BANK OF ENGLAND

Appendix to Staff Working Paper No. 935
Corporate debt booms, financial constraints and the investment nexus

Bruno Albuquerque

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ONLINE APPENDIX

Corporate debt booms, financial constraints, and the investment nexus

Bruno Albuquerque*

This appendix is structured as follows. In Section A I replicate some of the regressions from the main paper at the industry level. Section B takes the GFC period as a laboratory experiment to study the cross-sectional behaviour of investment during a period of large credit supply shocks. Section C studies the response of liquid assets in the aftermath of a debt boom. Section D includes several additional figures from robustness checks performed in the main paper.

A: Industry analysis

I expand the analysis in the main text by looking at the four-digit SIC code sectors. Manufacturing, transportation (which includes communications, electric, gas and sanitary service), and services account for over 80% of the sample (Table A.1). The distribution of vulnerable firms varies widely across industries. Transportation and mining, for instance, are two sectors where vulnerabilities appear to be more concerning: vulnerable firms account for 46% and 25% of all firms in these sectors. In contrast, manufacturing firms tend to be more financially resilient.

Table A.1: Industries by four-digit SIC codes

Industry	**N**	**%**	**% vulnerable**
Agriculture*	839	0.4	10.0
Mining	12,734	5.8	25.0
Construction	1,790	0.8	3.0
Manufacturing	109,177	50.1	4.7
Transportation**	35,475	16.3	46.1
Wholesale Trade	8,518	3.9	5.1
Retail trade	14,839	6.8	11.8
Services	33,269	15.3	10.0
Other	1,472	0.7	10.1

Notes: *'Agriculture, Forestry and Fishing'; **'Transportation, Communications, Electric, Gas and Sanitary service'.

Leverage and liquid assets vary substantially across sectors (Figure A.1). Although leverage in 2019Q1 was at historically high levels (compared to median long-term averages) across all

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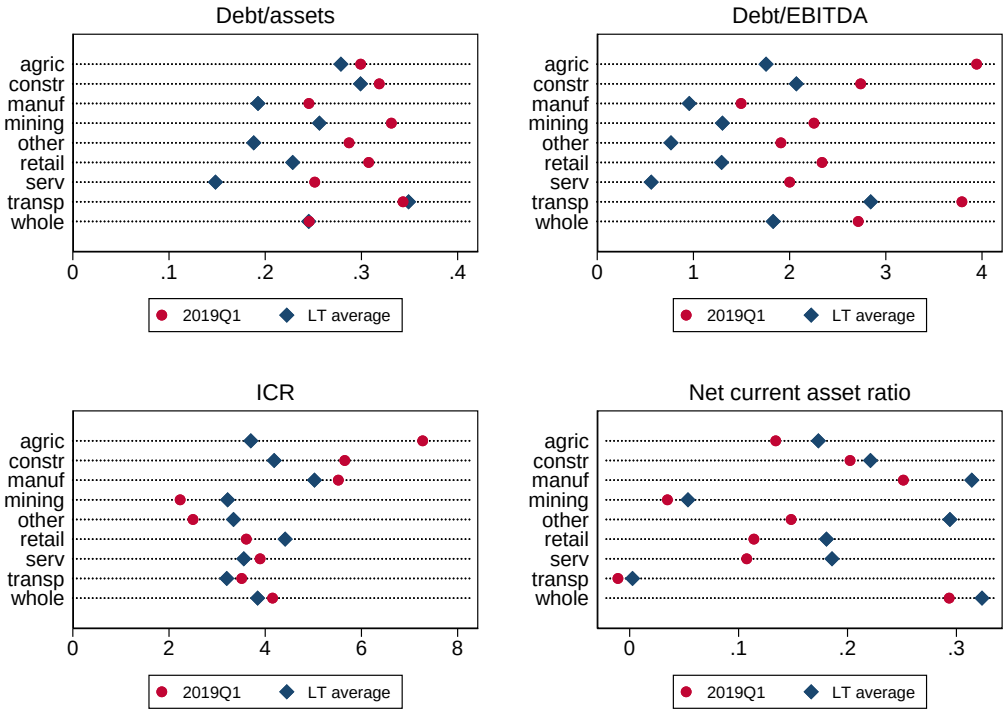
economic sectors, firms in the transportation, communications, electric, and gas sector ('transp') stand out; this sector also exhibits low ICRs and low liquidity, implying that debt booms have not been accompanied by similar improvements on the asset side of the firms' balance sheets.

Figure A.1: Leverage and liquidity indicators by industry



Sources: Compustat, and author's calculations.
Notes: The blue diamonds refer to the median long-term averages of each indicator for each industry, while the red circles indicate the median value for 2019Q1.

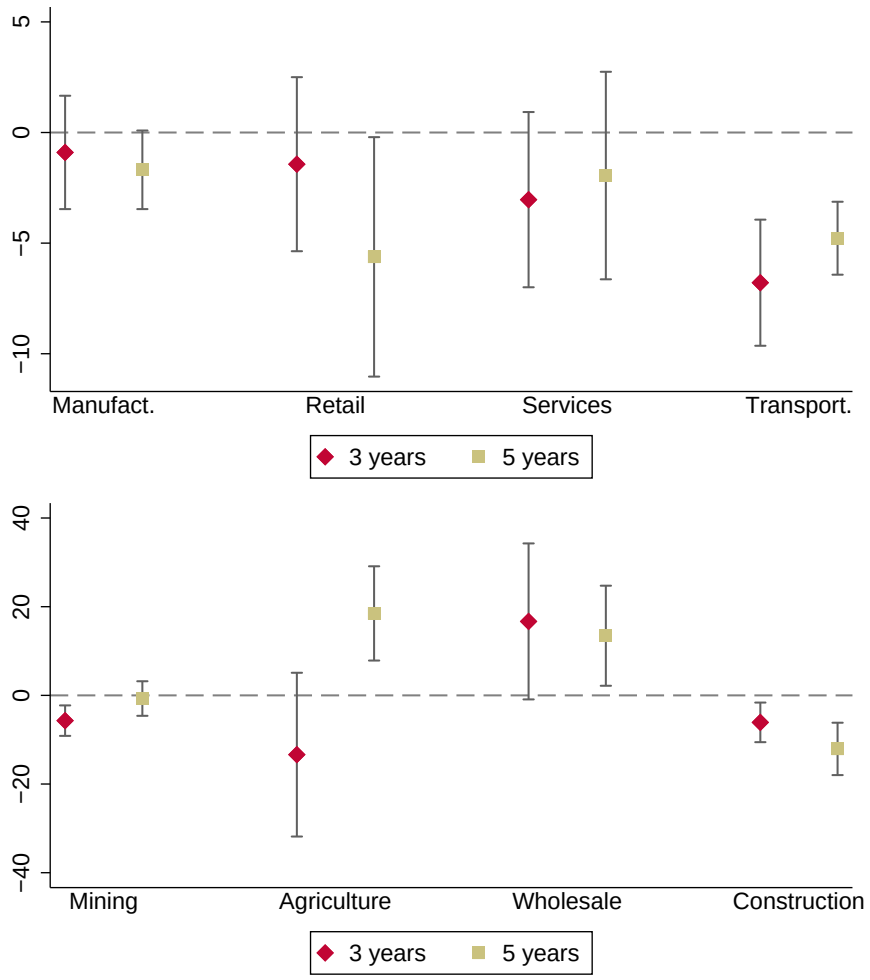
In the main text, I have shown that my results are robust to controlling for time-varying industry-specific shocks. In this section I run two additional exercises to explore further the association between debt booms and investment growth at the sectoral level. First, I run regressions for each one of the nine industries. These new regressions allow all the coefficients to vary across industries. The analysis will in effect explore the within-industry variation in the elasticity of investment spending to debt booms. I show point estimates for vulnerable firms of the elasticity of investment spending growth to a 10 p.p. change in the pace of credit accumulation for three- and five-years ahead (Figure A.2). I find the largest responses in transportation, construction, and retail trade; these are sectors that typically display weaker balance sheets, as shown in Figure A.1. When I compare vulnerable with non-vulnerable firms, I find that vulnerable firms in retail trade and construction experience statistically significant larger declines in investment five years after a debt boom (Figure A.3).

The transportation sector is quite large and heterogeneous: it includes firms in the transportation industry, communications, and energy (gas and electricity). I find a statistically significant link between debt build-ups and investment for both vulnerable and non-vulnerable firms only in the communications sector (Figure A.5).[1] Firms in this sector have similar balance-sheet positions, such as large levels of debt relative to assets, moderate to low liquid assets, and

[1] I show the responses for the overall transportation sector in Figure A.4.

small ICRs. This suggests that credit and liquidity constraints may be at play for both groups of firms, despite some firms not falling under my definition of financial constraints. I also find that the response of vulnerable firms is statistically larger compared to non-vulnerable firms only in the energy sector (Figure A.6). This is a sector in which two-thirds of the firms fall into the definition of financial vulnerability explored in this paper, while the remaining firms display relatively robust balance sheets. Finally, I do not find any association between debt booms and investment growth for the sub-category of transportation firms (Figure A.7).

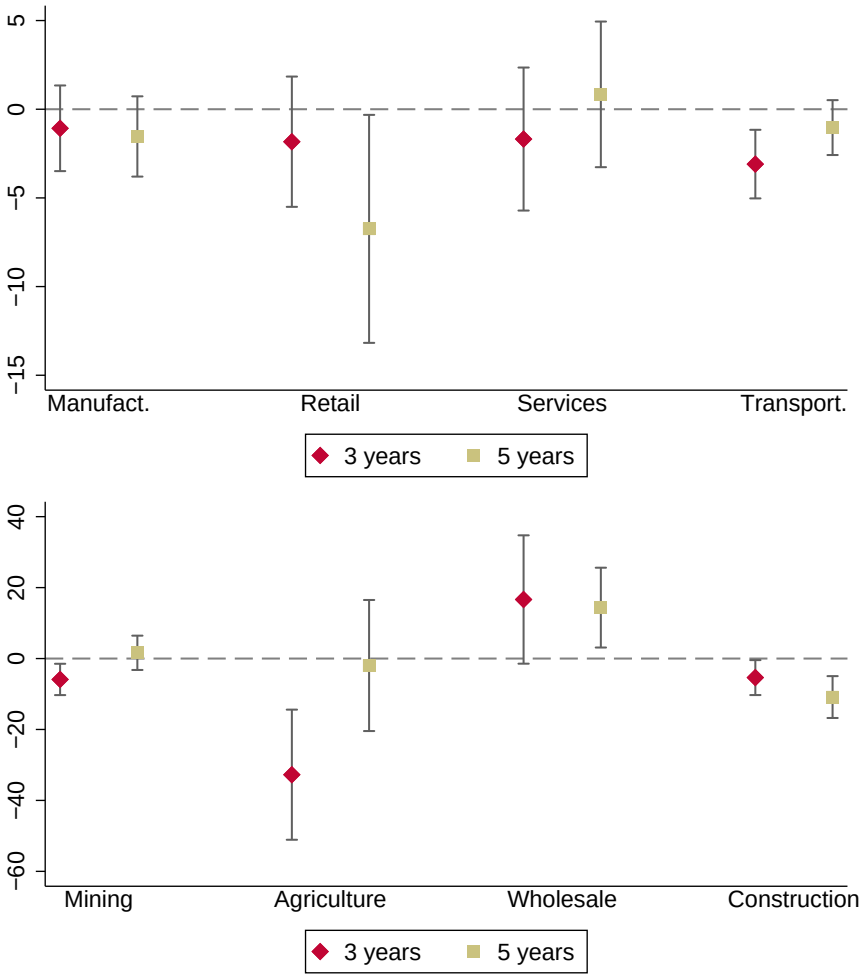
Figure A.2: Impulse responses of vulnerable firms by industry



Notes: The red (khaki) diamonds (circle) show the average response after 12 (20) quarters. The vertical lines show the 90% confidence interval of the estimated coefficients.

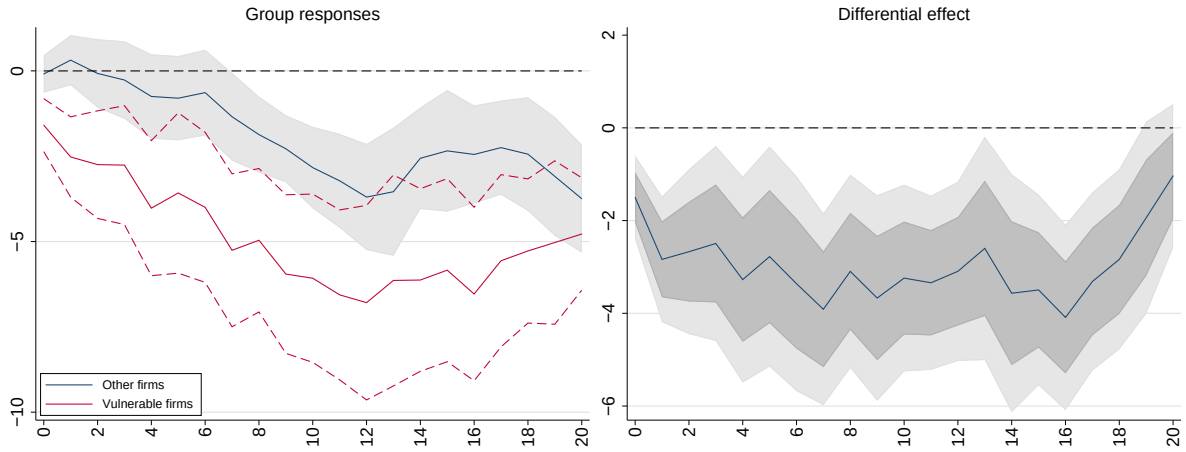
In a second exercise, I focus on manufacturing firms to provide more evidence on the negative association between financial constraints and future investment growth. The literature on monetary policy has found that durable goods-producing firms, such as manufacturing and construction, are more interest-rate sensitive and thus respond more to monetary policy (Barth and Ramey 2002, Dedola and Lippi 2005, Durante et al. 2020). Along these lines, and since debt booms are associated with an increase in borrowing costs, it could well be the case that my results are driven by the durability of output and not by financial constraints. If this is the case, I would expect durable goods-producing firms to be associated with weaker investment spending, irrespective of being credit constrained.

