ONLINE APPENDIX

The zombie lending channel of monetary policy

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Appendix A describes the adjustments to the Compustat sample of listed firms, variable definitions and descriptive statistics. Appendix B and C present additional tables and figures, while Appendix D discusses and presents additional robustness checks.

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

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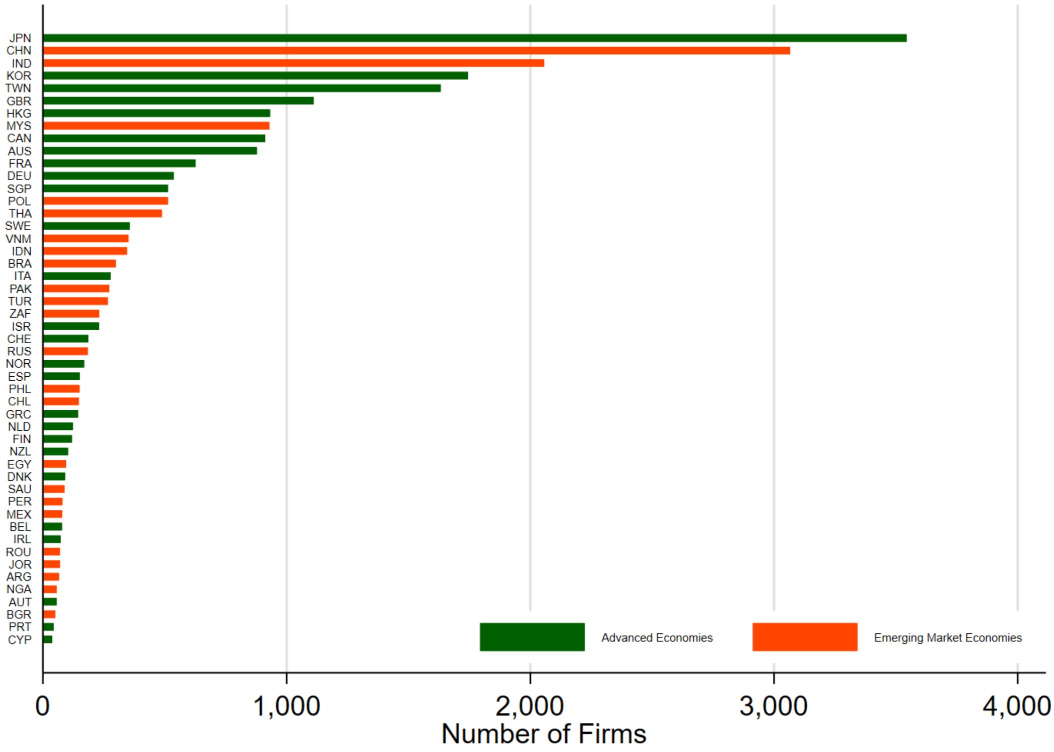
- drop firms with fewer than three years of data on the leverage ratio, the capital stock, the ICR, and sales
- drop observations for countries with fewer than five firms for each quarter
- winsorize key variables at the 2.5/97.5 percentiles at the country level
- drop countries with fewer than eight 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

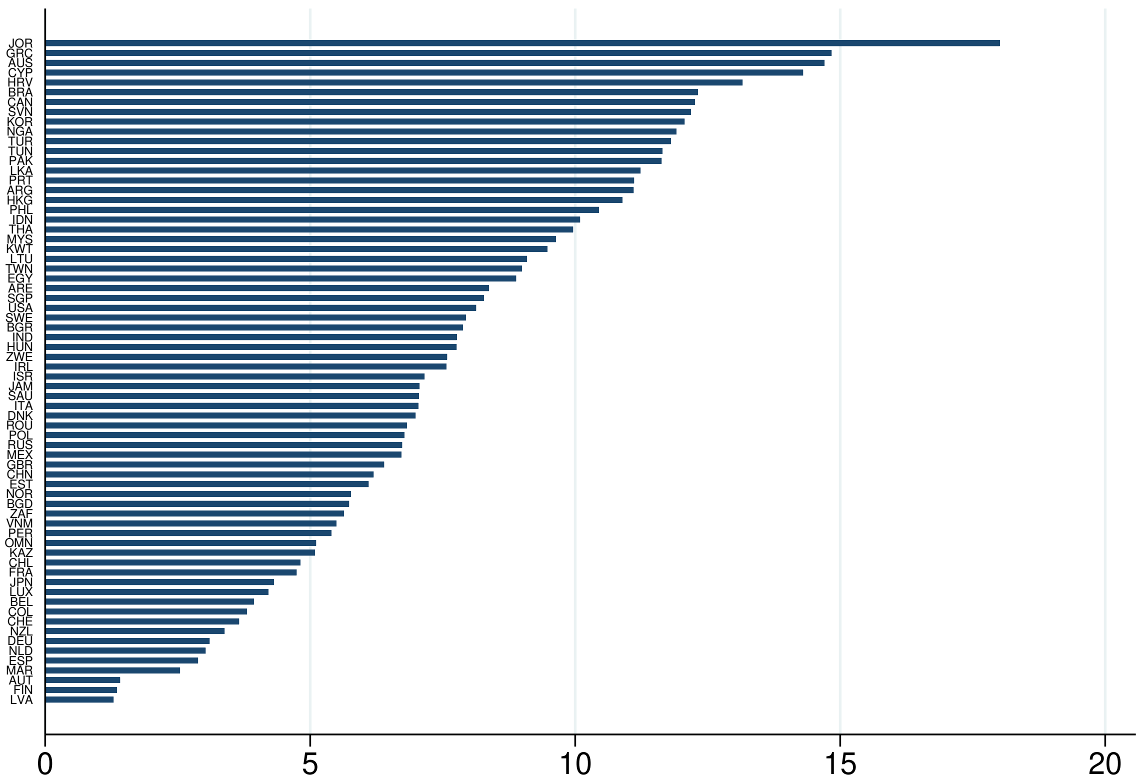
a. Transformation from year-to-date to quarterly. *b.* Annual data interpolated to quarterly.

Figure A.1: Number of firms



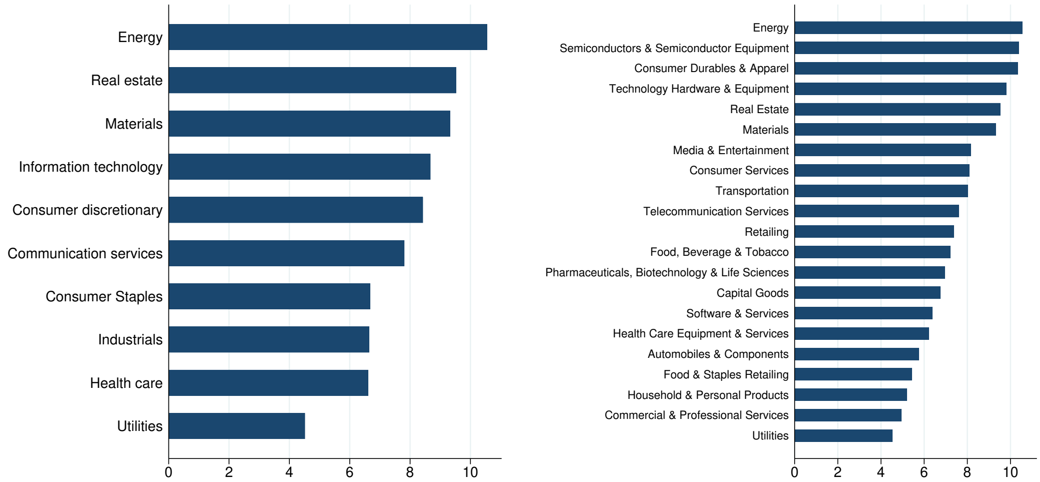
Notes: Number of distinct firms over 2000-19.

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.

Table A.2: 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 2 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.

