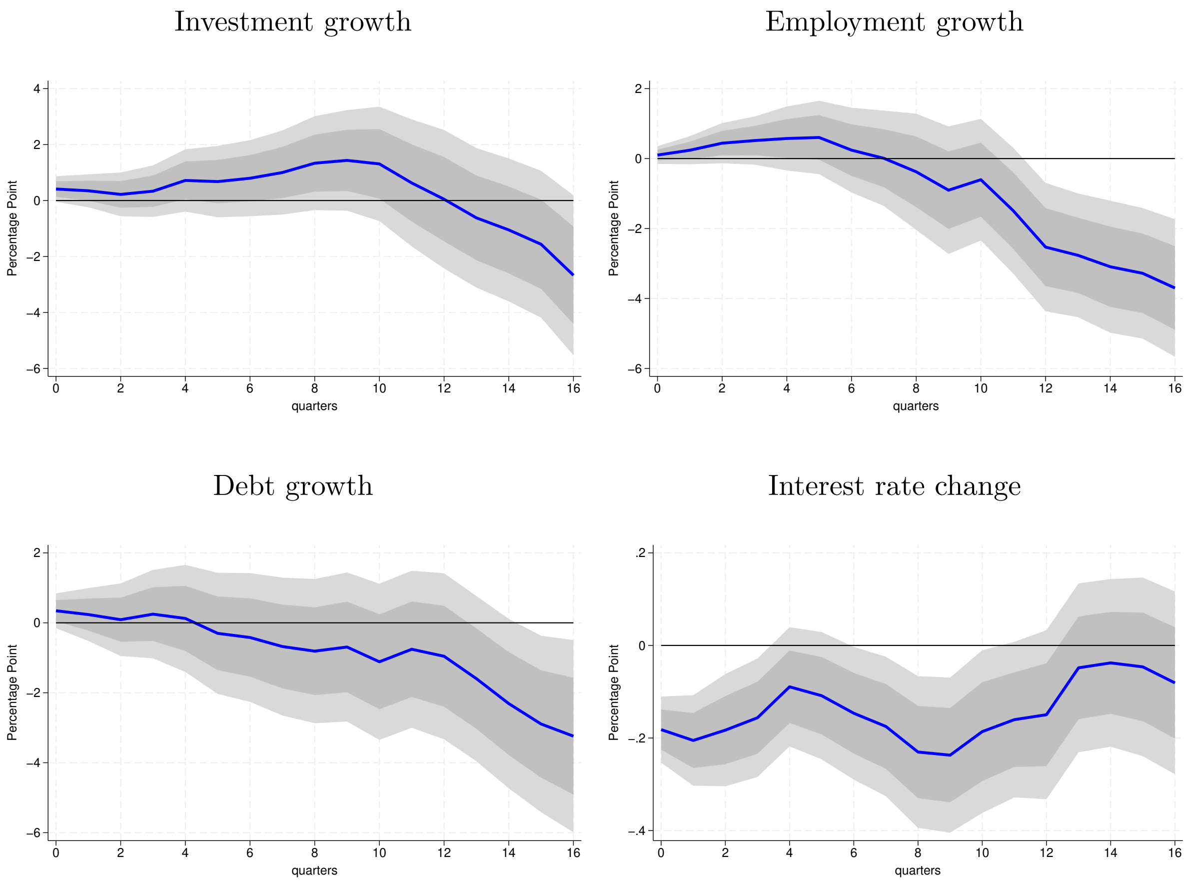
Notes: Cumulative impulse responses to a monetary policy shock that increases the country-specific three-month interest rates by 100 bps. The blue line is the average point estimate, and the dark (light) grey area refers to the 68 (90) percent confidence bands.

Figure C.4: Differential effect of monetary policy shocks on zombies versus nonzombies: ten-year bond yields