Figure A.3: Differences between the responses of vulnerable firms and other firms



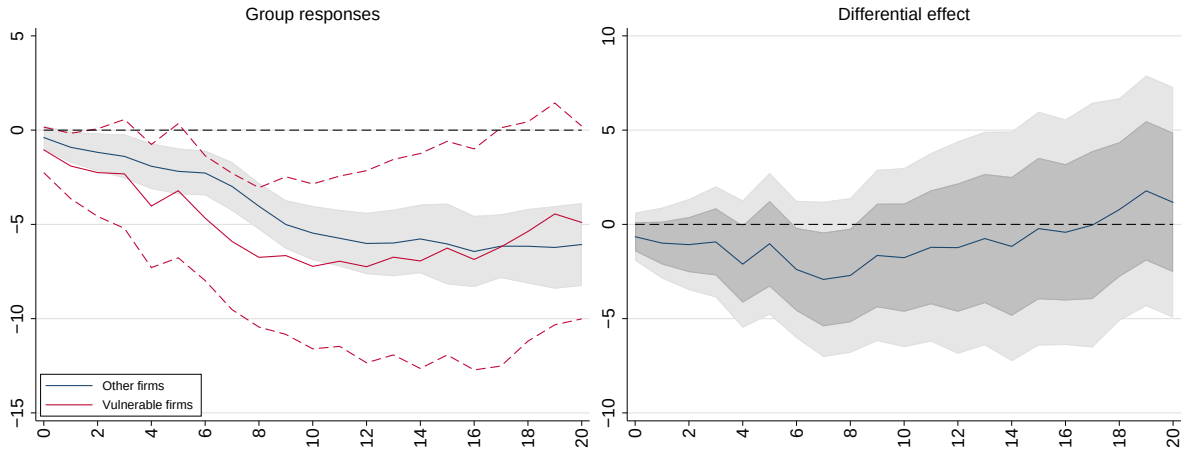
Notes: The red (khaki) diamonds (circle) show the difference in the average response between vulnerable and other firms after 12 (20) quarters. The vertical lines show the 90% confidence interval of the difference in the estimated coefficients.

Figure A.4: Impulse responses of transportation firms



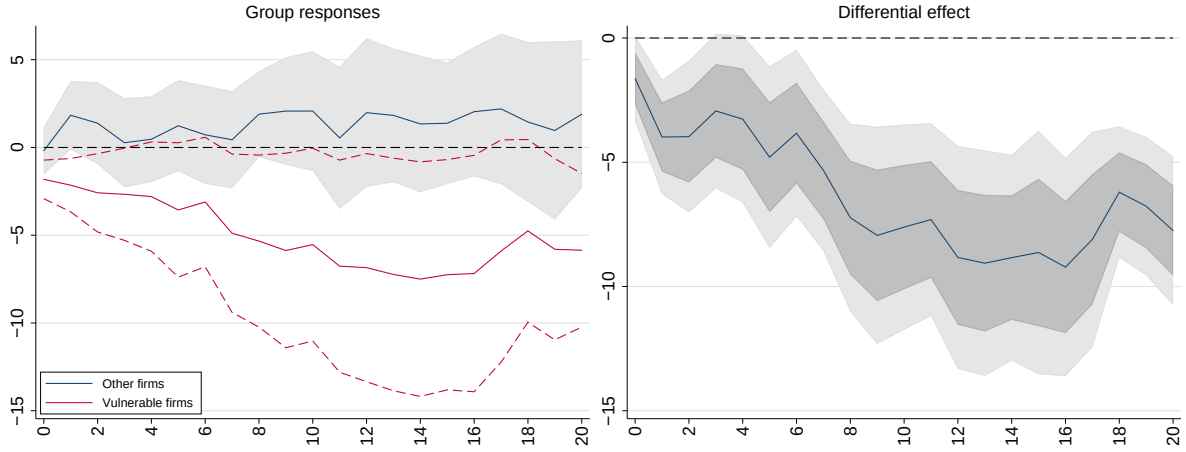
Notes: Cumulative impulse responses of capex to a 10 p.p. increase in corporate debt build-ups up to 20 quarters ahead. The red lines (blue line and grey area) refer to the response of vulnerable (other) firms and associated 90% confidence bands. The right panel depicts the difference, with the 68% and 90% confidence bands, between vulnerable and other firms.

Figure A.5: Impulse responses of communications firms



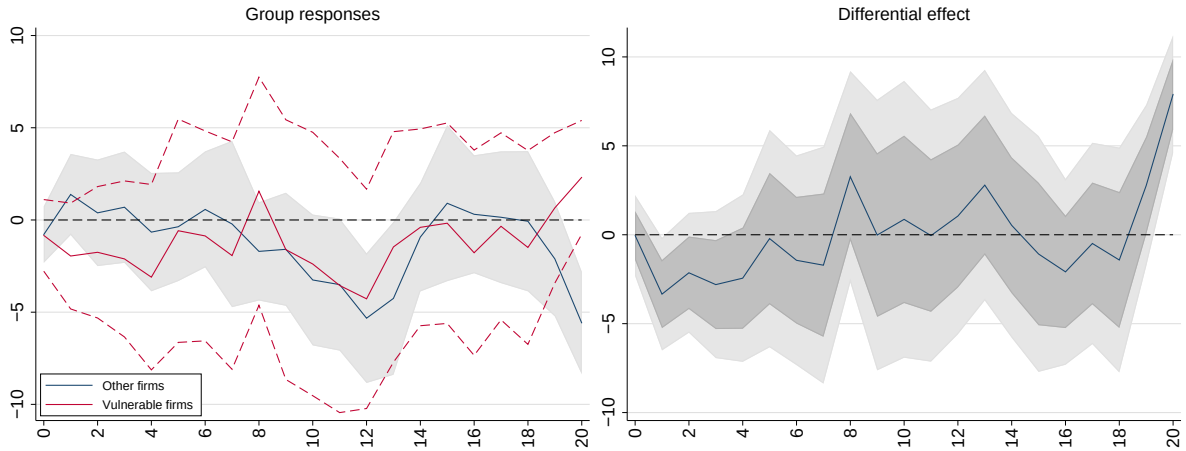
Notes: Cumulative impulse responses of capex to a 10 p.p. increase in corporate debt build-ups up to 20 quarters ahead. The red lines (blue line and grey area) refer to the response of vulnerable (other) firms and associated 90% confidence bands. The right panel depicts the difference, with the 68% and 90% confidence bands, between vulnerable and other firms.

Figure A.6: Impulse responses of energy firms



Notes: Cumulative impulse responses of capex to a 10 p.p. increase in corporate debt build-ups up to 20 quarters ahead. The red lines (blue line and grey area) refer to the response of vulnerable (other) firms and associated 90% confidence bands. The right panel depicts the difference, with the 68% and 90% confidence bands, between vulnerable and other firms.

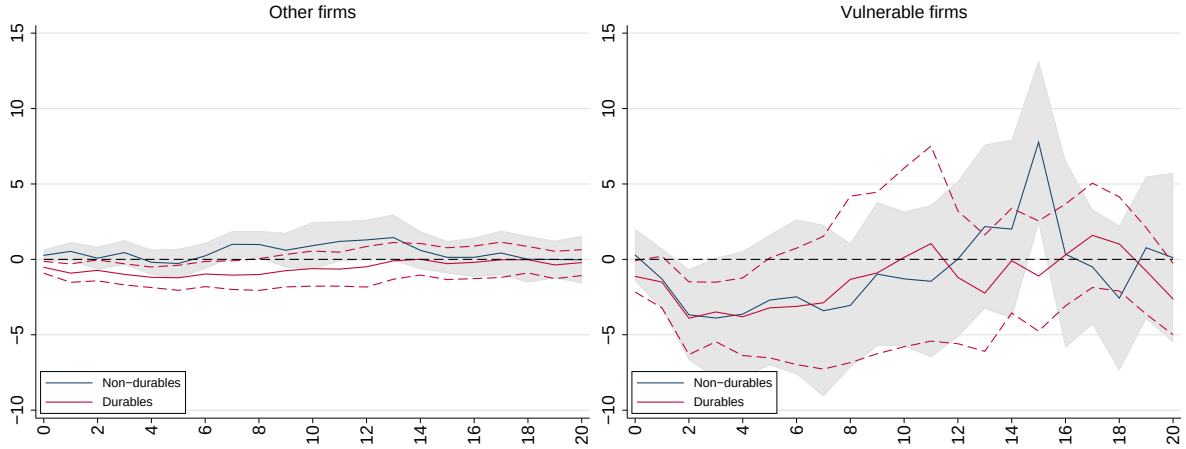
Figure A.7: Impulse responses of transportation sub-category firms



Notes: Cumulative impulse responses of capex to a 10 p.p. increase in corporate debt build-ups up to 20 quarters ahead. The red lines (blue line and grey area) refer to the response of vulnerable (other) firms and associated 90% confidence bands. The right panel depicts the difference, with the 68% and 90% confidence bands, between vulnerable and other firms.

I put this theory to a test. I split manufacturing firms, representing 50% of my sample, into durable and non-durable producing industries.[2] Figure A.8 shows that there is not a discernible difference in the reaction of investment to debt booms between manufacturing firms that produce durable goods and non-durable goods.[3] Credit and liquidity constraints, not the durability of output, seem to dominate in explaining why firms cut investment spending when facing a debt boom.

Figure A.8: Impulse responses of manufacturing firms: durable vs non-durables



Notes: Cumulative impulse responses of capex to a 10 p.p. increase in corporate debt build-ups up to 20 quarters ahead. The red lines (blue line and grey area) refer to the response of durable (non-durable) goods industries and associated 90% confidence bands.

B: The large credit supply shock around the GFC

I now explore the cross-sectional variation in the firms' responses to the large credit supply contraction of the 2007-09 recession. I focus on this period for two main reasons. First, the GFC provides a laboratory experiment for the differential behaviour of firms following a large credit supply shock. The 2007-09 recession deserves special attention as it was by far the largest financial shock since the Great Depression. Second, the GFC may provide us with some insights into what to expect when firms accumulate too much debt during periods of large credit supply shocks. Although, the COVID-19 shock is arguably very different in nature from the GFC, both periods are characterised by large build-ups in debt amid large credit supply shocks.[4]

The macro implications of a firm-specific debt boom preceding a financial crisis may be very

[2]I follow Durante et al. (2020) and select durable good-producing firms as those belonging to the following SIC broad categories: 'Lumber and Wood Products', 'Furniture and Fixtures', 'Stone, Clay, Glass and Concrete Products', 'Primary Metal Industries', 'Fabricated Metal Products', 'Industrial Machinery and Equipment', 'Electronic and Other Electric Equipment', 'Transportation Equipment', 'Instruments and Related Products', 'Miscellaneous Manufacturing Industries'.

[3]The results remain robust to adding other non-manufacturing sectors, such as construction, to the set of durable-producing firms.

[4]The GFC was preceded by a large build-up of imbalances in the housing market, and by an unprecedented accumulation of debt by the private sector. The inability of households to pay their mortgages led to massive losses to the financial sector. In turn, the reduction in credit supply that ensued reduced aggregate demand further. Households' and banks' balance sheets, amid a context of poorly capitalised banks, amplified the price re-valuation in the real estate sector (Brunnermeier and Krishnamurthy 2020). In turn, the 2020 crisis is rooted in a health shock that subsequently led to supply and demand shocks, as social distancing measures and several lockdowns were put in place in many parts of the world.

different depending on how firms use the accumulated debt. For instance, if a firm decides to allocate debt to productive investment, both capital expenditures or intangible investment, this could act as a countercyclical force during a recession; but if the firm decides to pay off debt or increase liquid asset holdings – even if it can increase the financial resilience of the firm – I would expect the fall in aggregate demand to amplify the recession. I run cross-sectional regressions to shed light on firms' balance sheet behaviour during the GFC for a given amount of debt accumulated pre-crisis. More specifically, I run the following regression:

$$\Delta Y_i^{07-10} = \alpha + \beta_1 \Delta Y_i^{04-07} + \beta_2 \Delta Debt_i^{04-07} + \beta_3 Z_i^{07} + \zeta_j + \epsilon_i, \tag{1}$$

where Y_i^{07-10} is the cumulative change between 2007q4 and 2010q4 for firm i in the following variables: (i) capital stock (tangible investment), (ii) intangible capital, (iii) liquid assets, (iv) acquisitions, and (v) total debt. I divide all variables by total assets, and then standardise them to make it easier to interpret the coefficients. The coefficient of interest is β_2, which measures the association between the rise in leverage in the three years preceding the crisis. Since all variables are standardised, I will interpret β_2 as the standard deviation change in the dependent variable between 2007q4 and 2010q4 from a one-standard deviation increase in the change in the debt-to-asset ratio between 2004q4 and 2007q4. I add a set of variables Z_i to control for the balance sheet position of firms at the end of 2007, namely the stock of liquid assets, leverage, and the log of total assets (similar to the main baseline model used throughout this paper). I also include the pre-crisis change in the dependent variable (Y_i^{04-07}) to control for possible reversion to the mean effects. Finally, ζ_j refers to industry-specific dummies.