Appendix B: Additional tables

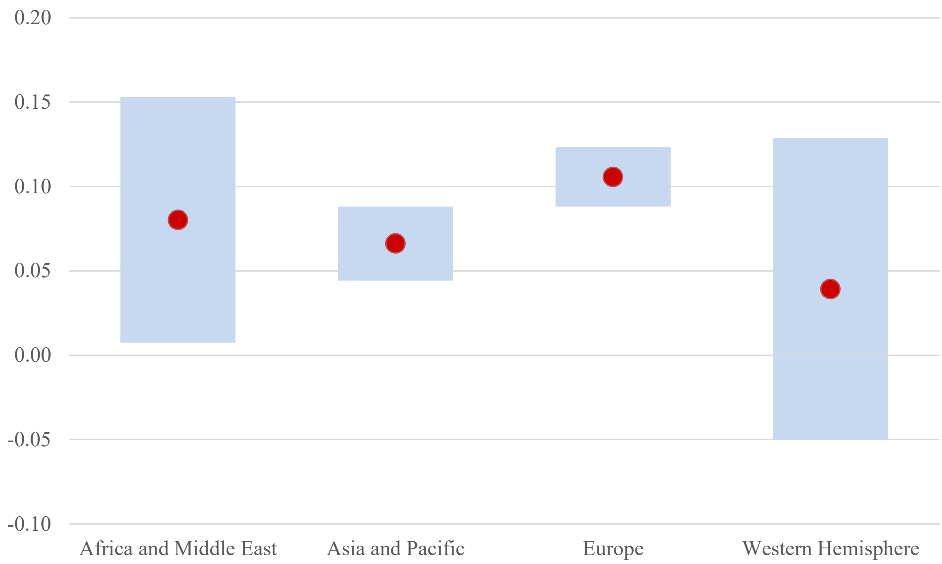
Table B.1: Effect of contractionary monetary policy shocks on new loans: high-PD firms

	(1)	(2)	(3)	(4)
High-PD$_{t-1}$	-0.642***	-0.615***		
	(0.145)	(0.153)		
MP shock × High-PD$_{t-1}$	-0.087***	-0.114***		
	(0.029)	(0.031)		
High-PD$_{t-1}$ × LC$_{t-1}$			-0.810	-0.220
			(0.492)	(0.718)
MP shock × High-PD$_{t-1}$ × LC$_{t-1}$			0.043	-0.000
			(0.051)	(0.088)
Firm controls	✓	✓		
Firm FE	✓	✓		
Bank FE	✓		✓	
Bank × Year FE		✓		✓
ILST FE	✓	✓		
Firm × Year FE			✓	✓
Observations	57,208	53,293	5,939	5,561
R^2	0.838	0.858	0.907	0.921

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.

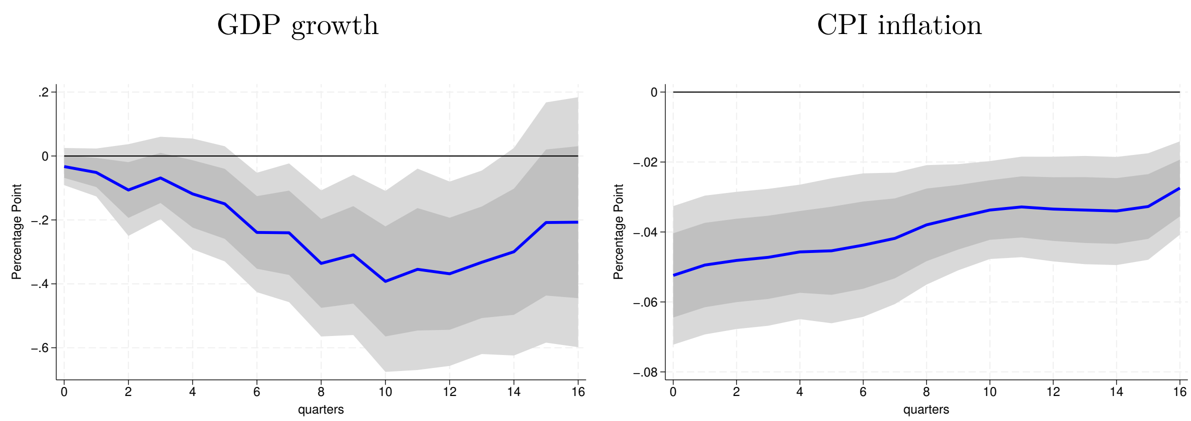
Appendix C: Additional figures

Figure C.1: First-stage coefficients by region



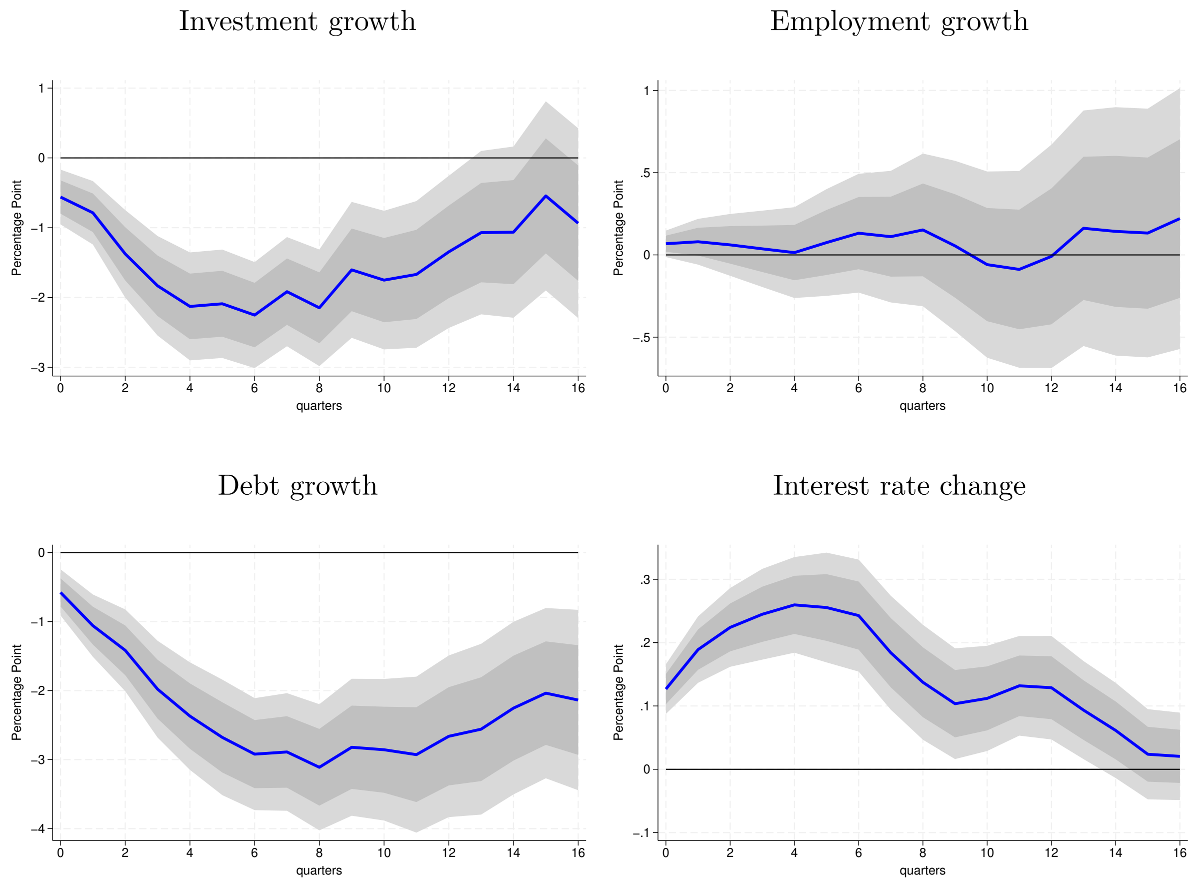
Notes: Red circles refer to the point estimates δ_c from Equation (1) in the main paper but estimated by region with country fixed effects, evaluated at the US monetary policy surprises sample mean. Blue bars refer to the 90 percent confidence bands.