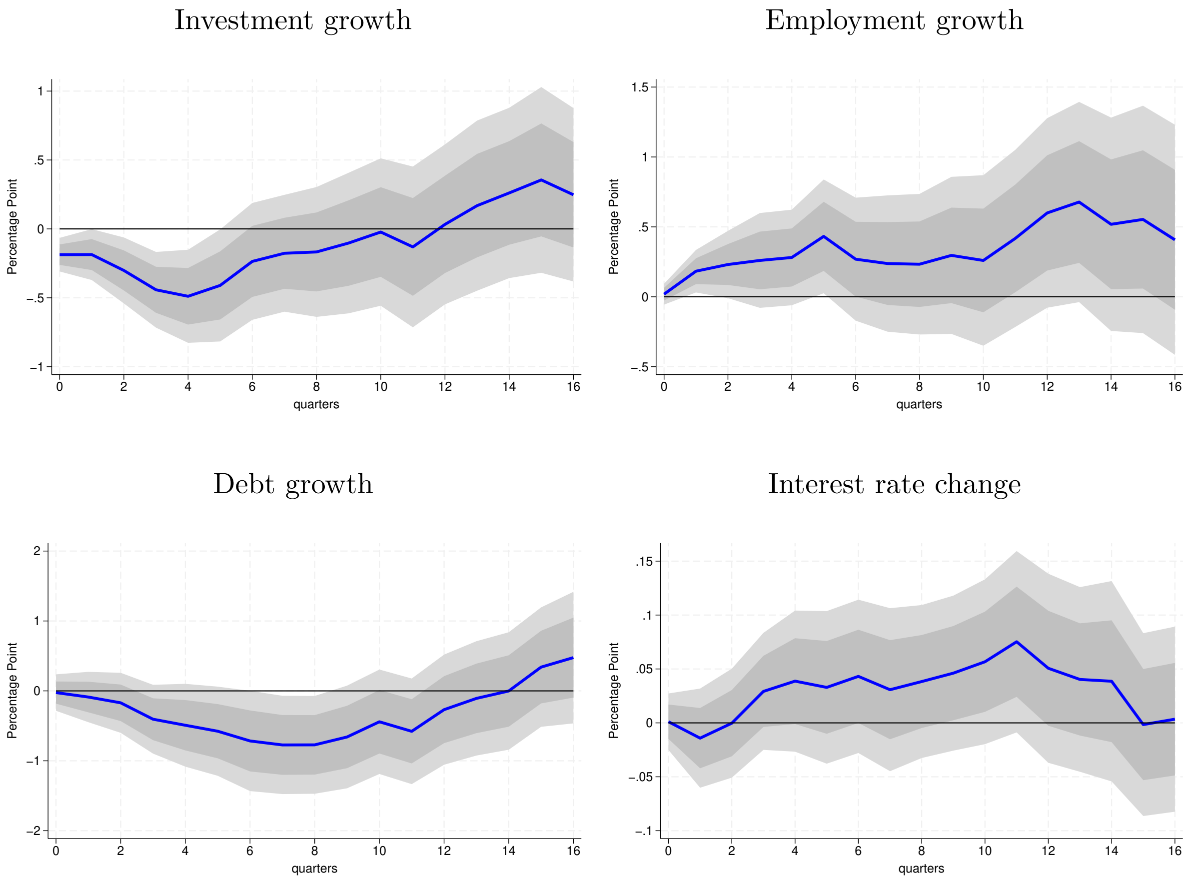
Notes: Cumulative impulse responses for zombie firms relative to nonzombies to a monetary policy shock that increases the country-specific ten-year sovereign bond yields by 100 bps. The blue line is the average point estimate, and the dark (light) grey area refers to the 68 (90) percent confidence bands.

Figure C.5: Differential effect of monetary policy shocks on zombies versus nonzombies: three-month interest rates



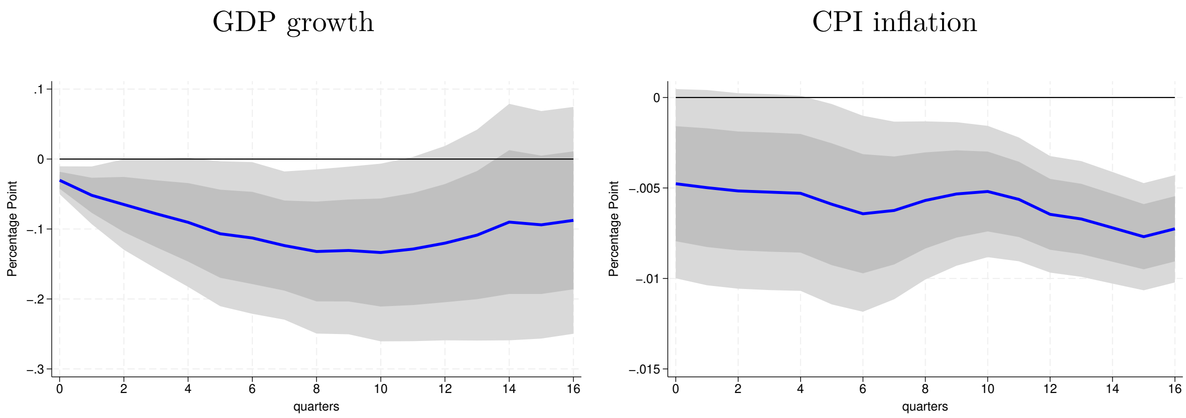
Notes: Cumulative impulse responses for zombie firms relative to nonzombies to a monetary policy shock that increases the country-specific three-month interest rates by 100 bps. The blue line is the average point estimate, and the dark (light) grey area refers to the 68 (90) percent confidence bands.

Figure C.6: Differential effect of monetary policy shocks on financially constrained firms



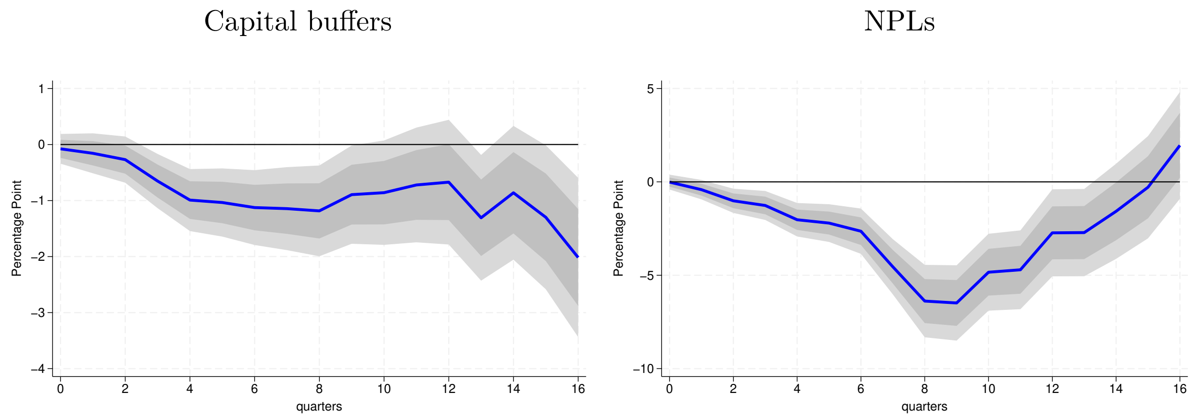
Notes: Cumulative impulse responses to a monetary policy shock that increases the country-specific ten-year sovereign bond yields by 100 bps. The blue line refers to the differential effect between high-PD and low-PD firms. High-PD firms are firms whose probability of default stands in the upper quartile of the country-specific distribution. The dark (light) grey area refers to the 68 (90) percent confidence bands.