In Table B.1 I show the coefficients when using the 2007-10 change in the capital stock divided by total assets as the dependent variable. One of the main findings that emerges is that firms that increased their pre-crisis leverage ratio by one standard deviation above the sample mean experienced a sharper reduction in the capital stock ratio during the GFC: one standard deviation of capital stock to assets is roughly 25% over the full sample, implying that the coefficient of -0.07 translates into a 1.8 p.p. decline in the capital stock ratio.

Moreover, I do not find that the level of the leverage ratio in 2007q4 is associated with larger cuts in investment during the recession, which is at odds with recent literature (Buera and Karmakar 2019, Kalemli-Ozcan et al. 2019, Blickle and Santos 2020). My results suggest, however, that it is the debt accumulated pre-crisis, not the level of debt at one point in time, that explains why some firms cut investment by more than others. This argument aligns well with Dell'Ariccia et al. (2016)'s findings that a rapid rise in corporate debt during good times make firms vulnerable to a sudden change in economic conditions, triggering deleveraging and leading to weaker investment down the road.

But the coefficient on liquid assets held at the end of 2007 is highly statistically significant, suggesting that liquidity played a role in allowing cash-rich firms to invest more (or disinvest less) than cash-poor firms during the GFC. This result is in line with (Joseph et al. 2019), who find that UK firms that entered the GFC with larger cash holdings managed to invest more during the recession and recovery. I also find that larger firms cut investment less. In contrast, I do not find any statistical association between the pre-crisis share of bank debt or short-term debt in total debt and investment growth. Note, however, that the sample size is

somewhat smaller, complicating the comparability of the results. Finally, I also do not find that investment has a non-linear association between debt accumulated pre-crisis for different levels of the liquid asset position or leverage ratio in 2007 (rows with interaction terms in the table).

Table B.1: Regression estimates: ΔInvestment ratio$^{07-10}$

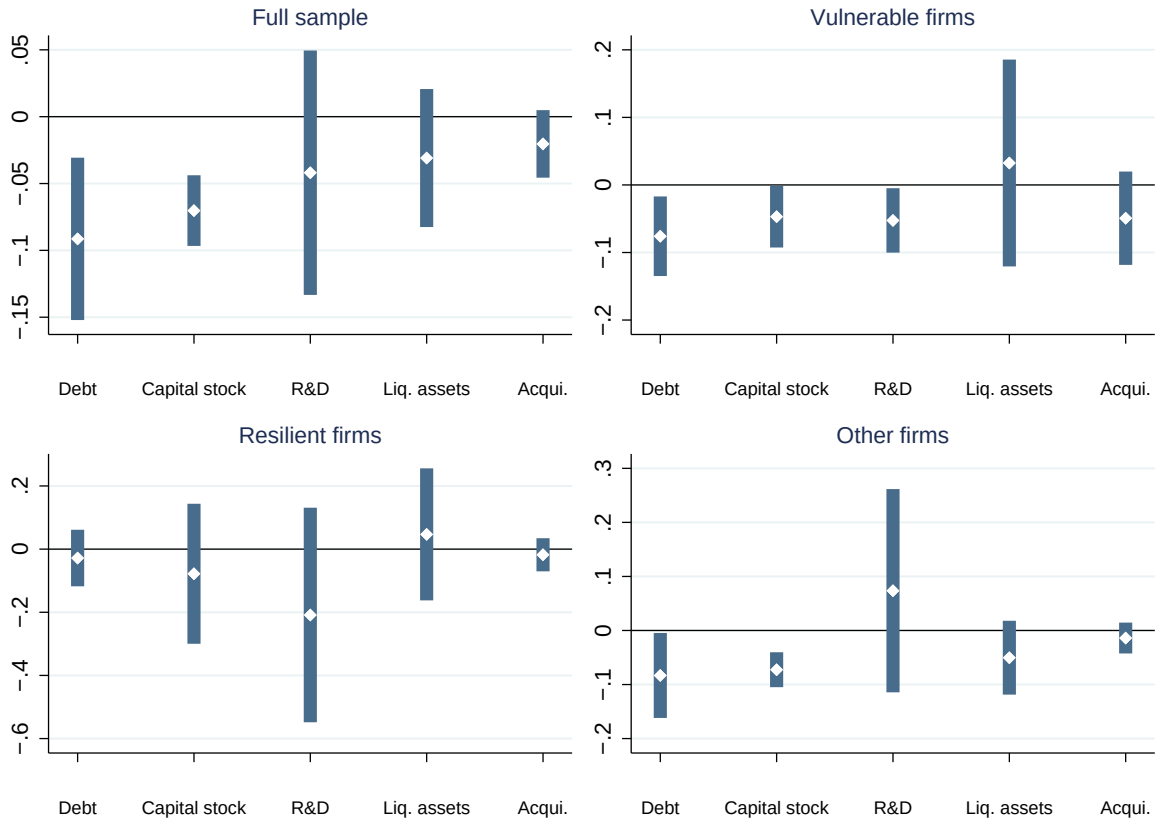
	(1)	(2)	(3)
ΔDebt$^{04-07}$	-0.070***	-0.072***	-0.090***
	(0.016)	(0.016)	(0.029)
Liq. asset ratio^{07}	0.193***	0.223***	0.195***
	(0.038)	(0.051)	(0.038)
Debt to assets^{07}	0.052	0.083*	0.062
	(0.043)	(0.050)	(0.050)
log(real assets)^{07}	0.107***	0.139***	0.106***
	(0.035)	(0.048)	(0.034)
Bank debt share^{07}		0.022	
		(0.034)	
Short-term debt share^{07}		0.015	
		(0.034)	
ΔDebt$^{04-07}$*Liq. asset ratio^{07}			-0.015
			(0.016)
ΔDebt$^{04-07}$*Debt to assets^{07}			-0.010
			(0.024)
ΔLagged dep. variable$^{07-10}$	-0.109***	-0.070*	-0.107***
	(0.038)	(0.041)	(0.038)
Observations	1,667	1,310	1,667
Adjusted R-squared	0.058	0.054	0.058

Notes: Regression estimates of Equation (1), where the dependent variable is the cumulative change in the capital stock ratio from 2007q4 to 2010q4. The constant and the industry dummies are omitted. Robust heteroskedastic standard errors in parentheses. Asterisks, *, **, and ***, denote statistical significance at the 10%, 5%, and 1% levels.

I now investigate how the pre-crisis change in the leverage ratio is associated with the other dependent variables, namely the total debt ratio, intangible investment ratio, liquid asset ratio, and acquisitions ratio. For ease of exposition, I show coefficients β_2 and associated 90% confidence intervals for each dependent variable in Figure B.1. In the upper left panel, I find that the rise in pre-crisis leverage is associated wiht subsequent deleveraging, in line with the view that firms had to restore their leverage ratios to more sustainable levels.

Although I also find that the pre-crisis increase in leverage is associated with declines in intangible investment, liquid assets and acquisitions, they lack statistical support at the 90% confidence level. The other panels in Figure B.1 highlight the differential responses across firms with different financial vulnerabilities. In particular, I find that the negative association between the pre-crisis boom and the decline in investment and in debt during the GFC is driven by vulnerable firms and other firms, not resilient firms. This is in line the full sample results in previous sections. My results also show that vulnerable firms also cut back on intangible investments, which makes total investment fall further relative to all the other firms in the dataset.

Figure B.1: Response of investment growth to a change in the leverage ratio (in pp)



Notes: Point estimates of a regression of the cumulative 2007-10 change in selected variables, shown in the x-axis, on the cumulative 2004-07 change in the leverage ratio. The blue bars refer to the 90% confidence bands. Coefficients have been standardised to make them comparable across columns.

C: The response of liquid assets

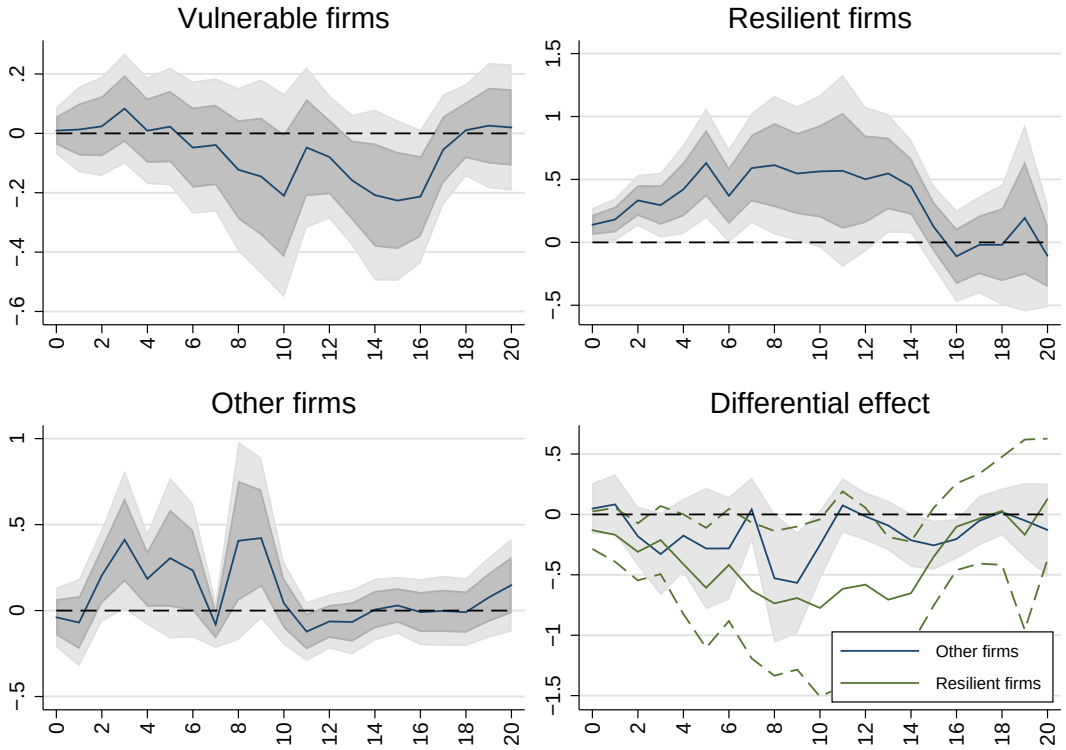
We have seen that firms that accumulate debt at a faster pace than their assets for a long period of time tend to experience weaker future investment growth. But if investment falls in the aftermath of a debt boom, it is still possible that firms may channel part of the debt raised to increasing liquid asset holdings. The general view in the literature is that financially constrained firms tend to build up cash reserves for precautionary reasons to cushion the impact of future credit supply shocks (Almeida et al. 2004, Bates et al. 2009, Campello et al. 2010, Bacchetta et al. 2019, Joseph et al. 2019, Melcangi 2019, Cunha and Pollet 2020). There is some recent evidence that constrained firms may then increase their liquid assets *during* episodes of credit supply shocks (Melcangi 2019), or at least keep them higher for longer (Cunha and Pollet 2020).[5]

I use the cumulative change in the liquid asset ratio as the dependent variable in Equation (2) in the main paper with the breakdown of firms into vulnerable, resilient, and other firms. I find that only vulnerable firms seem to decrease their liquid assets following a debt boom

[5] Cunha and Pollet (2020) document that financially constrained firms build their cash reserves using internal sources and that they start saving earlier and keep high cash levels longer. Unconstrained firms instead rely on external financing to both invest and build cash reserves, requiring them to save less and allowing them to incur lower costs of carry.

(Figure C.1). In turn, resilient firms tend to increase liquid assets following episodes of rapid accumulation of debt. The difference in the response of liquid assets between resilient firms and vulnerable firms is statistically significant for about three years. Results remain qualitatively robust if I instead use cash to assets as the measure of liquidity, as in Joseph et al. (2019) – Figure C.2.