Figure C.2: Average effects of monetary policy shocks on aggregate outcomes



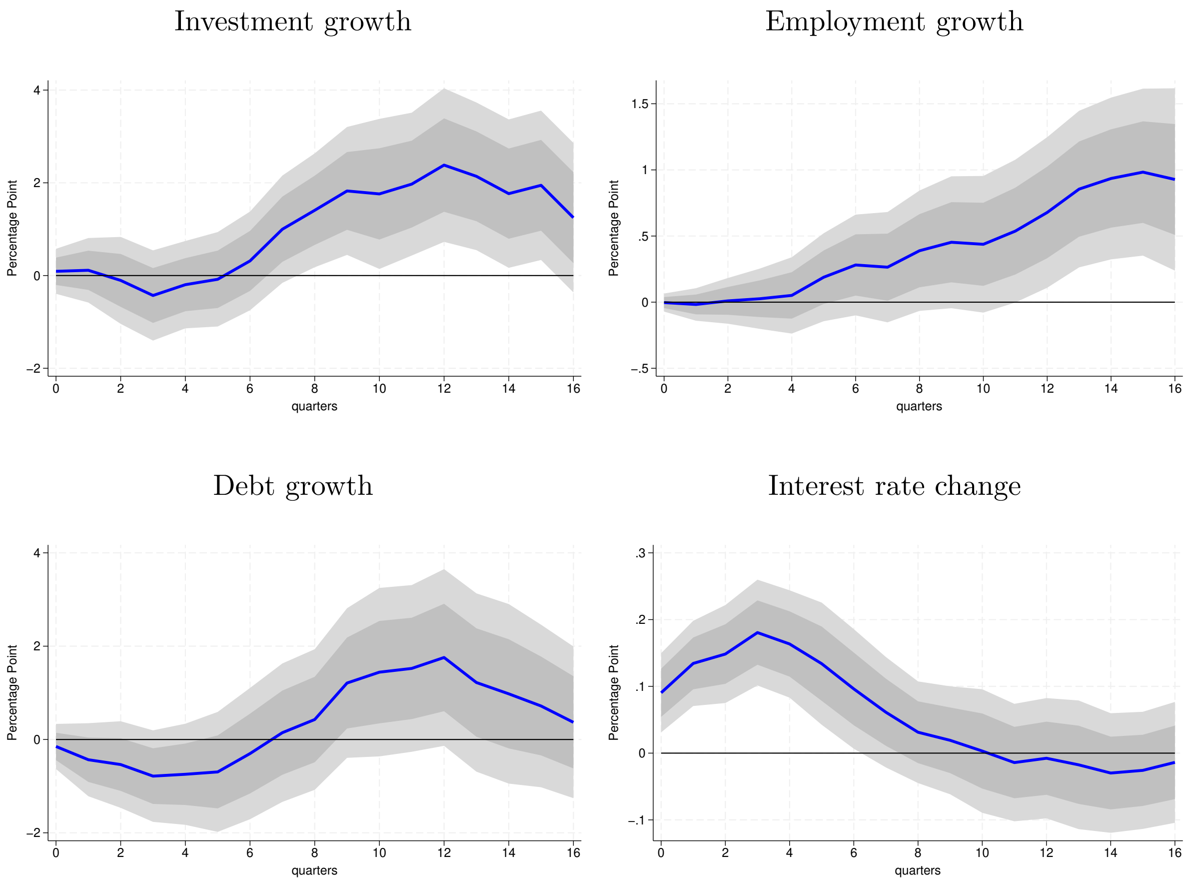
Notes: Cumulative impulse responses to a monetary policy shock that increases the country-specific one-year sovereign bond yields by 100 bps. The blue line is the average point estimate, and the dark (light) grey area refers to the 68 (90) percent confidence bands.

Figure C.3: Average effects of monetary policy shocks on nonfinancial firms: ten-year yields



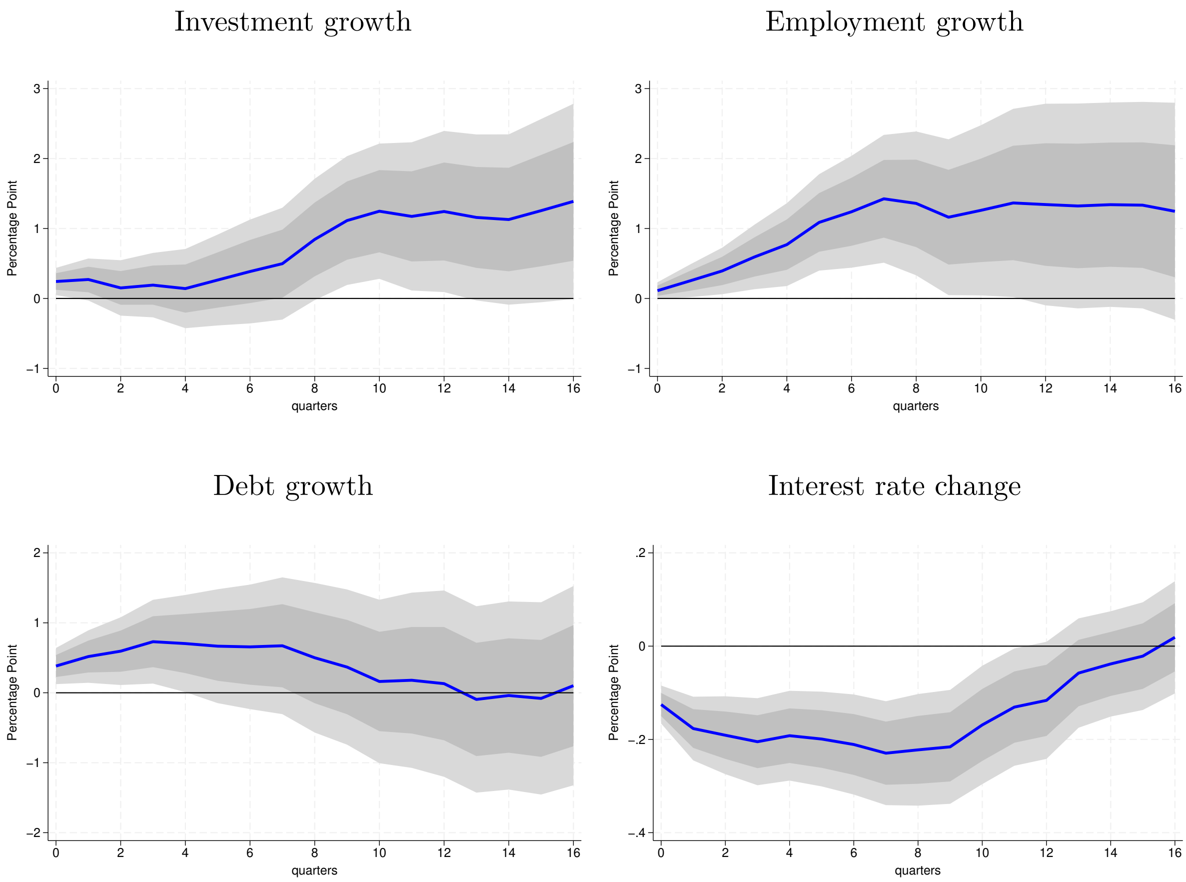
Notes: Cumulative impulse responses to a monetary policy shock that increases the country-specific ten-year sovereign bond yields by 100 bps. The blue line is the average point estimate, and the dark (light) grey area refers to the 68 (90) percent confidence bands.

Figure C.4: Average effects of monetary policy shocks on nonfinancial firms: three-month interest rates



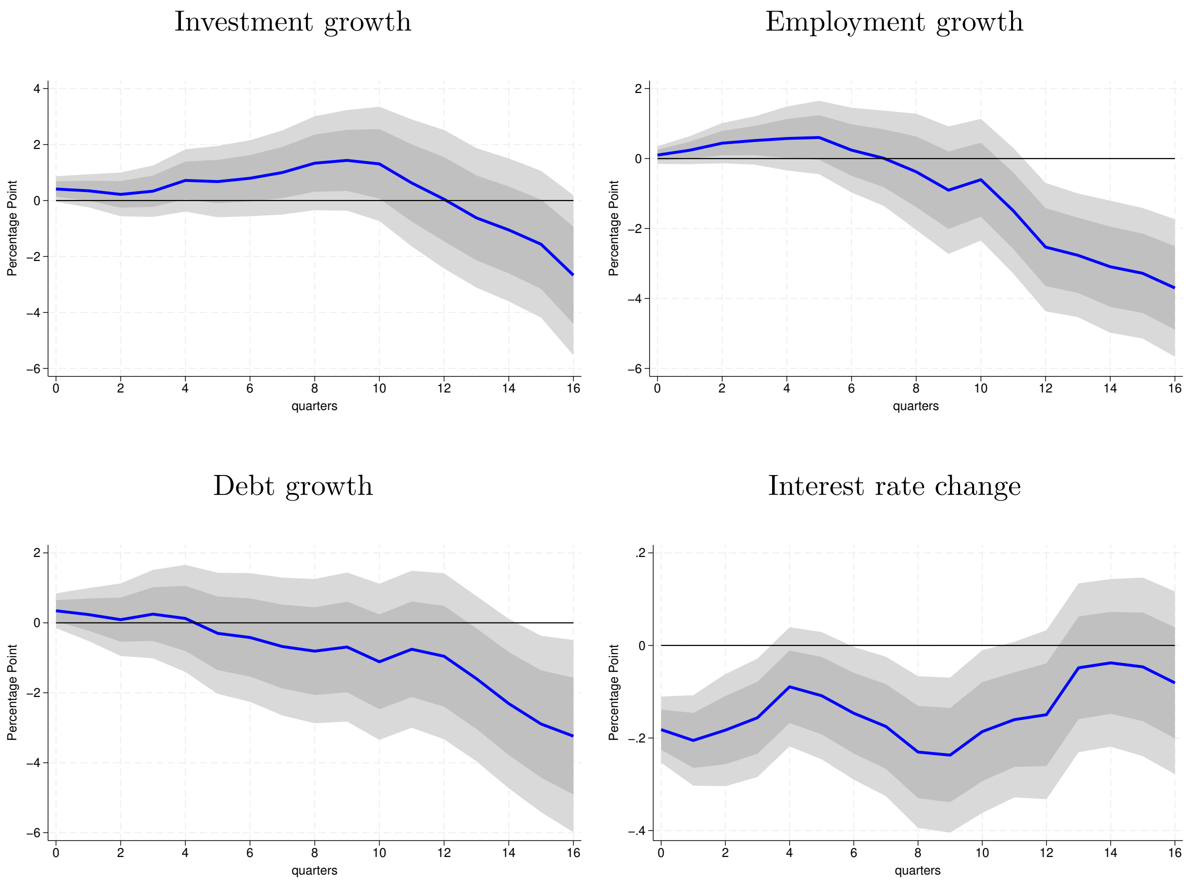
Notes: Cumulative impulse responses to a monetary policy shock that increases the country-specific three-month interest rates by 100 bps. The blue line is the average point estimate, and the dark (light) grey area refers to the 68 (90) percent confidence bands.