Figure C.7: Effect of monetary policy shocks on aggregate outcomes for countries with higher zombie shares



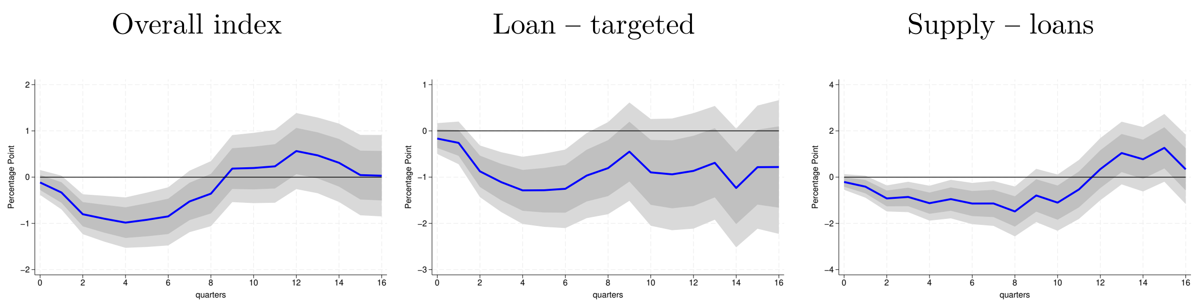
Notes: Cumulative impulse responses to a monetary policy shock that increases the country-specific one-year sovereign bond yields by 100 bps. The blue line is the marginal point estimate for countries whose zombie shares are one-standard deviation above the mean, and the dark (light) grey area refers to the 68 (90) percent confidence bands.

Figure C.8: Effect of monetary policy shocks on investment growth of zombies versus nonzombies: marginal effects of an improvement in selected bank indicators



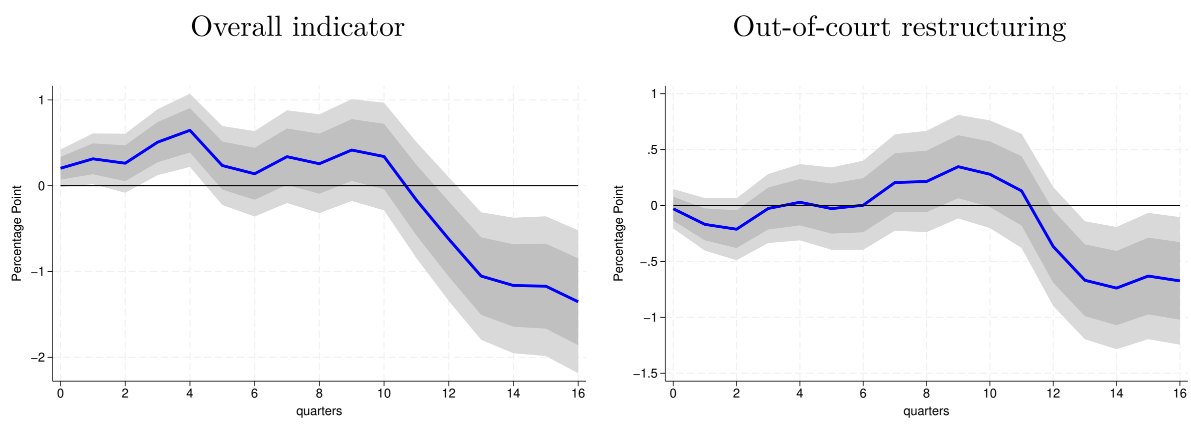
Notes: Cumulative marginal effects of a monetary policy shock that increases the country-specific one-year sovereign bond yields by 100 bps on the responses of investment growth for zombie firms relative to nonzombies when bank capital buffers (NPLs) increase (decrease) by one-standard deviation. The blue line is the average point estimate, and the dark (light) grey area refers to the 68 (90) percent confidence bands.

Figure C.9: Effect of monetary policy shocks on investment growth of zombies versus nonzombies: marginal effects in countries with tighter macroprudential policies