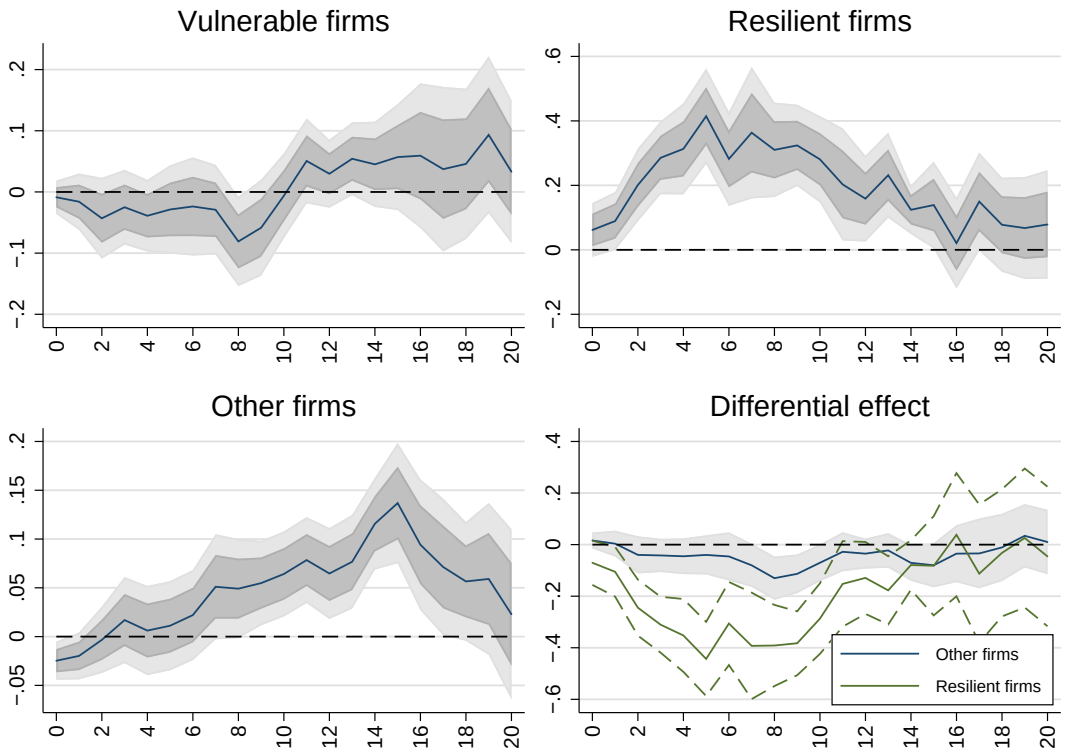
Figure C.1: Impulse responses of net current asset ratio



Notes: Cumulative impulse responses of the net current asset ratio to a 10 p.p. increase in corporate debt build-ups up to 20 quarters ahead. Each panel shows the average response and associated 68% and 90% confidence bands for vulnerable, resilient, and other firms. The bottom-right panel depicts the difference, with 90% confidence bands, between the responses of vulnerable and resilient firms (green lines), and between vulnerable and all other firms (blue line and grey area).

Overall, I find some supporting evidence for the view that constrained firms tend to burn through a large portion of their liquid assets during periods of negative credit supply shocks (Campello et al. 2010). The decline in liquid assets of vulnerable firms in the aftermath of debt booms may reflect the need to tap into liquidity to minimise the reduction in investment due to binding credit constraints. In contrast, I find that resilient firms tend to strengthen their liquid asset position following debt booms – presumably for precautionary reasons and to prevent them from becoming constrained (Melcangi 2019). Although this is not conclusive, I conjecture that the fall in investment for vulnerable firms could have been larger, had they increased their liquid assets along the dynamics observed in unconstrained firms.

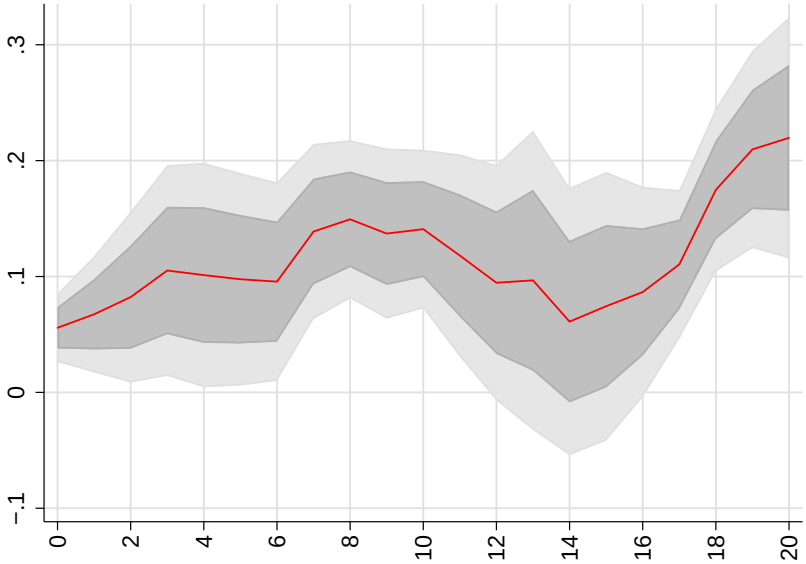
Figure C.2: Impulse responses of cash to assets



Notes: Cumulative impulse responses of the cash to asset ratio to a 10 p.p. increase in corporate debt build-ups up to 20 quarters ahead. Each panel shows the average response and associated 68% and 90% confidence bands for vulnerable, resilient, and other firms. The bottom-right panel depicts the difference, with 90% confidence bands, between the responses of vulnerable and resilient firms (green lines), and between vulnerable and all other firms (blue line and grey area).

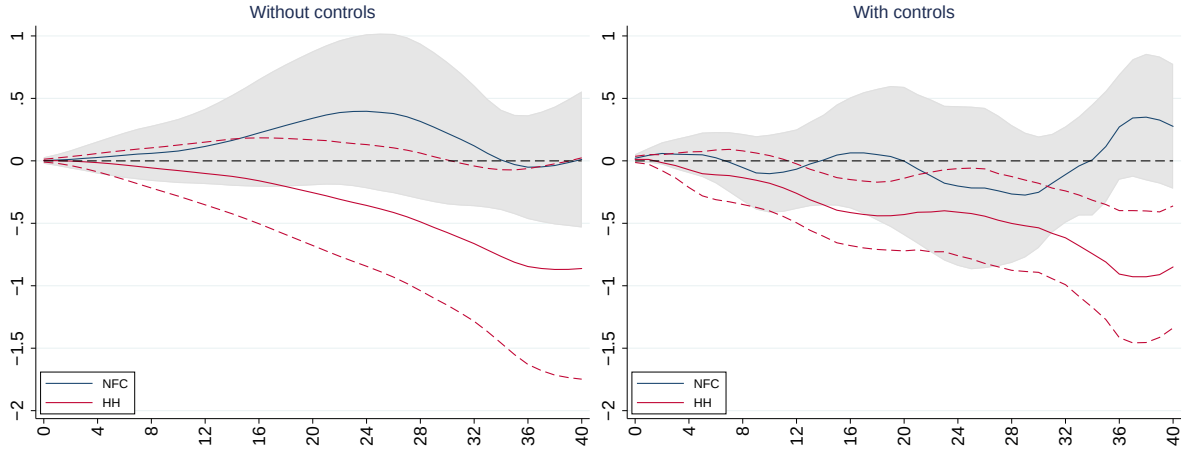
D: Additional figures

Figure D.1: Impulse responses of corporate bond yields to corporate debt build-ups



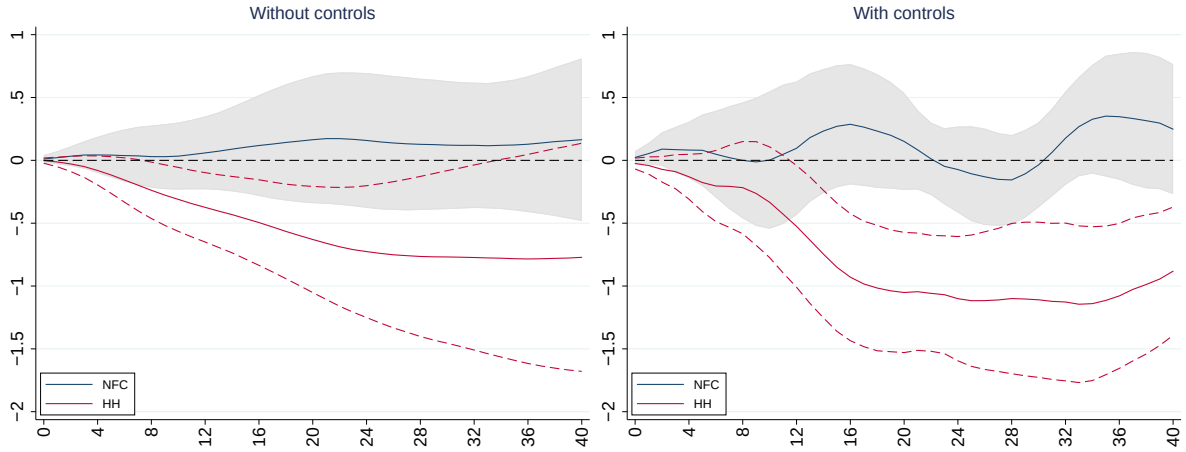
Notes: Cumulative impulse responses of corporate bond yields to a 10 p.p. increase in corporate debt build-ups up to 20 quarters ahead. The dark (light) grey area refers to the 68 (90)% confidence bands.

Figure D.2: Impulse responses of real GDP with aggregate FoF data



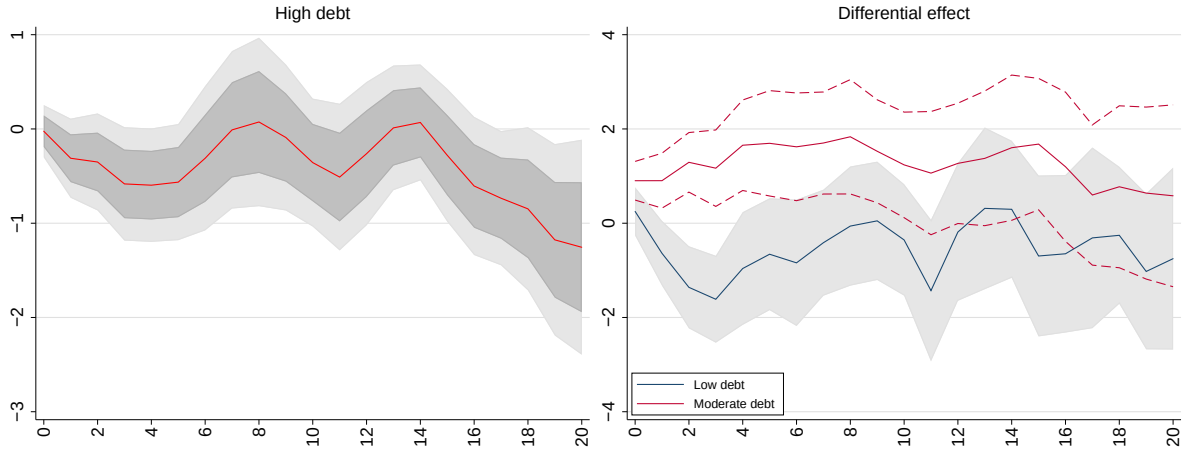
Notes: Cumulative impulse responses to a 1 p.p. increase in debt build-ups in the household and NFC sectors up to 20 quarters ahead. The grey area and dashed red lines refer to the 90% confidence bands.

Figure D.3: Impulse responses of real GDP with aggregate FoF data excluding the GFC



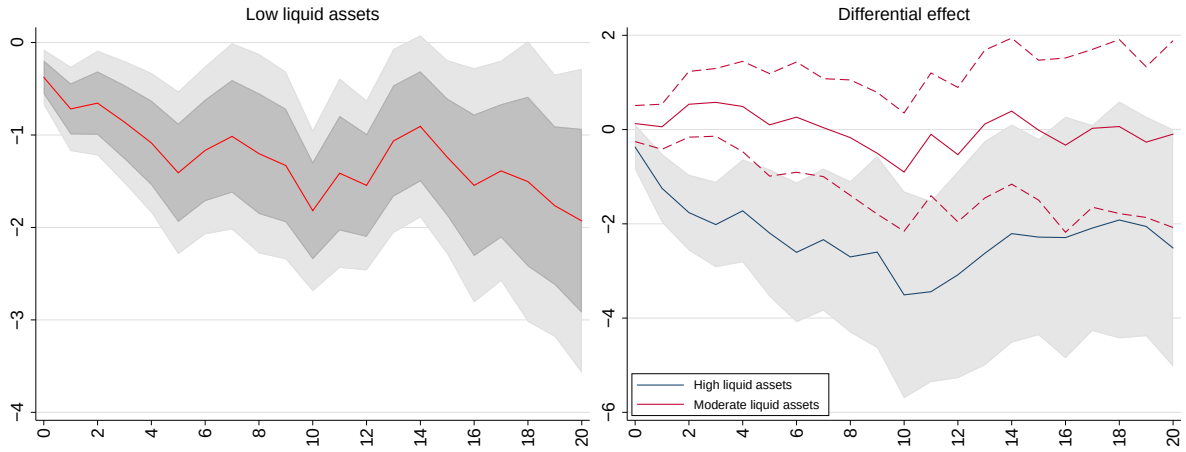
Notes: Cumulative impulse responses to a 1 p.p. increase in debt build-ups in the household and NFC sectors up to 20 quarters ahead. The grey area and dashed red lines refer to the 90% confidence bands.