Figure C.5: Differential effect of monetary policy shocks on zombies versus nonzombies: ten-year bond yields



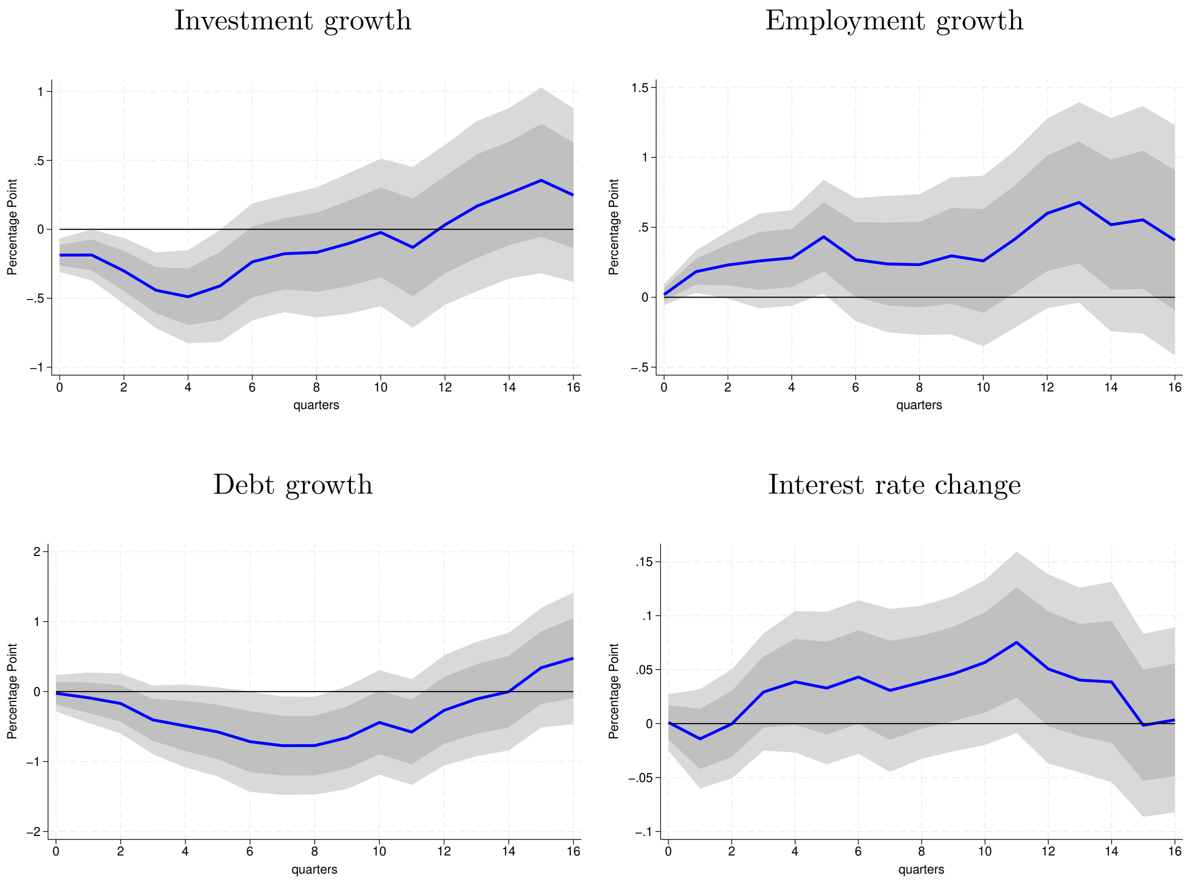
Notes: Cumulative impulse responses for zombie firms relative to nonzombies to a monetary policy shock that increases the country-specific ten-year sovereign bond yields by 100 bps. The blue line is the average point estimate, and the dark (light) grey area refers to the 68 (90) percent confidence bands.

Figure C.6: Differential effect of monetary policy shocks on zombies versus nonzombies: three-month interest rates



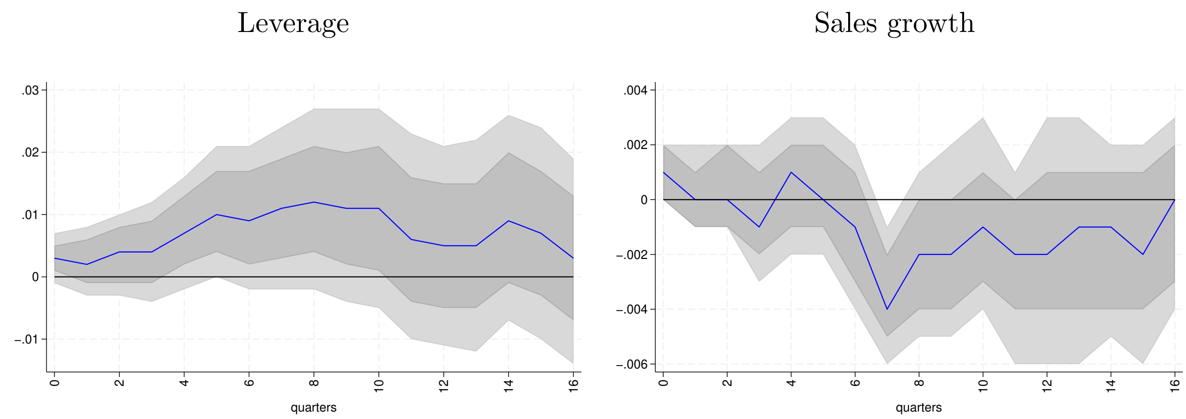
Notes: Cumulative impulse responses for zombie firms relative to nonzombies to a monetary policy shock that increases the country-specific three-month interest rates by 100 bps. The blue line is the average point estimate, and the dark (light) grey area refers to the 68 (90) percent confidence bands.

Figure C.7: Differential effect of monetary policy shocks on financially constrained firms



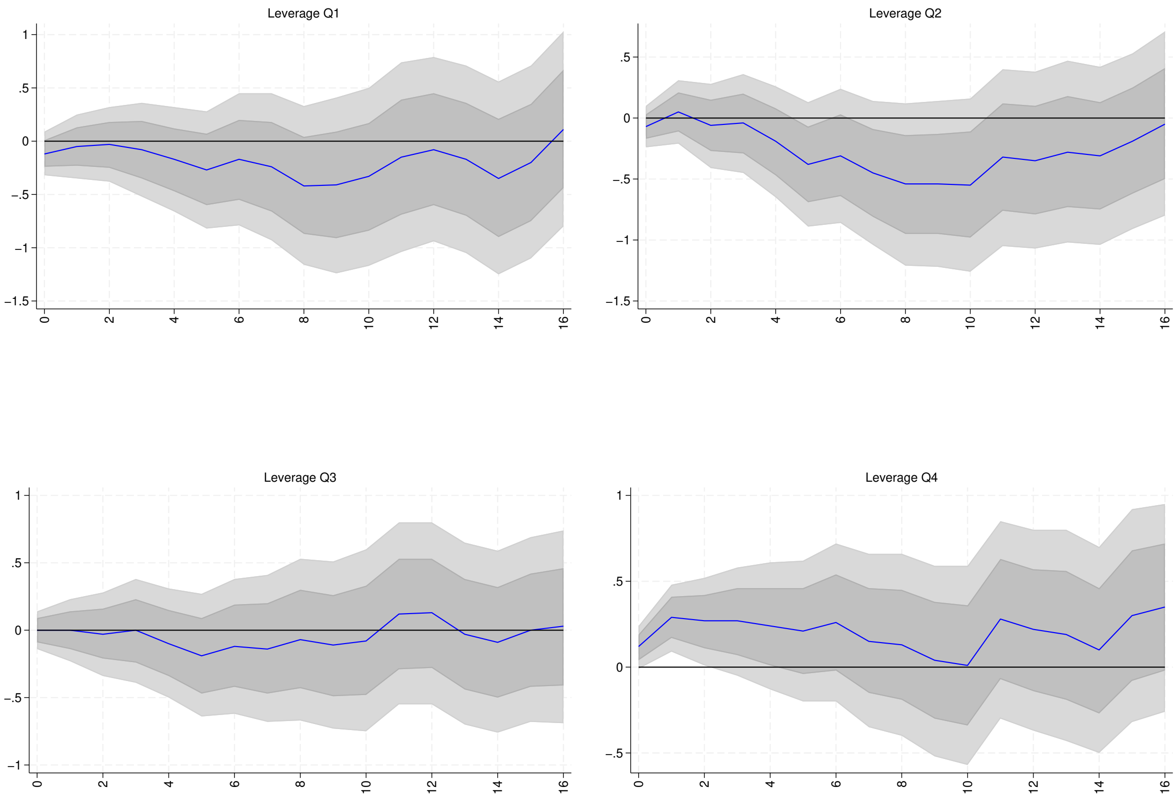
Notes: Cumulative impulse responses to a monetary policy shock that increases the country-specific ten-year sovereign bond yields by 100 bps. The blue line refers to the differential effect between high-PD and low-PD firms. High-PD firms are firms whose probability of default stands in the upper quartile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