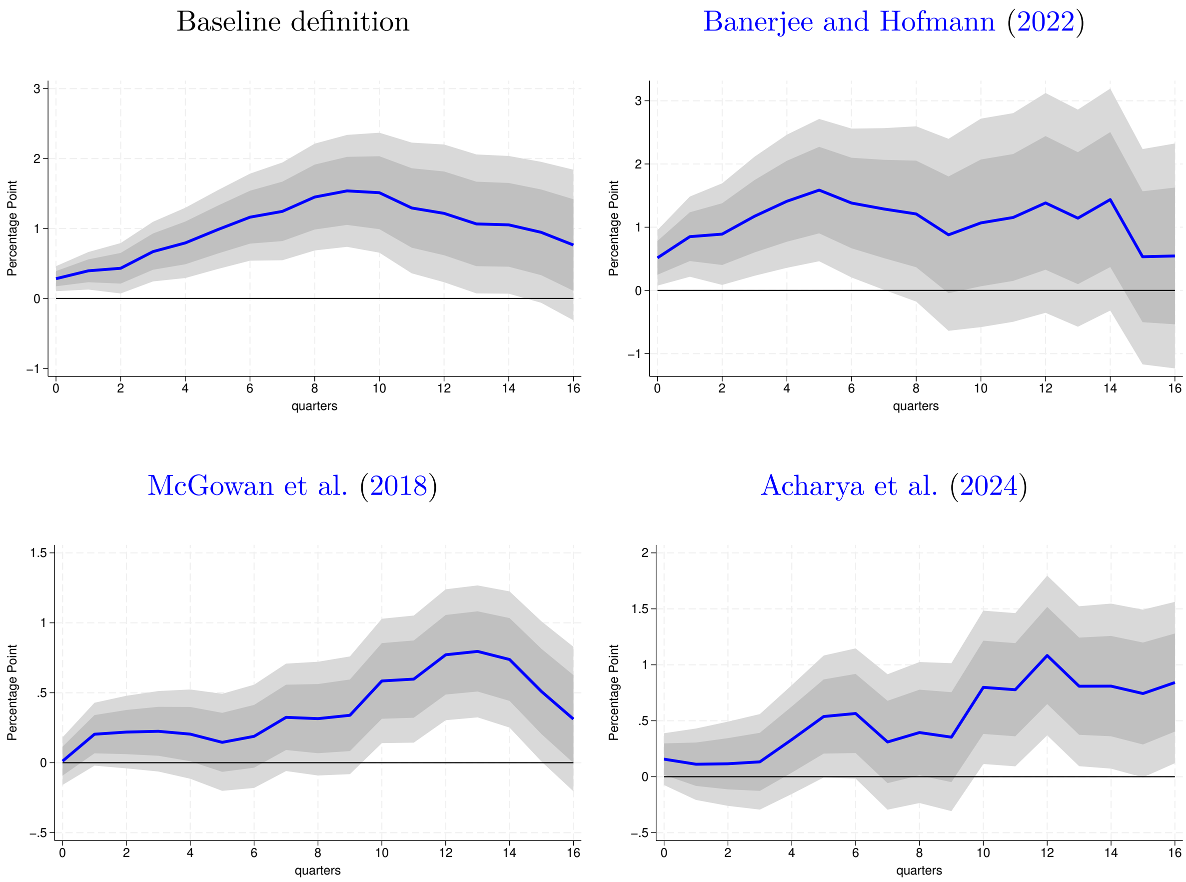
Notes: Cumulative marginal effects on investment growth of a monetary policy shock that increases the country-specific one-year sovereign bond yields by 100 bps. The blue line is the average point estimate for zombies versus nonzombies in countries that stand above the median sample of selected macroprudential indices. The dark (light) grey area refers to the 68 (90) percent confidence bands.

Figure C.10: Effect of monetary policy shocks on investment growth of zombies versus nonzombies: marginal effects of an improvement in the insolvency regimes



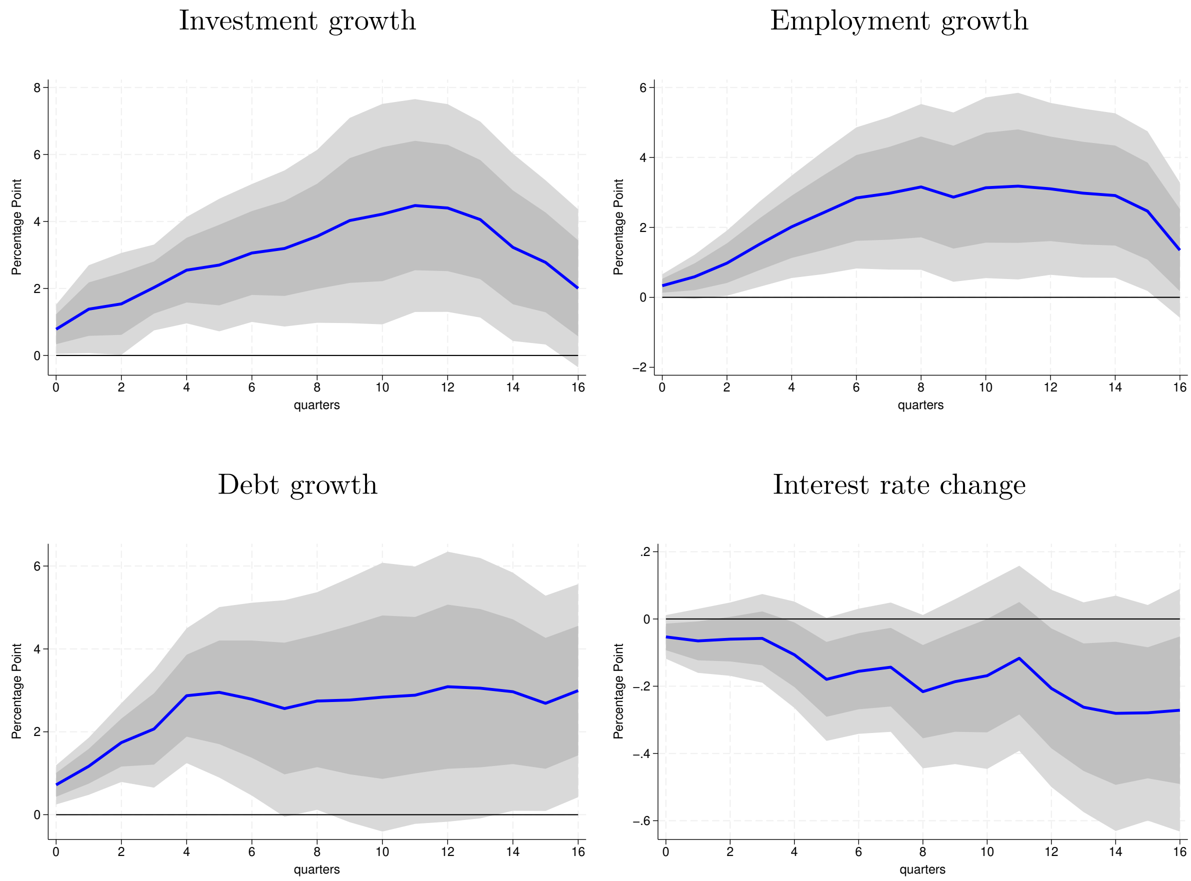
Notes: Cumulative marginal effects of a monetary policy shock that increases the country-specific one-year sovereign bond yields by 100 bps on the responses of investment growth or zombie firms relative to nonzombies when the Araujo et al. (2022) crisis preparedness indicator improves by one-standard deviation. The blue line is the average point estimate, and the dark (light) grey area refers to the 68 (90) percent confidence bands.