Figure D.4: Impulse responses of investment spending: leverage groups



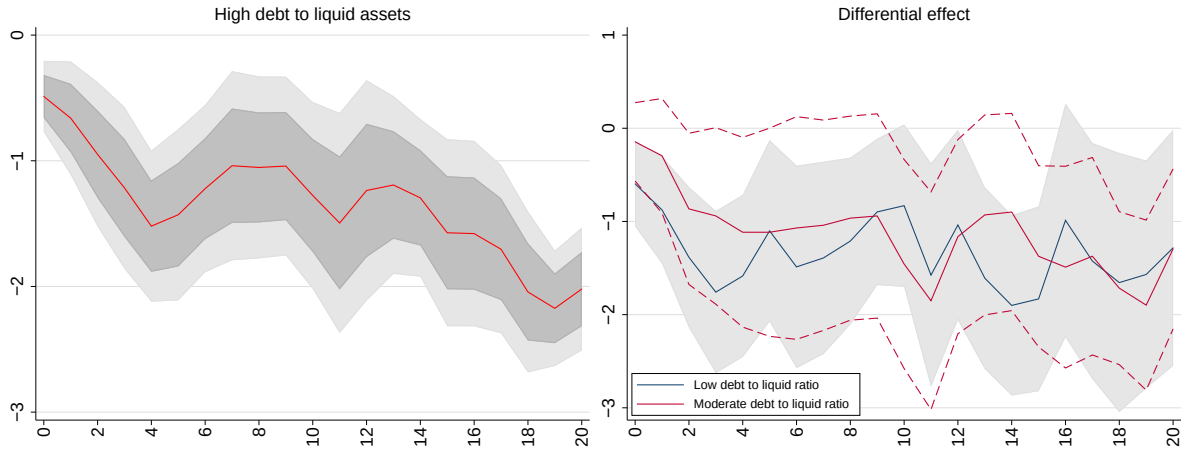
Notes: The left panel shows the cumulative impulse responses of capex for firms with high debt to a 10 p.p. increase in corporate debt build-ups up to 20 quarters ahead. The right panel shows the differences in point estimates, and associated 90% confidence bands, between the latter group and firms with a low/moderate debt (blue/red lines).

Figure D.5: Impulse responses of investment spending: liquidity groups



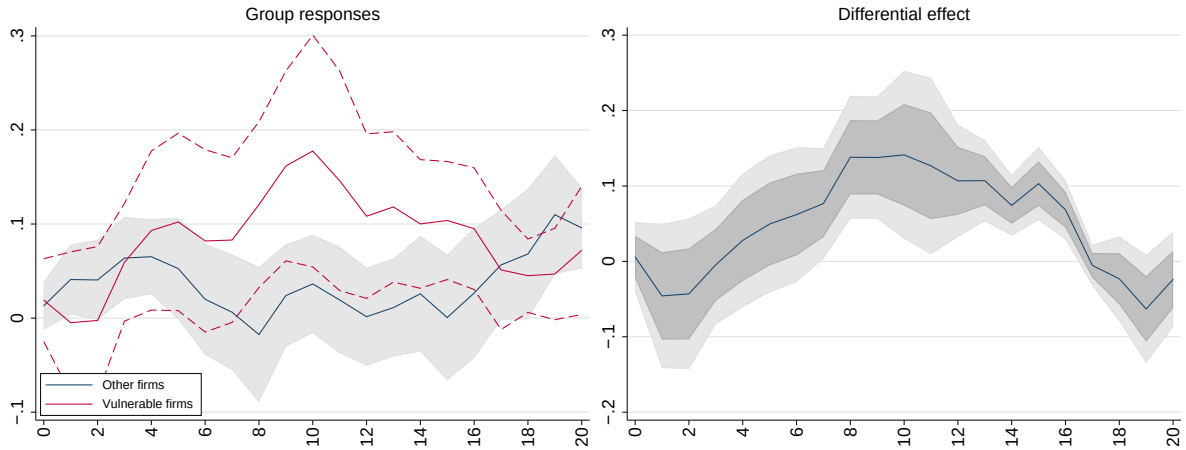
Notes: The left panel shows the cumulative impulse responses of capex for firms with low liquid assets to a 10 p.p. increase in corporate debt build-ups up to 20 quarters ahead. The right panel shows the differences in point estimates, and associated 90% confidence bands, between the latter group and firms with high/moderate liquidity (blue/red lines).

Figure D.6: Impulse responses of investment spending: debt-to-liquid assets



Notes: The left panel shows the cumulative impulse responses of capex for firms with high debt and low liquid assets to a 10 p.p. increase in corporate debt build-ups up to 20 quarters ahead. The dark (light) grey area refers to the 68 (90)% confidence bands. The right panel shows the differences in point estimates, and associated 90% confidence bands, between the latter grouping and firms with a low/moderate debt-to-liquid asset ratio (blue/red lines).

Figure D.7: Impulse responses of corporate bond yields: vulnerable firms



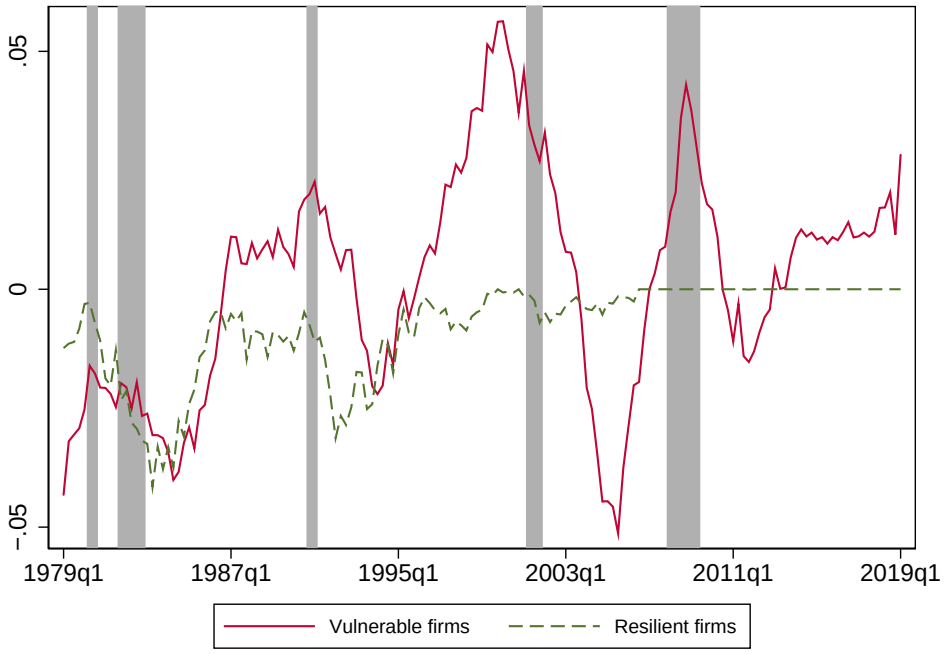
Notes: Cumulative impulse responses of corporate bond yields to a 10 p.p. increase in debt build-ups up to 20 quarters ahead. The right panel shows the difference between vulnerable and other firms. The dark (light) grey area refers to the 68% and 90% confidence bands.

Table D.1: Descriptive statistics for vulnerable firms vs resilient firms (median values)

	Size	Leverage	Liquidity	Δ log(*capex*)	ICR
Vulnerable firms	1508.10	0.37	-0.01	3.58	2.85
Resilient firms	67.25	0.03	0.51	10.70	25.29
Other firms	320.13	0.24	0.18	6.02	4.03

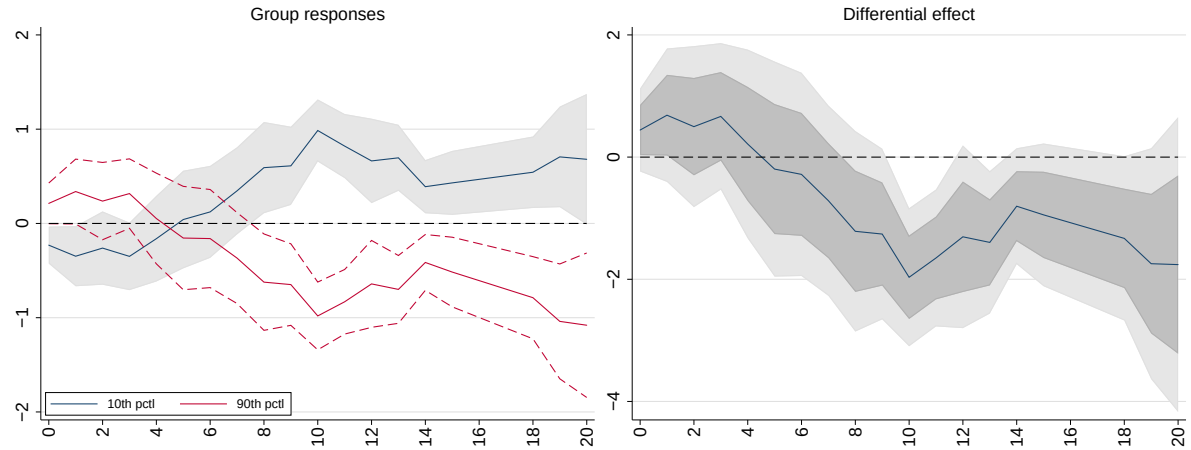
Notes: Size refers to total real assets in 2009 USD, leverage to the ratio of short-term and long-term debt to total assets, liquidity to the ratio of net current assets to total assets, capex to capital spending, and ICR to the ratio of EBIT to interest expenses.

Figure D.8: Corporate debt build-ups for vulnerable firms vs resilient firms



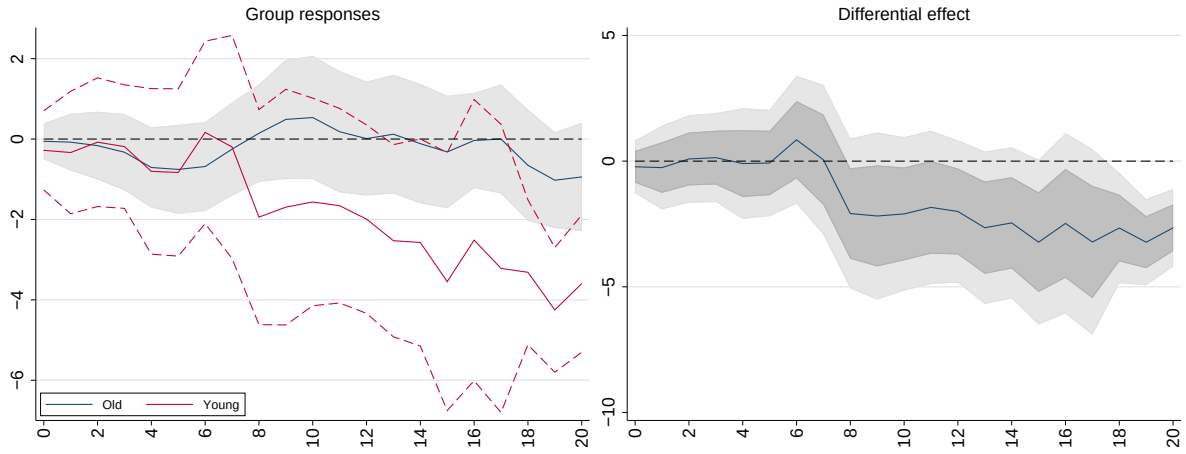
Sources: Compustat, and author's calculations.
Notes: Vulnerable (resilient) firms refer to firms that, at each point in time, belong simultaneously to the top (bottom) tertile of the leverage ratio and to the bottom (top) tertile of the liquid asset ratio. The shaded area indicates recessions as defined by the NBER.

Figure D.9: Financial constraints based on the HM index



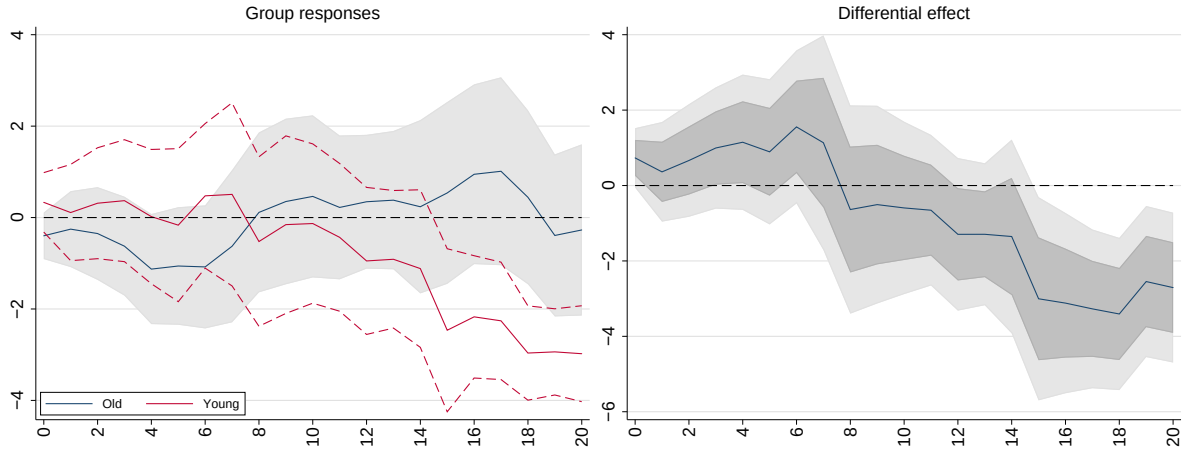
Notes: Cumulative impulse responses of capex to a 10 p.p. increase in corporate debt build-ups up to 20 quarters ahead. The grey area (red lines) refer to the mean response of the 10^{th} (90^{th}) percentile of the Hoberg and Maksimovic (2015)'s index and associated 90% confidence bands. The right panel depicts the difference, and associated 68% and 90% confidence bands, between the two impulse responses.