Figure C.8: Differential effect of monetary policy shocks on zombies versus nonzombies: leverage and sales growth



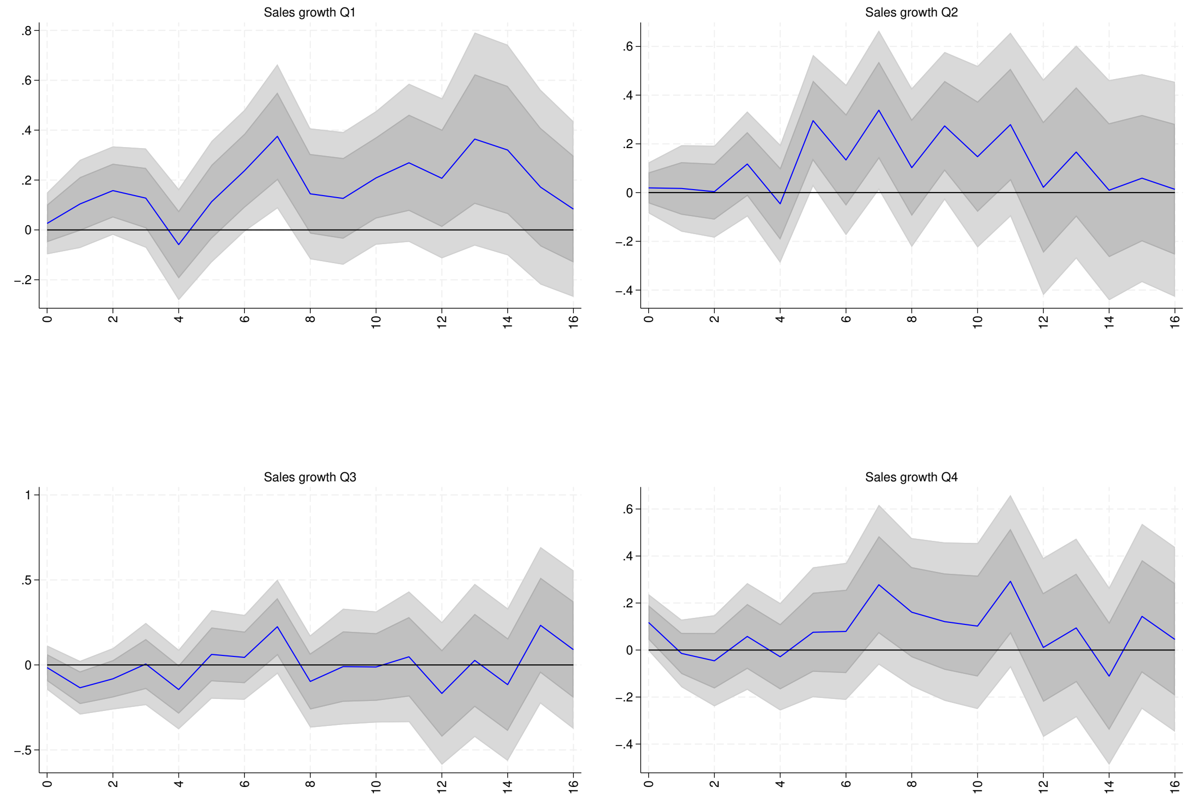
Notes: Cumulative impulse responses to a monetary policy shock that increases the country-specific one-year sovereign bond yields by 100 bps. The blue line is the average point estimate, and the dark (light) grey area refers to the 68 (90) percent confidence bands.

Figure C.9: Differential effect of monetary policy shocks conditional on leverage quintiles



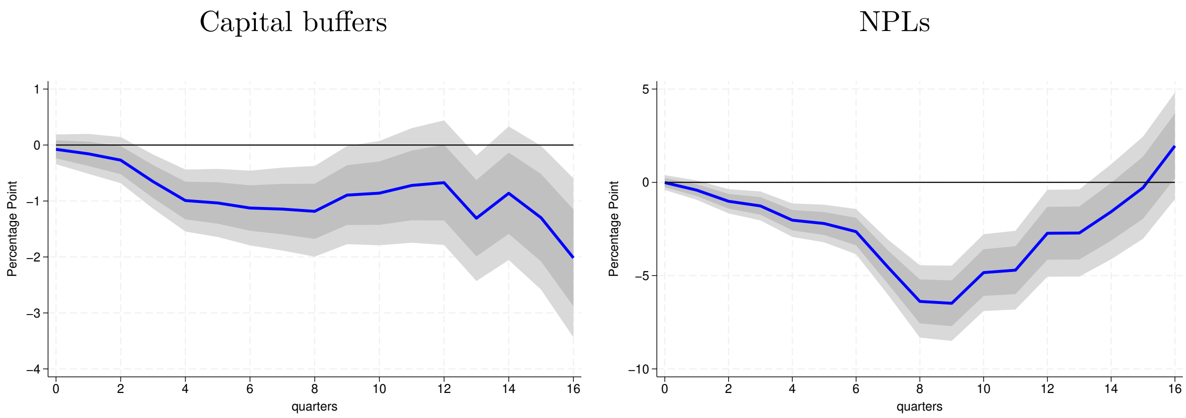
Notes: Cumulative impulse responses to a monetary policy shock that increases the country-specific one-year sovereign bond yields by 100 bps. The blue line in each figure shows the estimated average effect on each quintile relative to the top quintile, with the associated 68 (90) percent confidence bands.

Figure C.10: Differential effect of monetary policy shocks conditional on sales growth quintiles



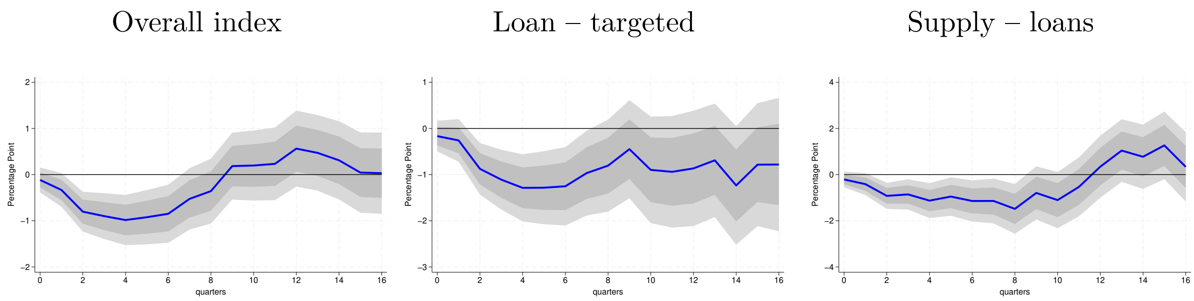
Notes: Cumulative impulse responses to a monetary policy shock that increases the country-specific one-year sovereign bond yields by 100 bps. The blue line in each figure shows the estimated average effect on each quintile relative to the top quintile, with the associated 68 (90) percent confidence bands.

Figure C.11: Effect of monetary policy shocks on investment growth of zombies versus nonzombies: marginal effects of an improvement in selected bank indicators



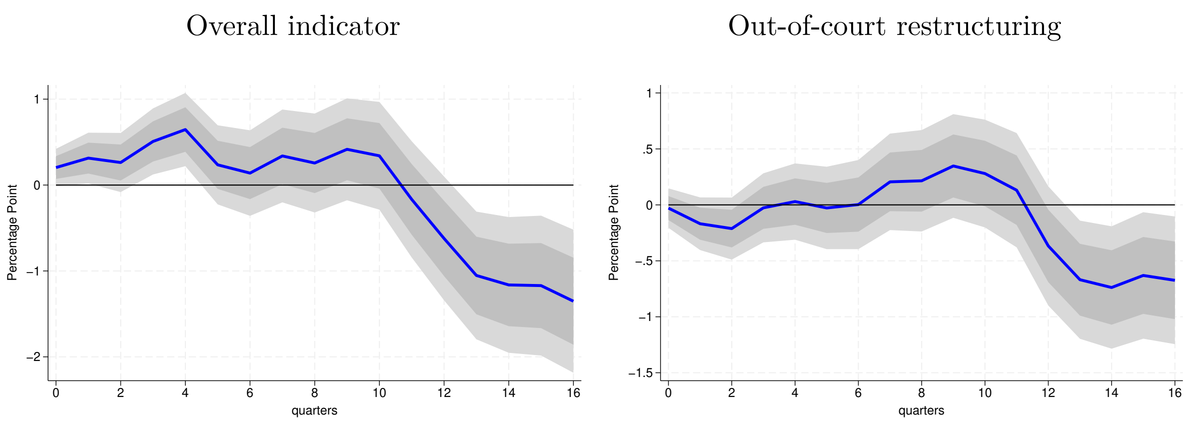
Notes: Cumulative marginal effects of a monetary policy shock that increases the country-specific one-year sovereign bond yields by 100 bps on the responses of investment growth for zombie firms relative to nonzombies when bank capital buffers (NPLs) increase (decrease) by one-standard deviation. The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

Figure C.12: 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.13: 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.