Figure C.11: Differential effect of monetary policy shocks on investment growth: alternative zombie definitions



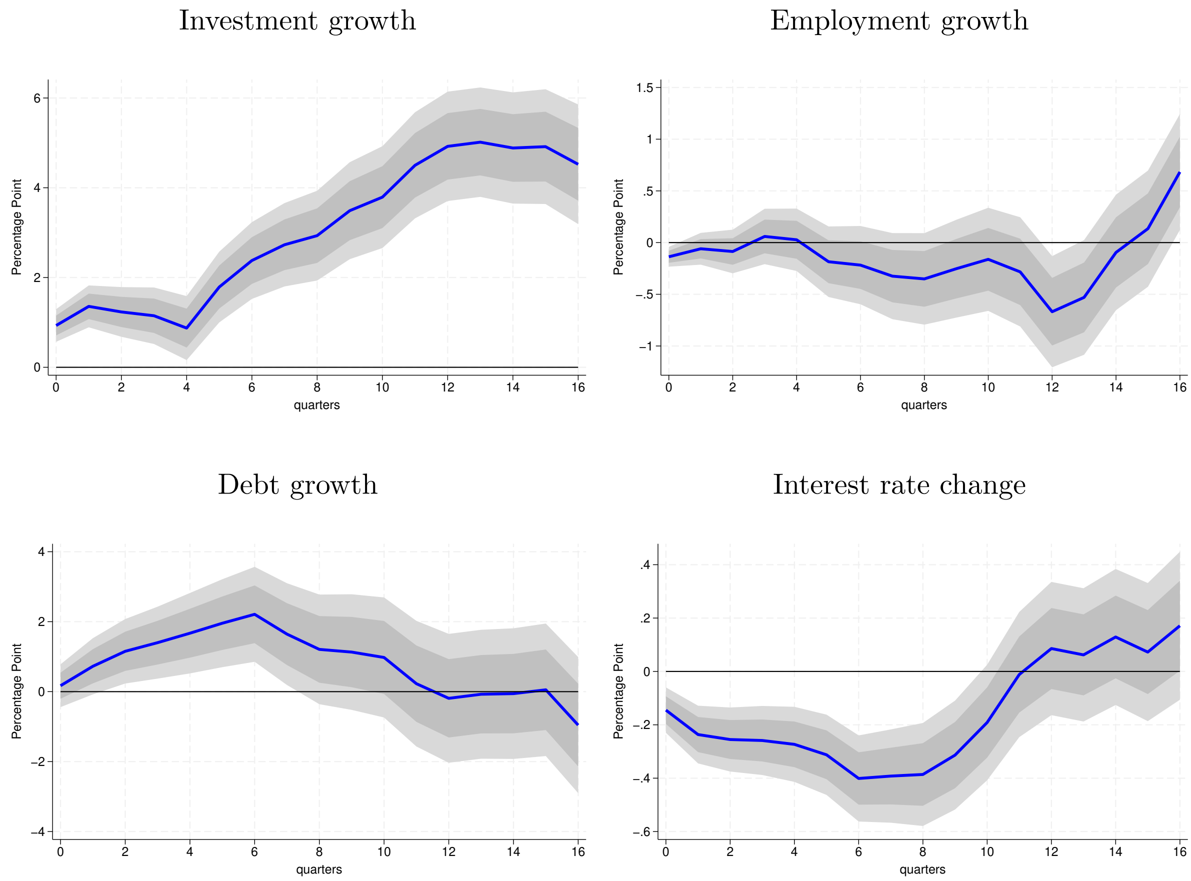
Notes: Cumulative impulse responses for zombie firms relative to nonzombies to a monetary policy shock that increases the country-specific one-year sovereign bond yields by 100 bps. The blue line is the average point estimate, and the dark (light) grey area refers to the 68 (90) percent confidence bands.