Figure D.10: Financial constraints based on firm age: young firms <=10 years



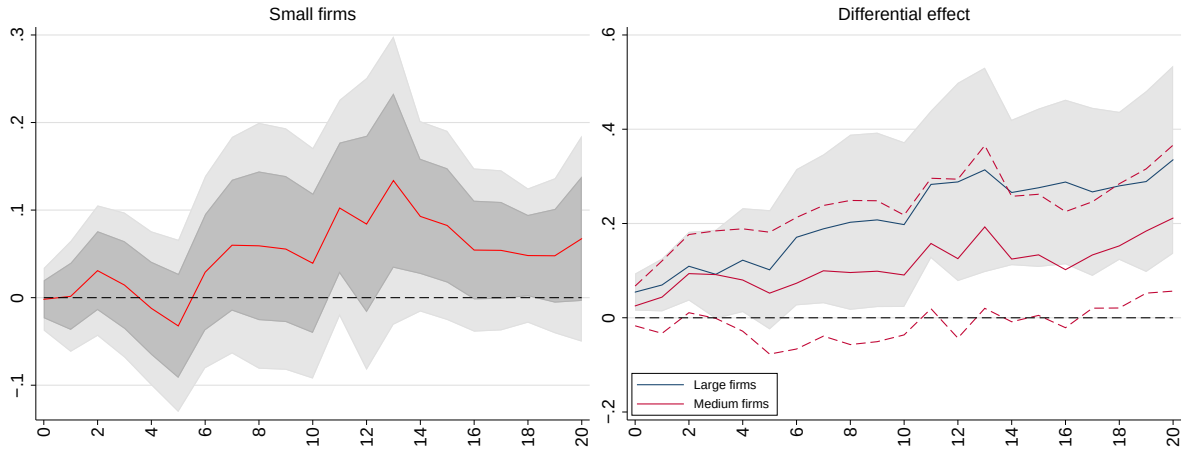
Notes: Cumulative impulse responses of capex to a 10 p.p. increase in corporate debt build-ups up to 20 quarters ahead. The grey area and red lines refer to the response of old and young firms and associated 90% confidence bands. Young firms are defined as firms that are less or equal than ten years old, and old firms above ten years old. The right panel depicts the difference, and associated 68% and 90% confidence bands, between the impulse responses of the young firms and old firms.

Figure D.11: Financial constraints based on firm age: young firms <=15 years



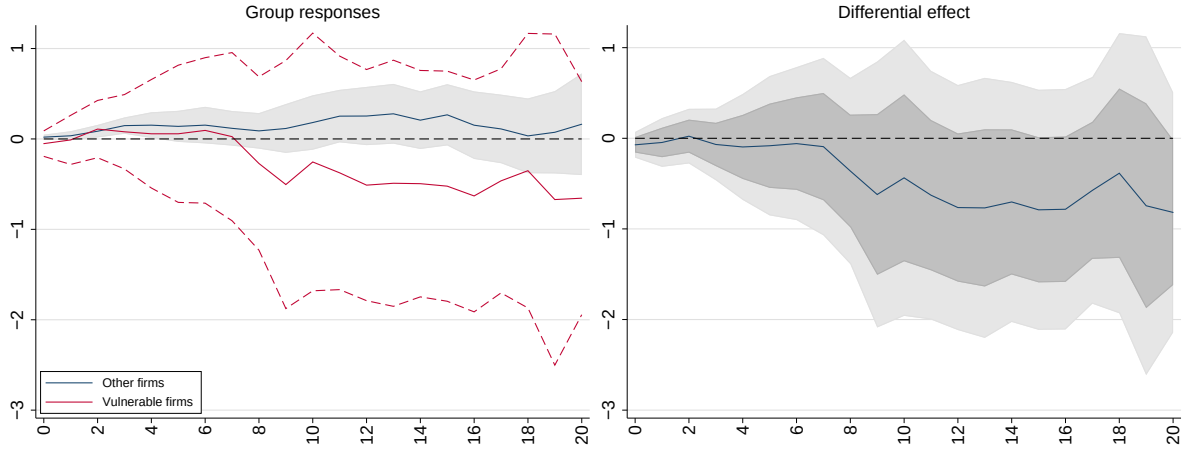
Notes: Cumulative impulse responses of capex to a 10 p.p. increase in corporate debt build-ups up to 20 quarters ahead. The grey area and red lines refer to the response of old and young firms and associated 90% confidence bands. Young firms are defined as firms that are less or equal than 15 years old, and old firms above 15 years old. The right panel depicts the difference, and associated 68% and 90% confidence bands, between the impulse responses of the young firms and old firms.

Figure D.12: Financial constraints based on firm size



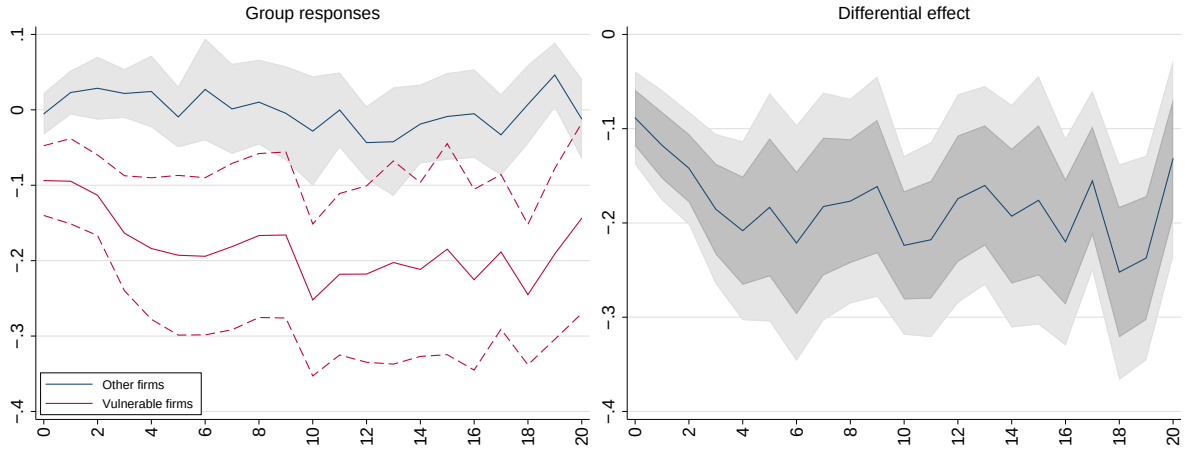
Notes: The left panel shows the cumulative impulse responses of capex for small firms to a 10 p.p. increase in corporate debt build-ups up to 20 quarters ahead. The right panel shows the differences in point estimates, and associated 90% confidence bands, between small firms and large/medium-sized firms (blue/red lines).

Figure D.13: Impulse responses of intangible investment from Ewens et al. (2019)



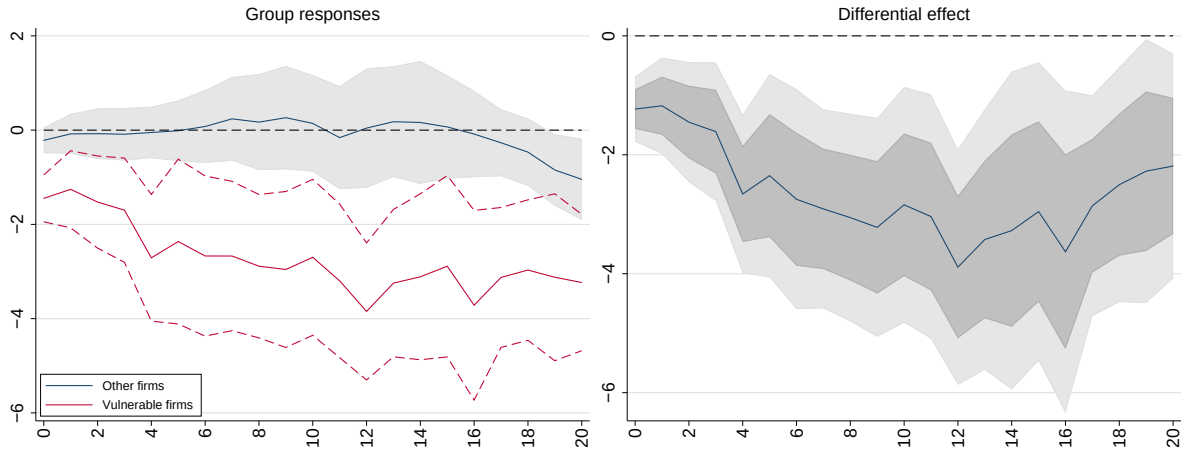
Notes: Cumulative impulse responses of the intangible capital-to-asset ratio from Ewens et al. (2019) to a 10 p.p. increase in corporate debt build-ups up to 20 quarters ahead. The red lines refer to the response of vulnerable firms and associated 90% confidence bands. The blue line and grey area refer to the response and 90% confidence bands for other firms. The right panel depicts the difference, and associated 68% and 90% confidence bands, between the responses of vulnerable firms and all other firms.

Figure D.14: Impulse responses with investment rate as the dependent variable



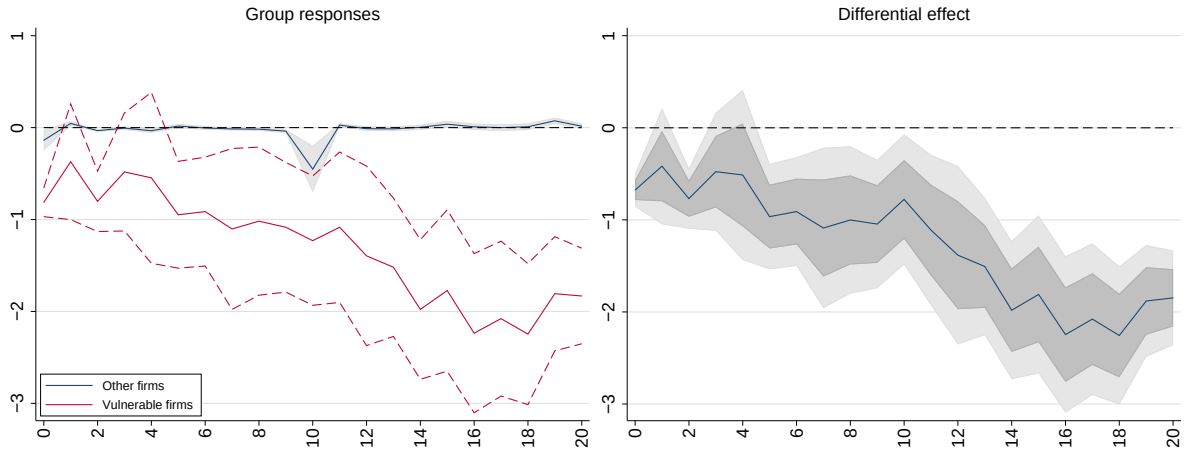
Notes: Cumulative impulse responses of the investment rate to a 10 p.p. increase in corporate debt build-ups up to 20 quarters ahead. The red lines (blue line and grey area) refer to the response of vulnerable (other) firms and associated 90% confidence bands. The right panel depicts the difference, with the 68% and 90% confidence bands, between vulnerable and other firms.

Figure D.15: Impulse responses with additional firm controls



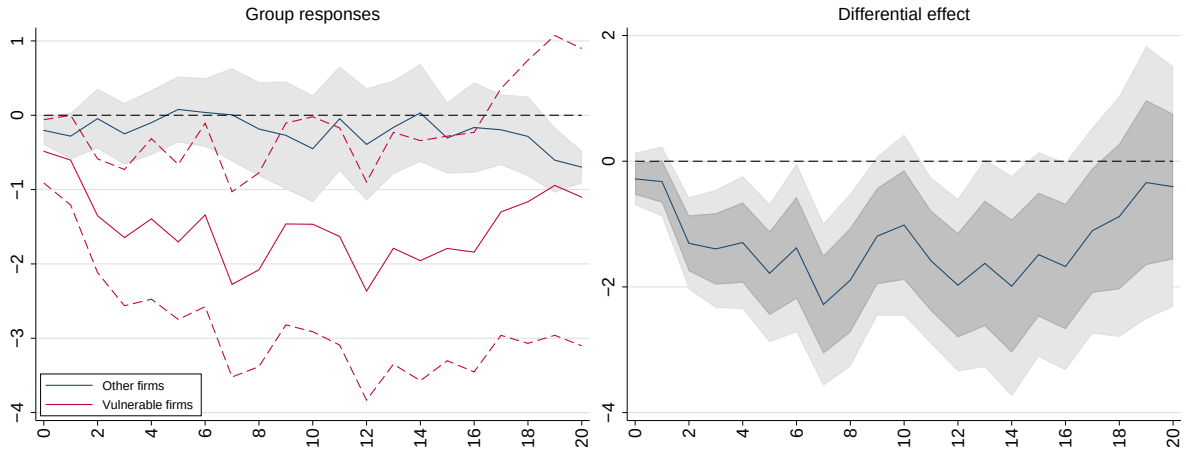
Notes: Cumulative impulse responses of capex to a 10 p.p. increase in corporate debt build-ups up to 20 quarters ahead. The red lines (blue line and grey area) refer to the response of vulnerable (other) firms and associated 90% confidence bands. The right panel depicts the difference, with the 68% and 90% confidence bands, between vulnerable and other firms.