Appendix D: Extensions and robustness checks

We check the sensitivity of our baseline results from Equation 3.

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 D.1).

Second, we examine whether the zombie lending channel of monetary policy is amplified during episodes of severe exogenous macroeconomic shocks—periods in which banks face heightened financial constraints. Our hypothesis is that banks' incentives to extend credit to zombie firms may be particularly pronounced when monetary policy tightens during bad times, as the likelihood of default among these firms increases significantly. In such environments, contractionary monetary policy could exacerbate the congestion effects associated with zombie lending.

To identify episodes of major negative macroeconomic shocks, we rely on the banking crises dataset from Laeven and Valencia (2020). Banking crises are periods of acute banking sector stress typically associated with large-scale policy interventions aimed at containing losses and restoring financial stability. We match 32 countries in our sample to banking crisis episodes over the 2000–2017 period. This dataset allows us to go beyond the GFC period by incorporating country-specific banking crises outside that episode.

We estimate our baseline specification by allowing for heterogeneous effects of monetary policy shocks on the investment performance of zombie versus nonzombie firms. The results suggest that zombie firms are less responsive to contractionary monetary policy during banking crises than in normal times (Figure D.2). While the standard errors are relatively large, warranting some caution in the interpretation, the evidence is consistent with stronger evergreening incentives during periods of large macroeconomic shocks (Albuquerque and Iyer 2024).

Third, 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 D.3 shows that our results remain qualitatively similar, with a quantitatively stronger effect for the weighted regression.

Fourth, 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). In addition, the quantitative impact of domestic monetary policy shocks on the differential effect on investment of zombie firms relative to nonzombies is magnified when compared to the baseline approach. Overall, we find 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 D.4).

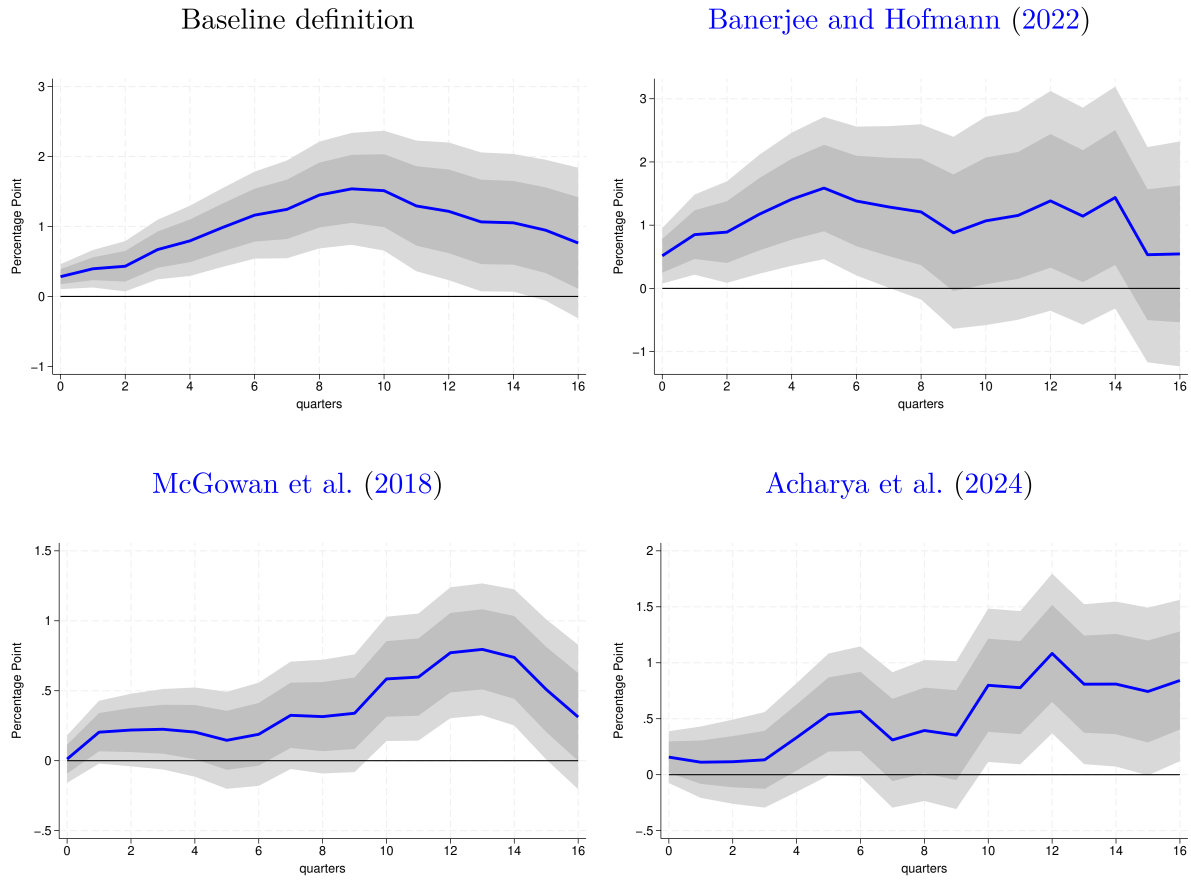
Fifth, we drop from our sample countries with low F-tests in the first-stage regression (Equation 1 in the main paper). Specifically, we only keep countries with an F-test of at least five.[1] Figure D.5 shows that our baseline results remain practically the same, but with slightly higher confidence bands, especially for debt growth.[2]

Finally, 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, Miranda-Agrippino and Ricco 2021, Jarociński 2022, Degasperi et al. 2023). 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 D.6 and D.7 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.

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

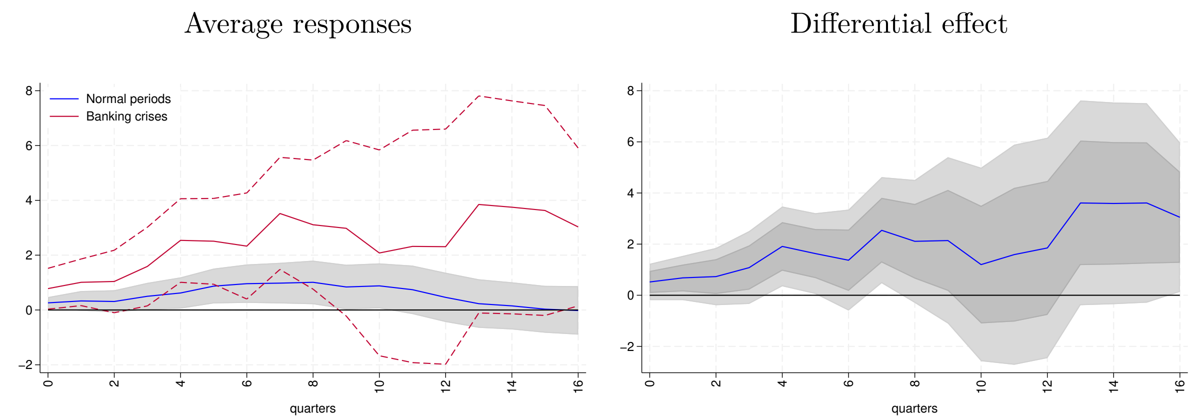
[2] We have also checked that our main results are quantitatively amplified if we were to select only countries in which local interest rates increase following contractionary US monetary policy ($\delta_c>0$ in the first-stage regression in Equation 1 in the main paper). Moreover, the point estimates remain similar to our baseline if we were to select only countries that experience a fall in local interest rates after the US monetary policy shock ($\delta_c<0$), although the responses are subject to higher estimation uncertainty.