Figure C.12: Differential effect of monetary policy shocks: weighted-least squares



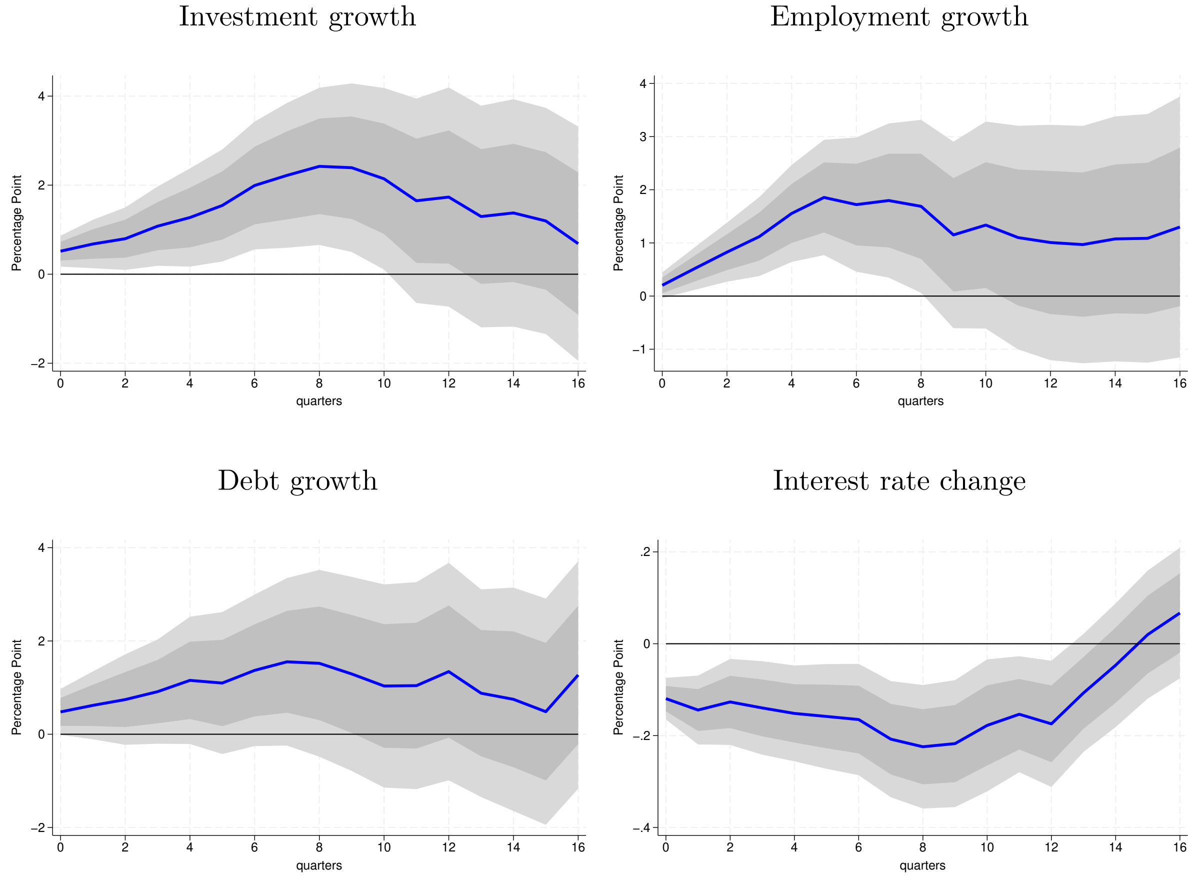
Notes: Cumulative impulse responses for zombie firms relative to nonzombies to a monetary policy shock that increases the country-specific one-year sovereign bond yields by 100 bps. The blue line is the average point estimate, and the dark (light) grey area refers to the 68 (90) percent confidence bands.

Figure C.13: Differential effect of monetary policy shocks: Choi et al. (2024) MP shocks



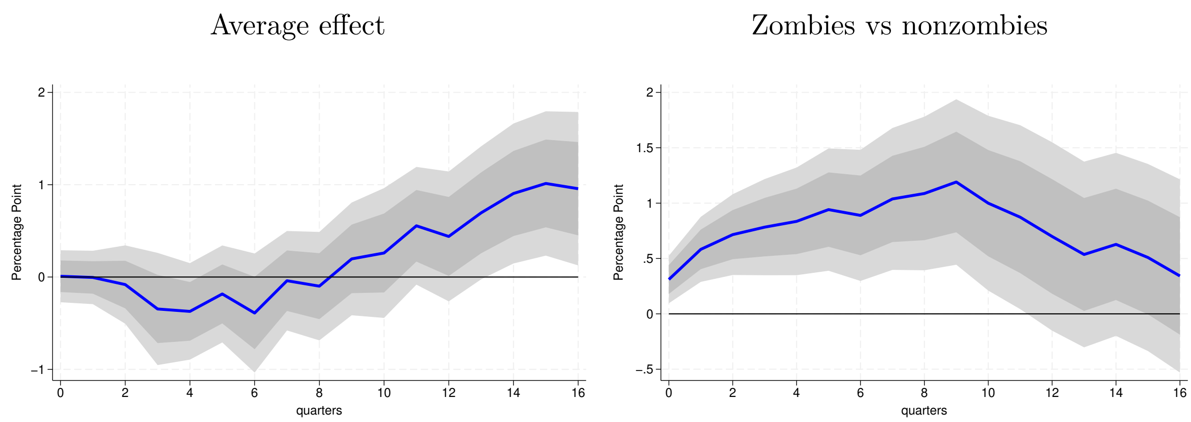
Notes: Cumulative impulse responses for zombie firms relative to nonzombies to a monetary policy shock that increases the country-specific one-year sovereign bond yields by 100 bps. The blue line is the average point estimate, and the dark (light) grey area refers to the 68 (90) percent confidence bands.