Figure D.16: Impulse responses to debt booms in the net debt-to-asset ratio



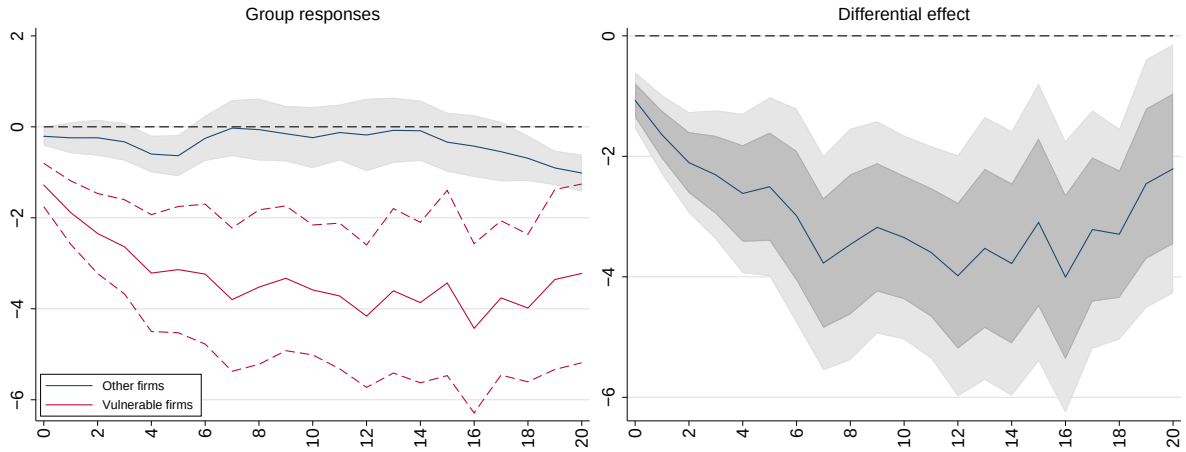
Notes: Cumulative impulse responses of capex to a 10 p.p. increase in corporate debt build-ups up to 20 quarters ahead. The red lines (blue line and grey area) refer to the response of vulnerable (other) firms and associated 90% confidence bands. The right panel depicts the difference, with the 68% and 90% confidence bands, between vulnerable and other firms.

Figure D.17: Impulse responses to debt booms over the past five years



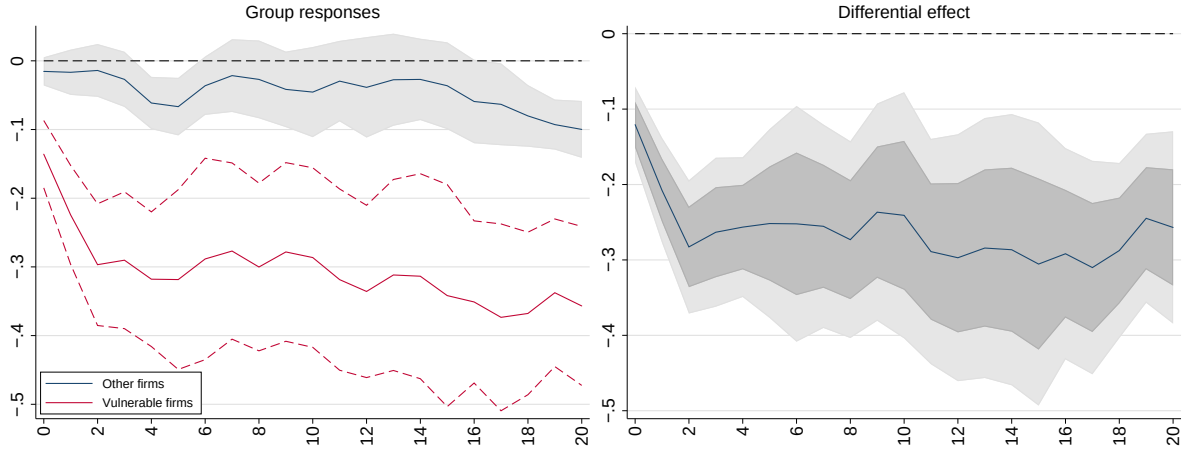
Notes: Cumulative impulse responses of capex to a 10 p.p. increase in corporate debt build-ups up to 20 quarters ahead. The red lines (blue line and grey area) refer to the response of vulnerable (other) firms and associated 90% confidence bands. The right panel depicts the difference, with the 68% and 90% confidence bands, between vulnerable and other firms.

Figure D.18: Impulse responses with gross current assets as the proxy for liquid assets



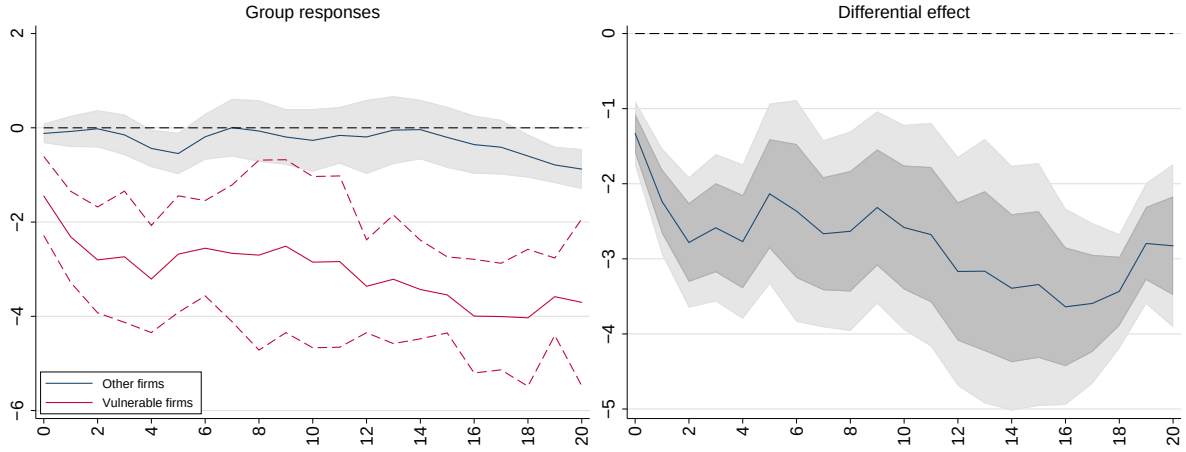
Notes: Cumulative impulse responses of capex to a 10 p.p. increase in corporate debt build-ups up to 20 quarters ahead. The red lines (blue line and grey area) refer to the response of vulnerable (other) firms and associated 90% confidence bands. The right panel depicts the difference, with the 68% and 90% confidence bands, between vulnerable and other firms.

Figure D.19: Impulse responses of vulnerable firms with cash as the proxy for liquid assets



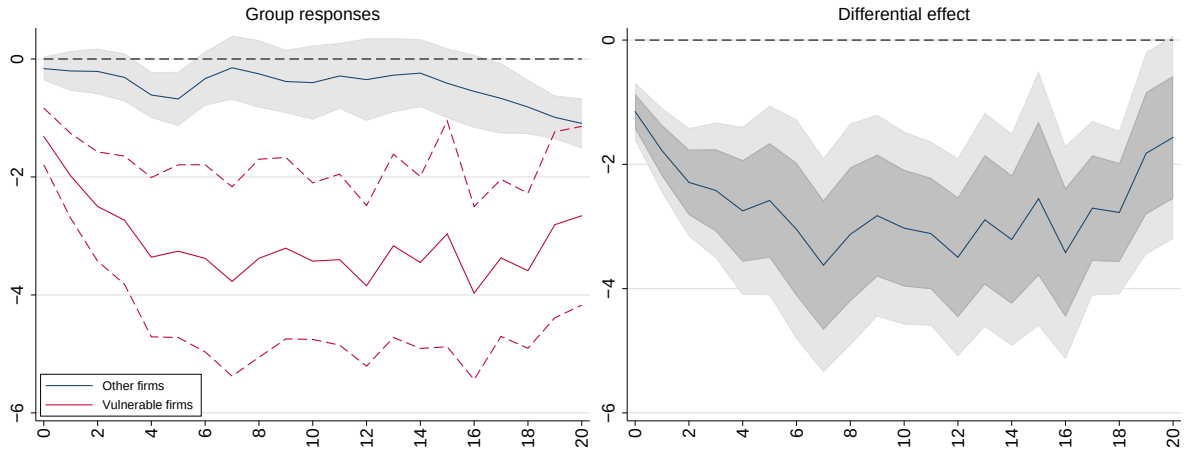
Notes: Cumulative impulse responses of capex to a 10 p.p. increase in corporate debt build-ups up to 20 quarters ahead. The red lines (blue line and grey area) refer to the response of vulnerable (other) firms and associated 90% confidence bands. The right panel depicts the difference, with the 68% and 90% confidence bands, between vulnerable and other firms.

Figure D.20: Impulse responses of vulnerable firms: restrict to ICR < 2



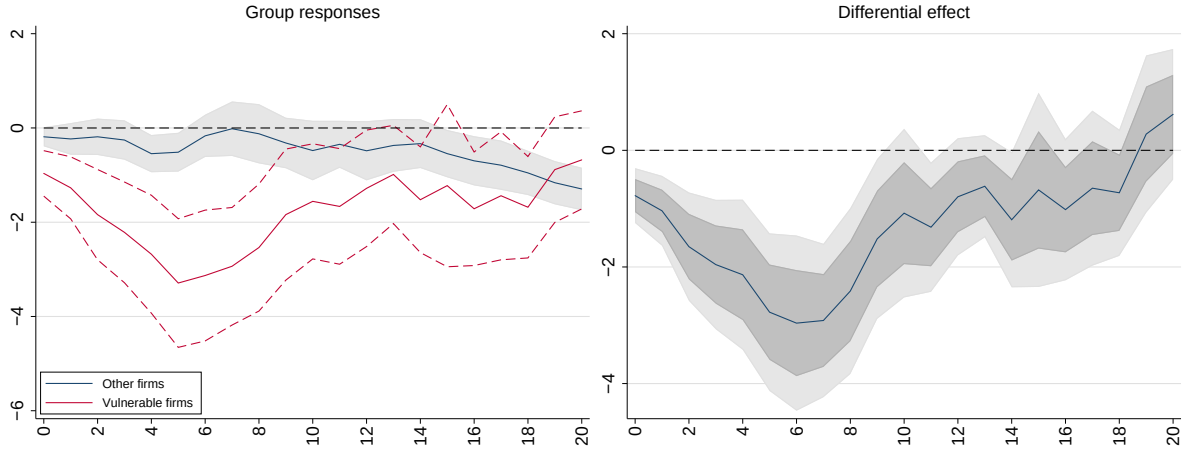
Notes: Cumulative impulse responses of capex to a 10 p.p. increase in corporate debt build-ups up to 20 quarters ahead. The red lines (blue line and grey area) refer to the response of vulnerable (other) firms and associated 90% confidence bands. The right panel depicts the difference, with the 68% and 90% confidence bands, between vulnerable and other firms.

Figure D.21: Impulse responses with industry-specific shocks



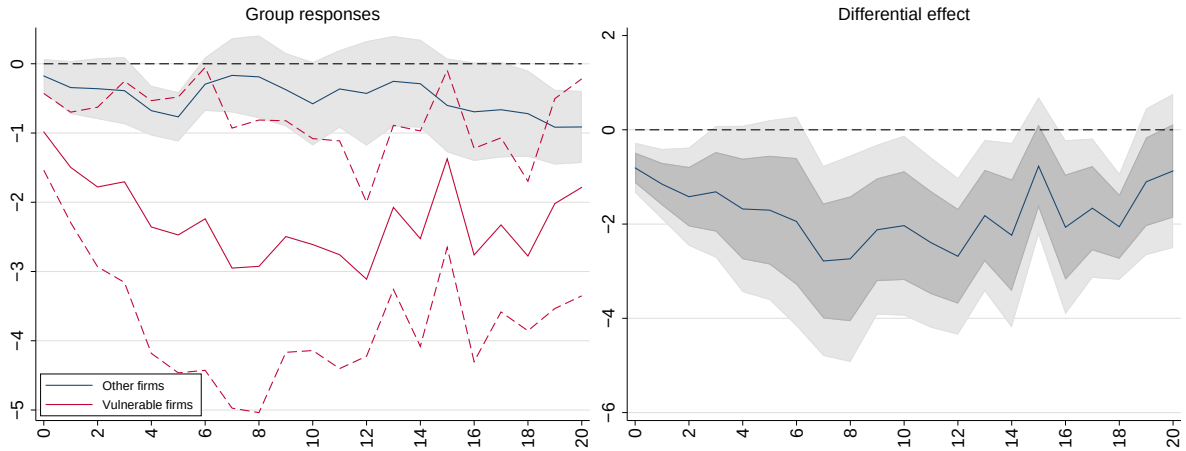
Notes: Cumulative impulse responses of capex to a 10 p.p. increase in corporate debt build-ups up to 20 quarters ahead. The red lines (blue line and grey area) refer to the response of vulnerable (other) firms and associated 90% confidence bands. The right panel depicts the difference, with the 68% and 90% confidence bands, between vulnerable and other firms.

Figure D.22: Impulse responses of vulnerable firms: definition within each industry



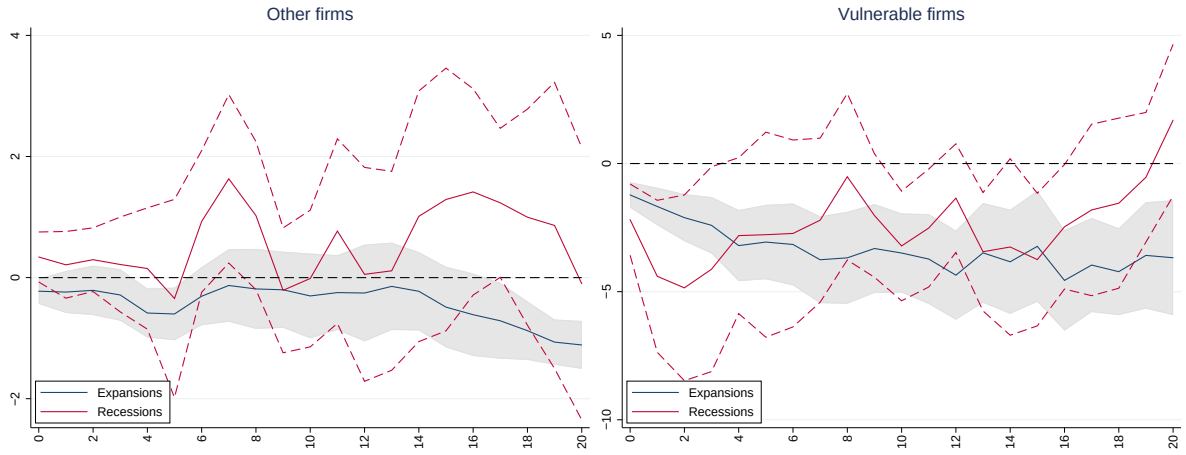
Notes: Cumulative impulse responses of capex to a 10 p.p. increase in corporate debt build-ups up to 20 quarters ahead. The red lines (blue line and grey area) refer to the response of vulnerable (other) firms and associated 90% confidence bands. The right panel depicts the difference, with the 68% and 90% confidence bands, between vulnerable and other firms.