Figure D.1: Differential effect of monetary policy shocks on investment growth: alternative zombie definitions



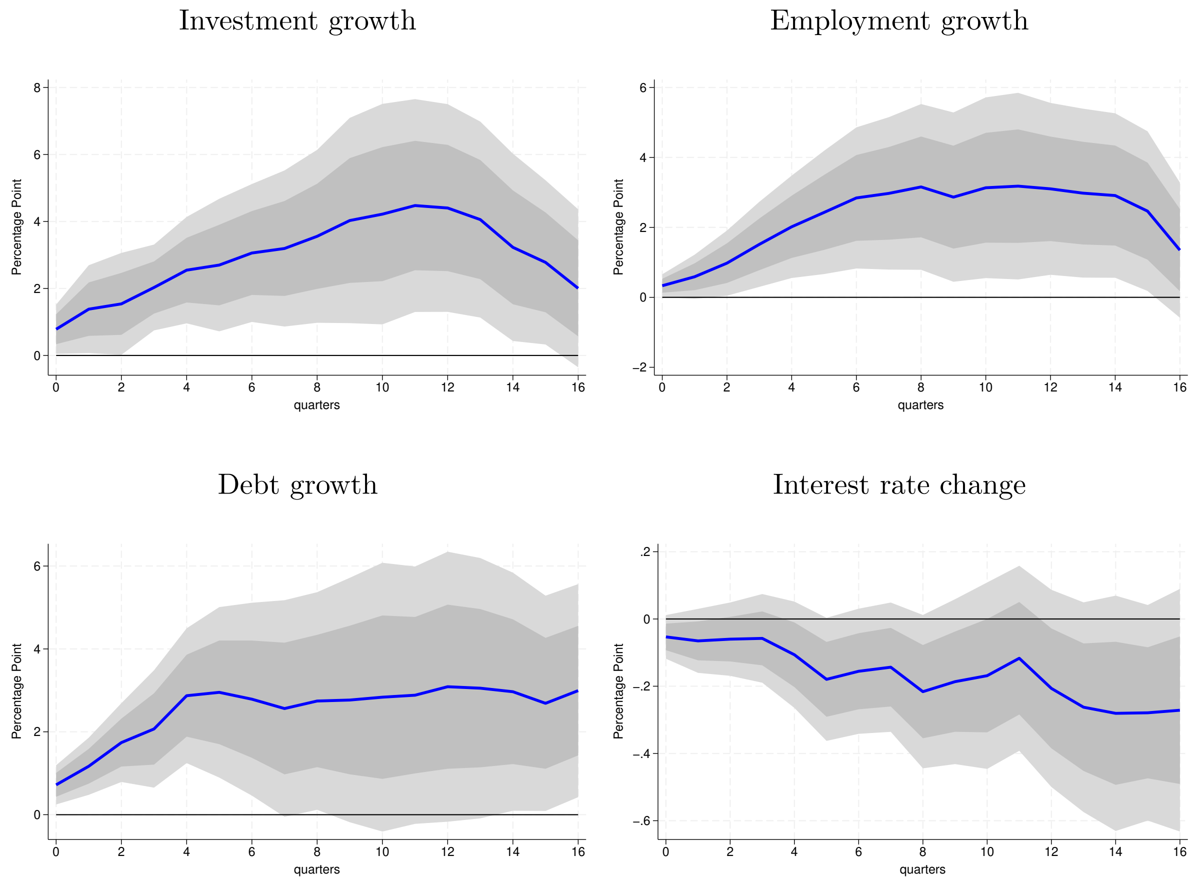
Notes: Cumulative impulse responses for zombie firms relative to nonzombies to a monetary policy shock that increases the country-specific one-year sovereign bond yields by 100 bps. The blue line is the average point estimate, and the dark (light) grey area refers to the 68 (90) percent confidence bands.

Figure D.2: Differential effect of monetary policy shocks on zombies versus nonzombies: banking crises



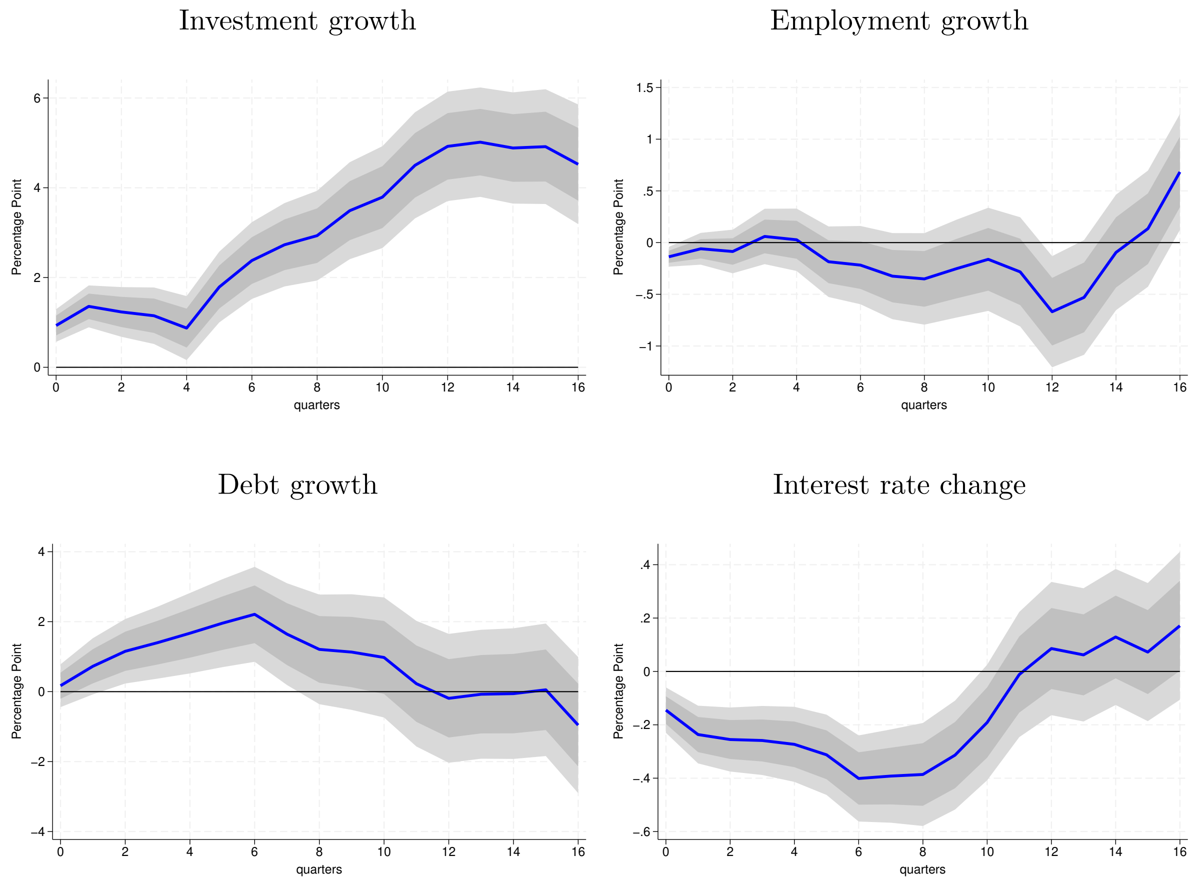
Notes: Cumulative impulse responses for zombie firms relative to nonzombies to a monetary policy shock that increases the country-specific one year sovereign bond yields by 100 bps. The blue and red lines on the left panels refer to the average point estimate for each selected period, with the associated 90 percent confidence bands. The right panels show the statistical difference between the two groups, with the dark (light) grey area referring to the 68 (90) percent confidence bands.

Figure D.3: Differential effect of monetary policy shocks: weighted-least squares