Figure C.14: Differential effect of monetary policy shocks: restricted country sample



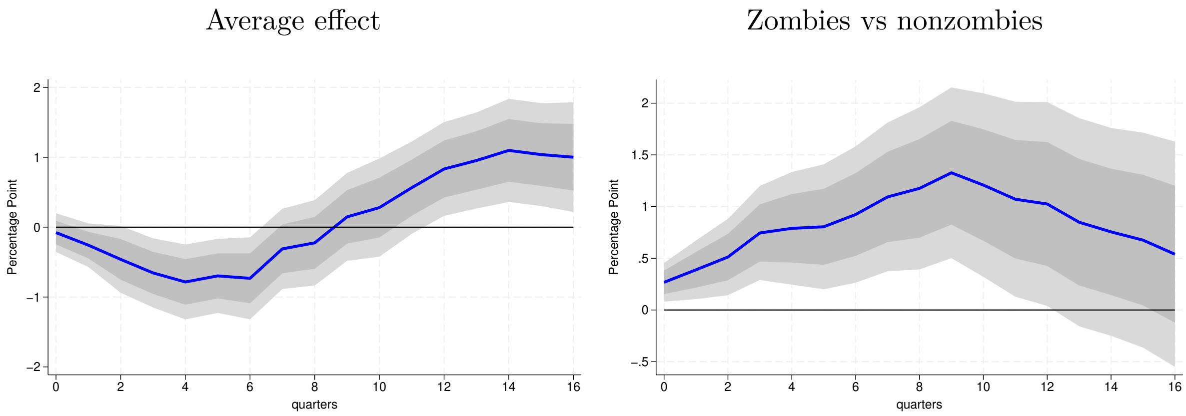
Notes: Cumulative impulse responses for zombie firms relative to nonzombies to a monetary policy shock that increases the country-specific one-year sovereign bond yields by 100 bps. The blue line is the average point estimate, and the dark (light) grey area refers to the 68 (90) percent confidence bands.

Figure C.15: US monetary policy shocks on zombies vs nonzombies: Jarociński and Karadi (2020) shocks



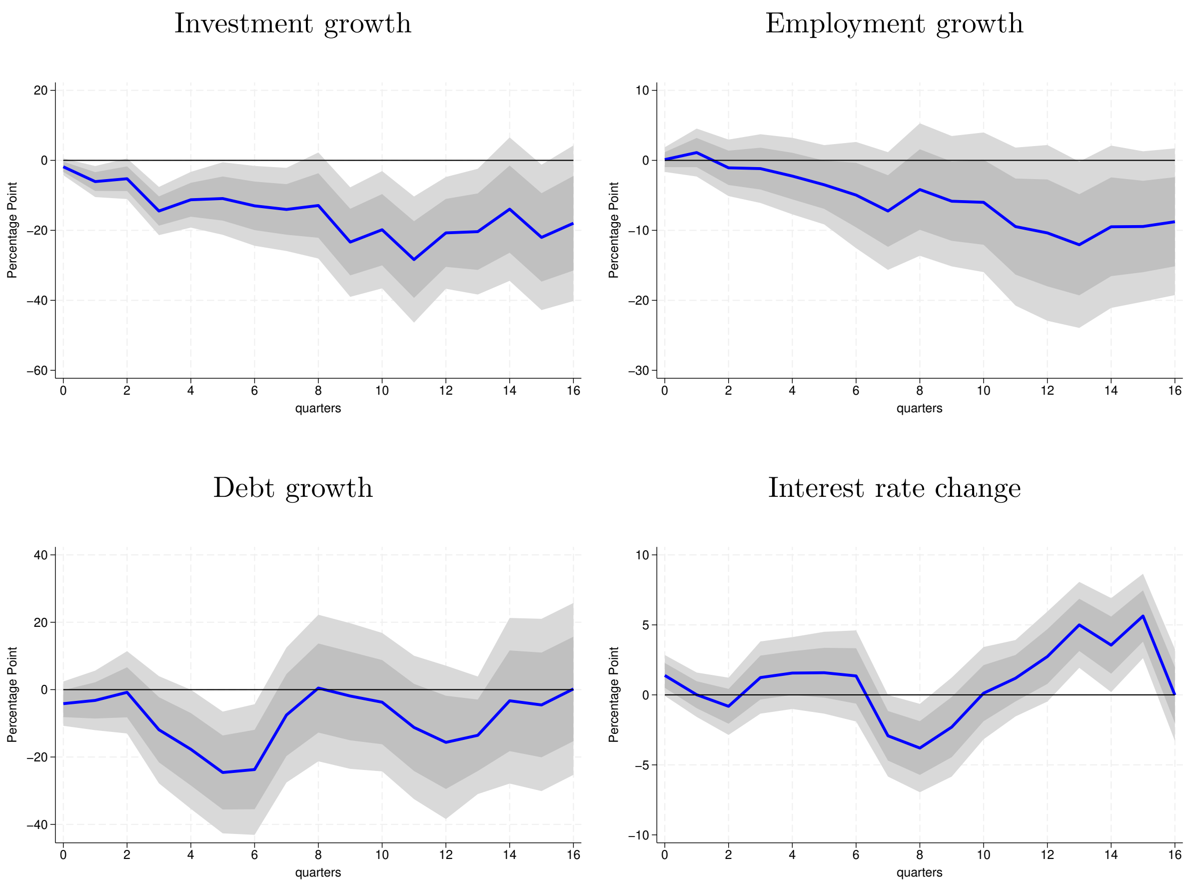
Notes: Cumulative impulse responses of investment growth to a US monetary policy shock that increases the country-specific one-year sovereign bond yields by 100 bps. The blue line is the average point estimate, and the dark (light) grey area refers to the 68 (90) percent confidence bands.