Figure D.23: Impulse responses in the pre-GFC period



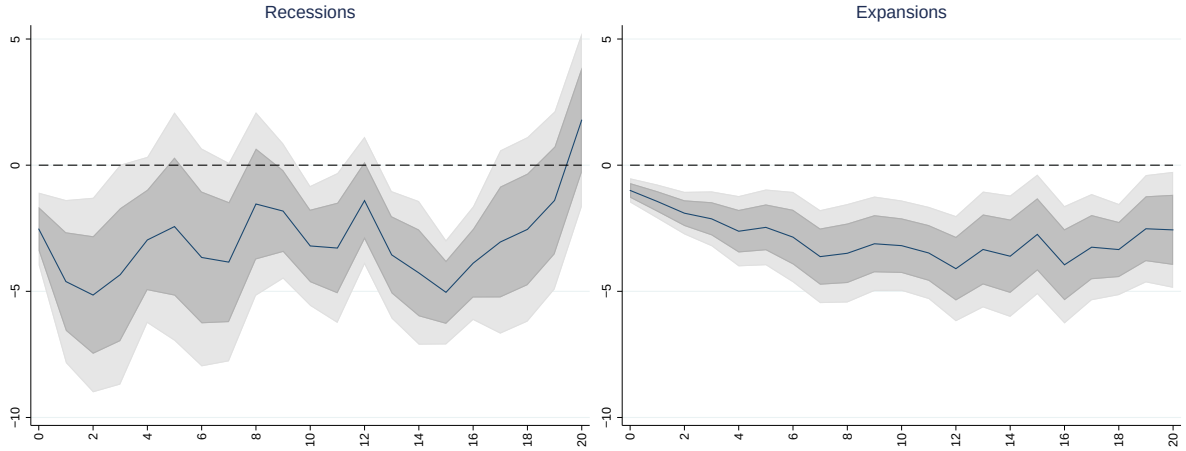
Notes: Cumulative impulse responses of capex to a 10 p.p. increase in corporate debt build-ups up to 20 quarters ahead. The red lines (blue line and grey area) refer to the response of vulnerable (other) firms and associated 90% confidence bands. The right panel depicts the difference, with the 68% and 90% confidence bands, between vulnerable and other firms.

Figure D.24: Impulse responses in expansions and recessions



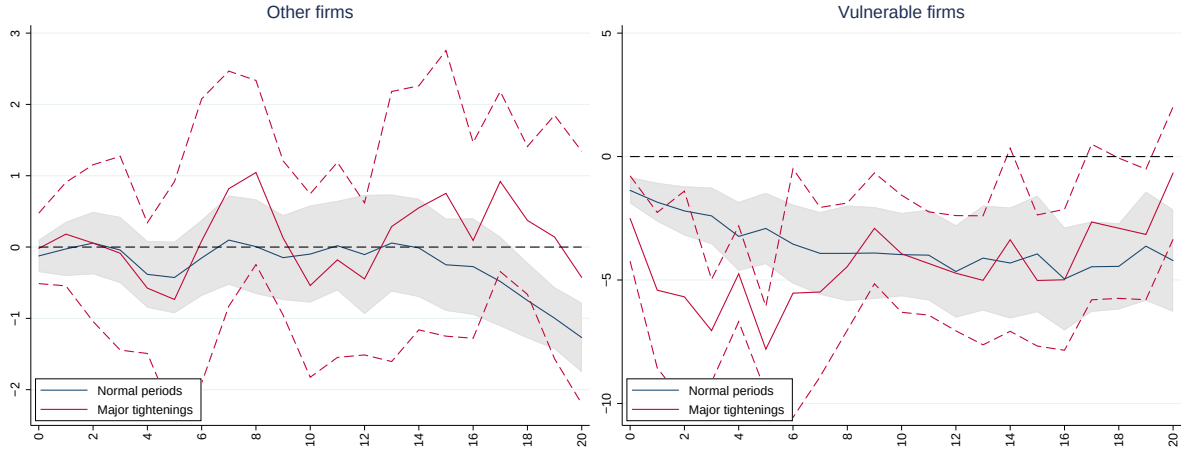
Notes: Cumulative impulse responses of capex to a 10 p.p. increase in corporate debt build-ups up to 20 quarters ahead. The dashed red lines and grey area refer to the 90% confidence bands for the response in recessions and expansions.

Figure D.25: Difference in impulse responses between vulnerable firms and other firms in expansions and recessions



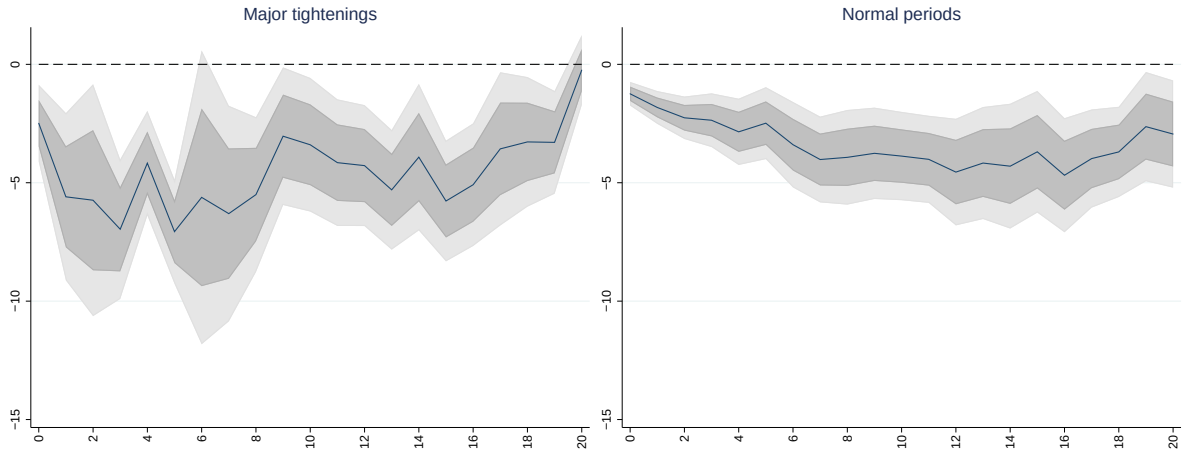
Notes: The figure shows the difference in cumulative impulse responses of capex between vulnerable firms and other firms to a 10 p.p. increase in corporate debt build-ups up to 20 quarters ahead in recessions (left panel) and expansions (right panel). The dark (light) grey area refers to the 68% and 90% confidence bands.

Figure D.26: Impulse responses during periods of major tightenings in credit conditions



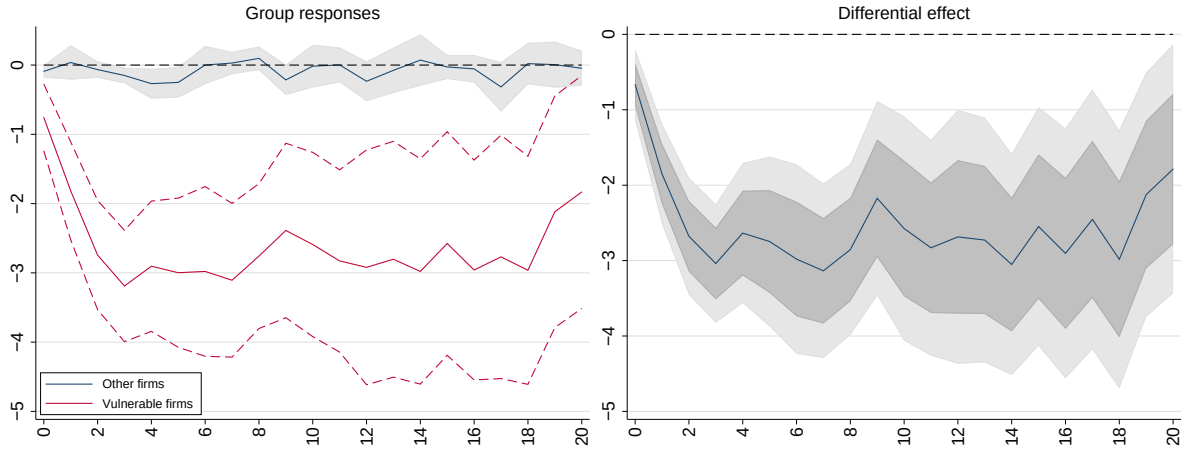
Notes: Cumulative impulse responses of capex to a 10 p.p. increase in corporate debt build-ups up to 20 quarters ahead. The dashed red lines and grey area refer to the 90% confidence bands for the response during periods of major tightenings in credit conditions and during normal periods.

Figure D.27: Difference in impulse responses between vulnerable firms and other firms during periods of large tightenings in credit conditions



Notes: The figure shows the difference in cumulative impulse responses of capex between vulnerable firms and other firms to a 10 p.p. increase in corporate debt build-ups up to 20 quarters ahead during major tightening periods in credit conditions (left panel) and during normal times (right panel). The dark (light) grey area refers to the 68% and 90% confidence bands.

Figure D.28: Impulse responses with a one-lag model



Notes: Cumulative impulse responses of capex to a 10 p.p. increase in corporate debt build-ups up to 20 quarters ahead. The red lines (blue line and grey area) refer to the response of vulnerable (other) firms and associated 90% confidence bands. The right panel depicts the difference, with the 68% and 90% confidence bands, between vulnerable and other firms.

References

Almeida, H., Campello, M. and Weisbach, M. S. (2004), 'The cash flow sensitivity of cash', *The Journal of Finance* **59**(4), 1777–1804.

Bacchetta, P., Benhima, K. and Poilly, C. (2019), 'Corporate Cash and Employment', *American Economic Journal: Macroeconomics* **11**(3), 30–66.

Barth, M. J. and Ramey, V. A. (2002), The Cost Channel of Monetary Transmission, *in* 'NBER Macroeconomics Annual 2001, Volume 16', NBER Chapters, National Bureau of Economic Research, Inc, pp. 199–256.

Bates, T. W., Kahle, K. M. and Stulz, R. M. (2009), 'Why Do U.S. Firms Hold So Much More Cash than They Used To?', *The Journal of Finance* **64**(5), 1985–2021.

Blickle, K. S. and Santos, J. A. C. (2020), The Costs of Corporate Debt Overhang, Available at https://ssrn.com/abstract=3708502, SSRN.

Brunnermeier, M. and Krishnamurthy, A. (2020), 'Corporate Debt Overhang and Credit Policy', *Brookings Papers on Economic Activity* (forthcoming).

Buera, F. and Karmakar, S. (2019), Real effects of financial distress: the role of heterogeneity, Bank of England working papers 814, Bank of England.

Campello, M., Graham, J. R. and Harvey, C. R. (2010), 'The real effects of financial constraints: Evidence from a financial crisis', *Journal of Financial Economics* **97**(3), 470–487.

Cunha, I. and Pollet, J. (2020), 'Why Do Firms Hold Cash? Evidence from Demographic Demand Shifts', *Review of Financial Studies* **33**(9), 4102–4138.

Dedola, L. and Lippi, F. (2005), 'The monetary transmission mechanism: Evidence from the industries of five OECD countries', *European Economic Review* **49**(6), 1543–1569.

Dell'Ariccia, G., Igan, D., Laeven, L. and Tong, H. (2016), 'Credit booms and macrofinancial stability', *Economic Policy* **31**(86), 299–355.

Durante, E., Ferrando, A. and Vermeulen, P. (2020), Monetary policy, investment and firm heterogeneity, Working Paper Series 2390, European Central Bank.

Ewens, M., Peters, R. H. and Wang, S. (2019), Measuring Intangible Capital with Market Prices, NBER Working Papers 25960, National Bureau of Economic Research, Inc.

Hoberg, G. and Maksimovic, V. (2015), 'Redefining Financial Constraints: A Text-Based Analysis', *The Review of Financial Studies* **28**(5), 1312–1352.

Joseph, A., Kneer, C., van Horen, N. and Saleheen, J. (2019), All you need is cash: corporate cash holdings and investment after the financial crisis, Bank of England working papers 843, Bank of England.

Kalemli-Ozcan, S., Laeven, L. and Moreno, D. (2019), Debt overhang, rollover risk, and corporate investment: evidence from the European crisis, Working Paper Series 2241, European Central Bank.

Melcangi, D. (2019), Firms' Precautionary Savings and Employment during a Credit Crisis, Staff Reports 904, Federal Reserve Bank of New York.