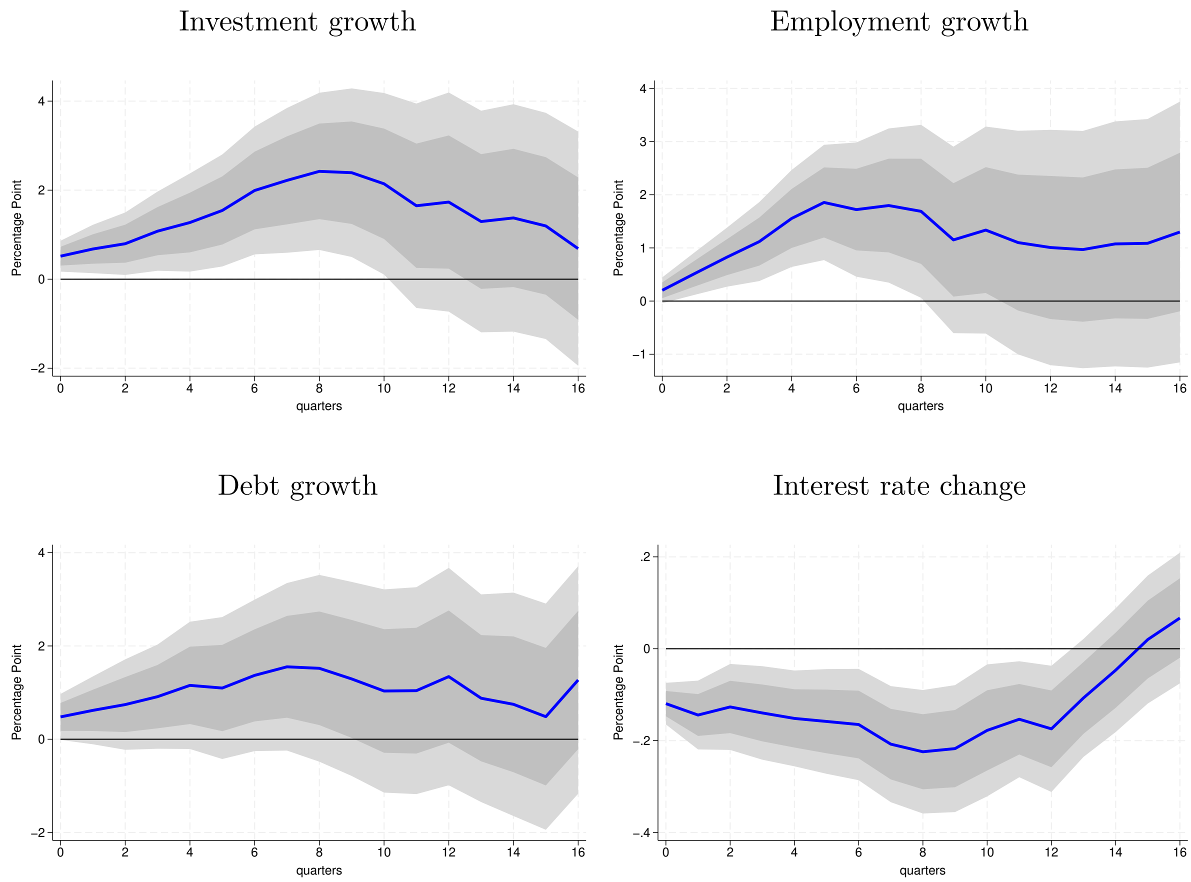
Notes: Cumulative impulse responses for zombie firms relative to nonzombies to a monetary policy shock that increases the country-specific one-year sovereign bond yields by 100 bps. The blue line is the average point estimate, and the dark (light) grey area refers to the 68 (90) percent confidence bands.

Figure D.4: Differential effect of monetary policy shocks: Choi et al. (2024) MP shocks



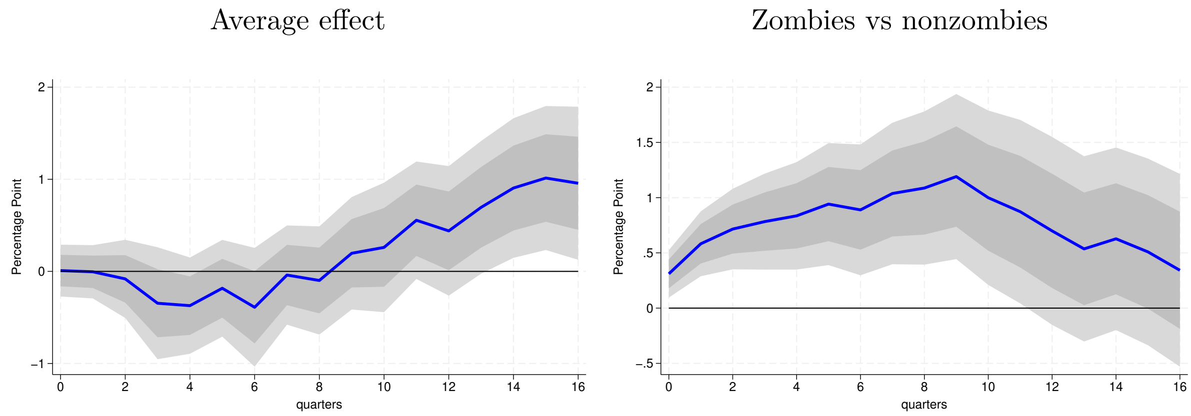
Notes: Cumulative impulse responses for zombie firms relative to nonzombies to a monetary policy shock that increases the country-specific one-year sovereign bond yields by 100 bps. The blue line is the average point estimate, and the dark (light) grey area refers to the 68 (90) percent confidence bands.

Figure D.5: Differential effect of monetary policy shocks: restricted country sample



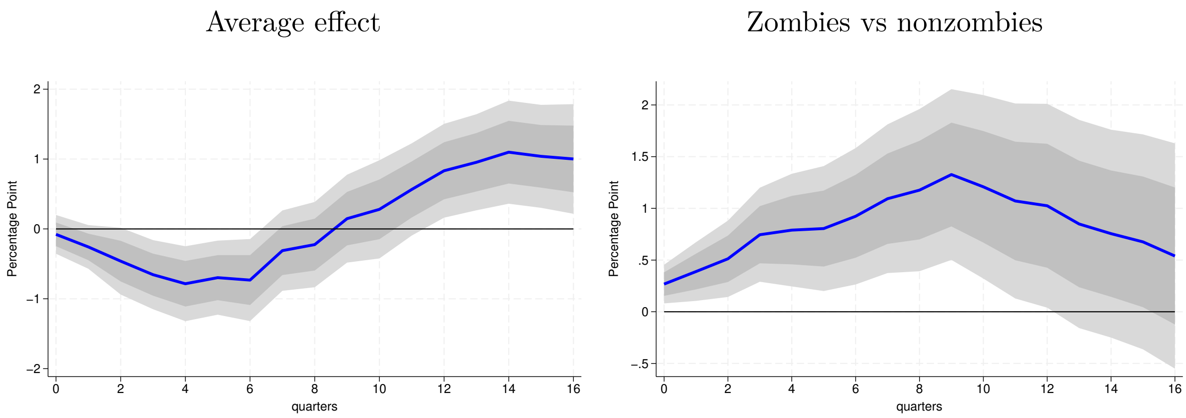
Notes: Cumulative impulse responses for zombie firms relative to nonzombies to a monetary policy shock that increases the country-specific one-year sovereign bond yields by 100 bps. The blue line is the average point estimate, and the dark (light) grey area refers to the 68 (90) percent confidence bands.

Figure D.6: Monetary policy shocks on zombies vs nonzombies: Jarociński and Karadi (2020) shocks



Notes: Cumulative impulse responses of investment growth 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 D.7: Monetary policy shocks on zombies vs nonzombies: Bauer and Swanson (2023) shocks



Notes: Cumulative impulse responses of investment growth 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.

References

Acharya, V. V., Crosignani, M., Eisert, T. and Eufinger, C. (2024), 'Zombie Credit and (Dis-)Inflation: Evidence from Europe', *The Journal of Finance* **79**(3), 1883–1929.

Acharya, V. V., Eisert, T., Eufinger, C. and Hirsch, C. (2019), 'Whatever It Takes: The Real Effects of Unconventional Monetary Policy', *Review of Financial Studies* **32**(9), 3366–3411.

Albuquerque, B. and Iyer, R. (2024), 'The Rise of the Walking Dead: Zombie Firms Around the World', *Journal of International Economics* **152**, 104019.

Araujo, J. D., Garrido, J., Kopp, E., Varghese, R. and Yao, W. (2022), Policy Options for Supporting and Restructuring Firms Hit by the COVID-19 Crisis, Departmental Paper 22/002, International Monetary Fund.

Banerjee, R. and Hofmann, B. (2022), 'Corporate zombies: anatomy and life cycle', *Economic Policy* **37**(112), 757–803.

Bauer, M. D. and Swanson, E. T. (2023), A Reassessment of Monetary Policy Surprises and High-Frequency Identification, *in* 'NBER Macroeconomics Annual, volume 37', NBER Chapters, National Bureau of Economic Research, Inc.

Caballero, R. J., Hoshi, T. and Kashyap, A. K. (2008), 'Zombie Lending and Depressed Restructuring in Japan', *American Economic Review* **98**(5), 1943–77.

Choi, S., Willems, T. and Yoo, S. Y. (2024), 'Revisiting the monetary transmission mechanism through an industry-level differential approach', *Journal of Monetary Economics* **145**, 103556.

Degasperi, R., Hong, S. S. and Ricco, G. (2023), The Global Transmission of U.S. Monetary Policy, Working Papers 2023-02, Center for Research in Economics and Statistics.

Jarociński, M. (2022), 'Central bank information effects and transatlantic spillovers', *Journal of International Economics* **139**, 103683.

Jarociński, M. and Karadi, P. (2020), 'Deconstructing Monetary Policy Surprises – The Role of Information Shocks', *American Economic Journal: Macroeconomics* **12**(2), 1–43.

Laeven, L. and Valencia, F. (2020), 'Systemic Banking Crises Database II', *IMF Economic Review* **68**(2), 307–361.

McGowan, M. A., Andrews, D. and Millot, V. (2018), 'The walking dead? Zombie firms and productivity performance in OECD countries', *Economic Policy* **33**(96), 685–736.

Miranda-Agrippino, S. and Rey, H. (2020), 'The Global Financial Cycle after Lehman', *AEA Papers and Proceedings* **110**, 523–28.

Miranda-Agrippino, S. and Ricco, G. (2021), 'The Transmission of Monetary Policy Shocks', *American Economic Journal: Macroeconomics* **13**(3), 74–107.