Figure C.16: US monetary policy shocks on zombies vs nonzombies: Bauer and Swanson (2023) shocks



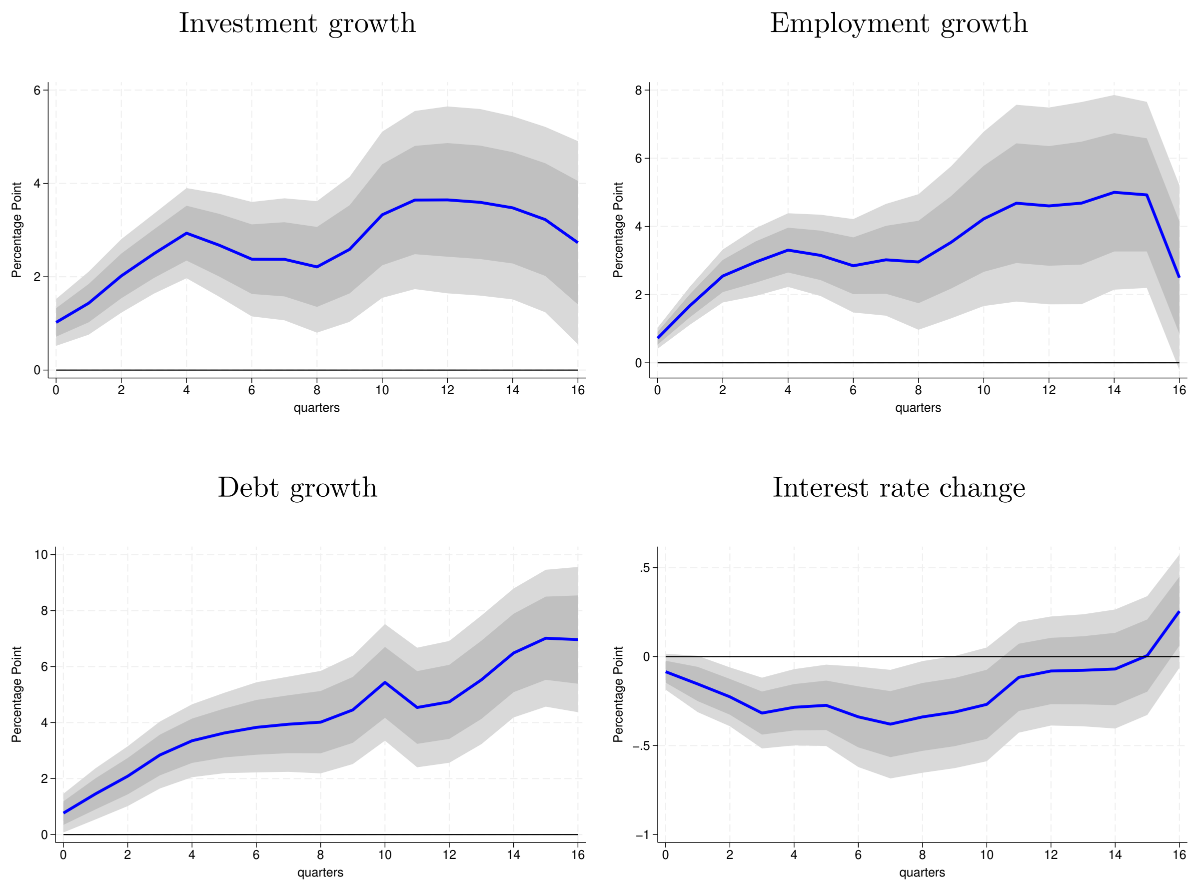
Notes: Cumulative impulse responses of investment growth to a US monetary policy shock that increases the country-specific one-year sovereign bond yields by 100 bps. The blue line is the average point estimate, and the dark (light) grey area refers to the 68 (90) percent confidence bands.

Figure C.17: Differential effect of US monetary policy on US zombies vs nonzombies



Notes: Cumulative impulse responses for zombie firms relative to nonzombies to a US monetary policy shock that increases the one-year US treasury bond yield by 100 bps. The blue line is the average point estimate, and the dark (light) grey area refers to the 68 (90) percent confidence bands.

Figure C.18: Differential effect of ECB monetary policy shocks on EA zombies vs nonzombies



Notes: Cumulative impulse responses for zombie firms relative to nonzombies to a euro area monetary policy shock that increases the country-specific one-year bond yields by 100 bps. The blue line is the average point estimate, and the dark (light) grey area refers to the 68 (90) percent confidence bands.

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